



Relating the Marginal Fit of the Castings to the Accuracy of the Impressions made from Laminated Hydrocolloid Impression Technique: A Comparative Study

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ABSTRACT

Aim: Relating the marginal fit of the castings, to the accuracy of the impression produced using laminated hydrocolloid impression technique, alginate and double-mixed polyvinyl siloxane. Basic objective of the study is to check the feasibility of the use of laminated hydrocolloid impression technique in the fixed partial denture.

Materials and methods: The precisely machined metal die was designed to simulate standard complete metal crown preparation. The preparation was mounted on cylindrical base of 20 mm length and diameter of 10 mm. Seven impressions were made from the each impression material onto the metal die, and total 21 impressions were obtained from all three impression materials, which were poured by the die stone, and stone die was prepared. Wax patterns were fabricated on stone dies obtained from each impression and then casting was done. All the castings were checked for the marginal fit on metal die after applying a uniform standardized load of 30 pounds using measuring microscope.

Results: Result revealed that the marginal fit of the castings obtained from group II (laminated hydrocolloid technique) and group III (double-mix polyvinyl polysiloxane) did not show the significant difference between the two of them. Marginal gap of the castings obtained from group I are significantly greater in comparison to the castings obtained from groups II and III ($p < 0.01$).

Conclusion: Group II (laminated hydrocolloid technique) impression material may be the choice of many clinicians over group III (double-mix polyvinyl polysiloxane) impression material. Group I (alginate impression material), though very cost-effective and easy to handle may not able to produce accurate results.

Clinical significance: The study gives overview of the best impression material that can be used clinically. Laminated hydrocolloid technique is the technique of choice.

Keywords: Laminated hydrocolloid technique, Impression materials, Polyvinyl polysiloxane, Alginate.

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INTRODUCTION

The dimensional accuracy of the impression materials crucial for the production of precise working cast in fixed prosthodontics. To achieve this, the impression materials should be able to accurately record the adjoining teeth and also teeth of the opposing arch for registration of their relationship.¹ It is essential, therefore, for the material of choice to exhibit minimum dimensional deformation and maximum elastic recoil, while making an impression.

The clinical use of hydrocolloid impression material had long been acceptable for making impression in fixed prosthodontics procedure. However, concern has been expressed regarding their dimensional stability. Due to improved quality of rubber base impression materials, in regards of dimensional stability and accuracy, many clinicians have accepted that it is the choice of material for fixed prosthodontics in comparative to hydrocolloid impression material.

But, since the introduction of reversible hydrocolloid (agar) by Sears (1973)^{1,2} and irreversible hydrocolloid (alginate) by Schoonover and Dickson,^{1,2} several efforts have been made to unite the materials for the combined impression. Many attempts have been made, since Schwartz³ in 1951, to combined reversible and irreversible hydrocolloid for an impression technique known as laminated hydrocolloid impression technique. Lie et al^{4,5} demonstrated the accuracy of combined hydrocolloid impression was comparable to that of rubber, base

impression material and better than either reversible or irreversible hydrocolloid impression.

The advantages of combined reversible and irreversible hydrocolloid impression over commonly used impression are reducing expense, less preparation time and uncomplicated technique. Many researchers have been done in the field of combined hydrocolloid impression and remarkable contribution has been made. The laminated hydrocolloid impression technique appears to produce excellent result and is gaining popularity among clinicians.⁵⁻⁸

A comparative study was, therefore, carried out by relating the marginal fit of the casting, to the accuracy of the impressions produced using laminated hydrocolloid impression technique, alginate and double-mixed polyvinyl siloxane. The basic objective of the study is to check the feasibility of the use of laminated impression technique in the fixed partial denture.

MATERIALS AND METHODS

Preparation of the Master Metal Die

The precisely machined metal die was designed to simulate standard complete metal crown preparation as per given by Hobo and Schilenburg.⁶ The preparation was mounted on cylindrical base of 20 mm length and diameter of 10 mm.

Fabrication of Special Trays

The special tray to carry out different impression material on the metal die was fabricated in autopolymerizing acrylic resin with uniform thickness of wax spacer (3 mm). Four stops with one on occlusal surface and three on the cylindrical sides of the metal die were made, which help in orientation of tray on metal die. Two types of tray were prepared, one is nonperforated for elastomeric impression material and other is perforated for alginate and laminated hydrocolloid techniques.

Impression of the Metal Die using Various Impression Materials

Three different impression materials namely: Alginate (Alginoplast, Heraeus Kulzer, Holland), double-mix polyvinyl siloxane (Take-1 Kerr, Michigan, USA), and laminated hydrocolloid combined system—agar (Van R, Duoloid System, Cadco Dental Products, California, USA) with alginate (Angioplast) were used.

The impression materials were grouped as follows:

- *Group I:* Alginate impression material
- *Group II:* Laminated hydrocolloid technique
- *Group III:* Double-mixed polyvinyl siloxane

Seven impressions using each alginate laminated hydrocolloid technique and double-mixed polyvinyl siloxane

were made. A total of 21 impressions were obtained. As regards, handling of each one of the materials manufacturer instructions in respect to water-powder ratio, mixing time and working time were strictly followed. All the impressions were strictly checked for voids and then selected for study purpose.

Pouring of the Dies

After the impressions were made, beading and boxing was performed in order to get border base and it also helps easy separation of tray from the die. The impression was poured in type IV die stone (Kalrock, Kalabhai Karson Private Limited, Mumbai) according to manufacturer instructions. A period of 1 hour was allowed to set before the stone die was removed from the impression.

Fabrication of Wax Pattern, Investing and Casting

A wax pattern was fabricated on stone die, using silicon putty mould (3M Express Std, 3M Dental Products, USA) mould on another brass model with dimension of 7 mm in length and 10 mm of diameter representing the shape of the final contour of wax pattern to be made. Final wax pattern was checked for the marginal integrity of the finish line on the stone die before investing was done. The wax patterns were invested immediately with phosphate bonded investment material (Bellavest T, Bego, Bremen, Germany) to minimize the possibility of distortion of the wax patterns. The invested wax pattern was casted by using Ni-Cr alloy (Sankin CB80, Tokyo, Japan) with induction casting machine (Dentaurum, Megaplus D200, Germany). After the completion of casting procedure, the casting was retrieved from the casting ring, by placing the casting ring under running cold water. The casting was further sandblasted, finished, polished and passively fitted on the stone die.

Measurement of the Marginal Fit

The finished and polished castings were seated onto the metal die one by one and a uniform load of 30 pounds was applied on each casting by load applying device as a standardization of load. Two measurements were made at two different locations for each casting using microscope (Nikon Measurescope-10, Japan). The readings were obtained and subjected to statistical analysis.

RESULTS

For each casting, two readings at two different locations were measured and the average value was taken (Table 1). Then from seven average values of each group, the mean of each group was calculated. The mean obtained from three different groups were then compared to check for accuracy

of the three different impression materials. The mean values were subjected to one-way ANOVA. The Studentized Newman-Keuls test was performed to analyze the data for different among the means. The results were plotted into Tables 1 to 4.

DISCUSSION

Making an accurate impression is the first step toward the fabrication of fixed partial denture. There are several impression materials and procedures available for making an accurate impression. The procedure for making impression varies depending on the type of material and their properties. A combined reversible (agar) and irreversible hydrocolloid (alginate) impression system has been introduced in the dental profession during recent times. This combination is known as 'laminated hydrocolloid technique'. In this technique, reversible hydrocolloid is injected onto the prepared tooth and custom tray loaded with irreversible hydrocolloid is positioned over the reversible hydrocolloid. During this process, alginate gels by chemical

reaction, at the same time, agar gel by contacting with cool alginate rather by cooled water tray. Since, agar has excellent surface reproducibility property; maximum details of prepared teeth was recorded.

Dimensional accuracy of laminated hydrocolloid technique was studied by Heering HW and Tames MA,⁷ who suggested that dimensional accuracy is clinically acceptable. David C and Cohen SR⁸ noted that laminated hydrocolloid technique is very useful in cases of partial veneer crown, post and core and porcelain fused to metal restoration. This technique is choice for the patient susceptible to gagging or heavy salivation. Chang-chi-lin et al⁴ studied the accuracy of six impression materials and suggested that elastomeric impression material was superior than laminated technique and irreversible hydrocolloid was the least accurate among all the materials tested.

Supowitz ML et al⁹ studied dimensional accuracy and surface details of stone cast obtained using laminated technique with those irreversible hydrocolloid, polysulfide and reversible hydrocolloid materials. Results of the study

Table 1: Marginal gap of each casting from three different groups at two different locations

Specimen no.	Alginate (group I)		Laminated hydrocolloid technique (group II)		Double-mix polyvinyl siloxane (group III)	
	Readings (mm)	Average (mm)	Readings (mm)	Average (mm)	Readings (mm)	Average (mm)
1	0.138 0.166	0.152	0.076 0.094	0.085	0.093 0.057	0.074
2	0.123 0.185	0.154	0.039 0.107	0.073	0.067 0.074	0.071
3	0.156 0.142	0.149	0.080 0.064	0.072	0.074 0.068	0.071
4	0.174 0.127	0.151	0.034 0.109	0.072	0.089 0.059	0.074
5	0.163 0.153	0.158	0.090 0.061	0.076	0.100 0.035	0.068
6	0.119 0.194	0.157	0.085 0.062	0.074	0.074 0.065	0.070
7	0.173 0.150	0.162	0.078 0.074	0.076	0.081 0.065	0.073

Table 2: Average values, mean, standard deviation and standard error of marginal gaps in millimeters (mm) and micron (μ m) of all the castings obtained from different groups

Specimen no.	Alginate (group I)		Laminated hydrocolloid technique (group II)		Double-mix polyvinyl siloxane (group III)	
	Millimeters (mm)	Microns (μ m)	Millimeters (mm)	Microns (μ m)	Millimeters (mm)	Microns (μ m)
1	0.152	152	0.085	85	0.075	75
2	0.154	154	0.073	73	0.071	71
3	0.149	149	0.072	72	0.071	71
4	0.158	158	0.072	72	0.074	74
5	0.157	157	0.076	76	0.068	68
6	0.151	151	0.074	74	0.070	70
7	0.162	162	0.076	76	0.073	73
Mean	0.155	154.7	0.075	75.4	0.072	71.7
SD	0.005	4.5	0.005	4.5	0.002	2.4
SE	0.002	1.7	0.002	1.7	0.001	0.9

SD: Standard deviation, SE: Standard error

show that irreversible hydrocolloid produced cast which prevents accurate measurement of dimensional change.

Five elastomeric impression materials were evaluated: Two polysulfides (one lead-cure and one nonlead cure), two silicones (one condensation polymerization and one addition polymerization) and one polyether. All impression materials that were poured immediately and evaluated using a custom tray and adhesive consistently demonstrated superior results in comparison to those tested without the custom tray. Polyether material consistently yielded superior results with or without a custom tray, when compared to the other impression materials. The addition polymerization silicone ranked second, followed by the lead-cure polysulfide and the condensation polymerization silicone respectively.¹⁰

The accuracy of a combined hydrocolloid impression system was studied as a function of time of pour. The hydrocolloid impression system tested resulted in a stone cast of slightly deviating dimensions compared with the master model. Therefore, laboratory procedures should compensate for cement thickness, taking into account the minimal changes in dimensions of the die.¹¹

The accuracy and bond strength of several combinations of agar and alginate hydrocolloid impression materials were assessed. The buccal-lingual diameter was 0.32% larger, whereas the mesial-distal diameter was only 0.06% larger. Regarding bond strength, alginate hydrocolloids in combination with agar hydrocolloids produced the best results of all combinations tested.¹²

The polyether and both addition silicone impression materials were significantly more accurate than the reversible hydrocolloid, when compared the marginal fit of complete arch fixed prostheses under simulated clinical conditions.¹³

This study primarily investigated the effect of disinfection procedures (perform and sodium hypochlorite) on the dimensional accuracy and surface quality of four

irreversible hydrocolloid impression materials and the resultant gypsum casts. The dimensional accuracy of the impression materials tested were of a comparable standard following disinfection.^{14,15}

From above-mentioned studies, it has been concluded that laminated hydrocolloid technique is good alternative to elastomeric impression material. So, the present study aims for checking the feasibility of the use of laminated hydrocolloid technique in fixed partial denture. The present study was carried out to determine which of the three materials used for the study yield best result. This objective is achieved by relating marginal fit of the casting obtained from the stone dies to the accuracy of the impression made using three different impression materials.

From the statistical analysis (Table 3), the result revealed that the marginal fit of the castings obtained from group II [laminated hydrocolloid technique and group III (double-mix polyvinyl polysiloxane)] did not show the significant difference between the two of them. This is because Studentized Newman-Keuls test shows that minimum significant range of marginal gap should be 7.04 μm . As the mean marginal gap obtained from group II was 75.4 μm and group III was 71.7 μm , the difference in mean was only 3.7 μm .

The mean marginal gap obtained from group I (alginate impression) as shown in Table 3 was 154.7 μm . This is much greater than those obtained from group III. Therefore, it can be said that the marginal gap of the castings obtained from group I are significantly greater in comparison to the castings obtained from groups II and III ($p < 0.01$).

ANOVA technique was also carried out to access the different impression material exhibit different marginal gap in the castings obtained from them. F-test reveals the marginal gaps different in the difficult groups compared ($F = 980.2$, $p < 0.001$) (Table 4).

Table 3: Comparison of marginal gaps of castings obtained from different groups in microns

Groups	Impression materials	Marginal gap (microns)				Group-wise comparison*
		Range (μm)	Mean (μm)	SD (μm)	SE (μm)	
I	Alginate	149-162	154.7	4.5	1.7	Group I vs group II ($p < 0.01$ sig)
II	Laminated hydrocolloid technique	72-85	75.4	4.5	1.7	Group I vs group III ($p < 0.01$ sig)
III	Double-mix polyvinyl siloxane	68-75	71.7	2.4	0.9	Group II vs group III (NS)

*One-way ANOVA ($F = 980.2$, $p < 0.001$)

Studentized Newman-Keuls test shows minimum significance range = 7.04 μm ($p < 0.01$)

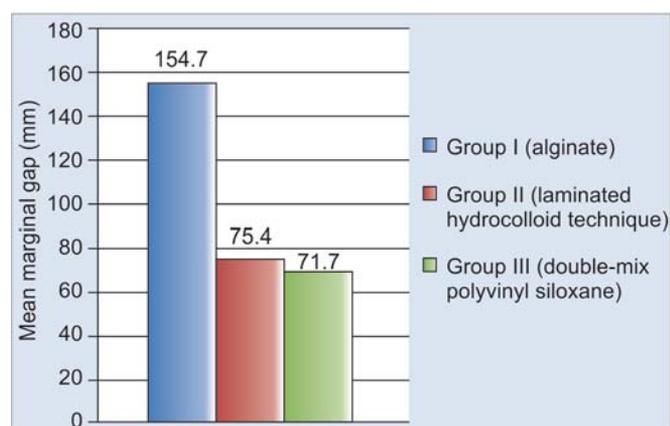
Sig: Significant; NS: Not significant

Table 4: Application of ANOVA test

Source of variation	Sum of squares	Degree of freedom	Mean sum of squares	Variance ratio (F-value)	p-value
Between groups	30774.4	2	15387.2	980.2	<0.001
Within groups	282.6	18	15.7		
Total	31056.95	20			

By relating the marginal fit of the castings to the accuracy of different impression materials used in the study, it has been found that the accuracy of groups II and III impression materials much better than that of group I impression material. The possible reason being that groups II and III impression materials record the impression of the metal die more accurately and there may be less distortion of the impression after removal as compared to group I impression material. Also, the accuracy of the group II impression material was found to be similar to group III impression material.

Therefore, from the above discussion, it can be concluded that laminated hydrocolloid technique (group II) and double-mix polyvinyl siloxane (group III) impression materials were much superior than alginate (group I) in accuracy of the impression made from them. Though negligible difference of 3.7 μm is found between groups II and III impression materials, it is considered statistically insignificant. So, it can be said that the accuracy of group II impression material was similar to group III impression material (Graph 1).



Graph 1: Comparison of mean marginal gap of casting obtained from different groups

The group II impression material has certain superior quality than group III impression material, in regards of low cost, simple conditioning without water cooled tray, rapid gelation, clinically acceptable result, good wettability, when poured with gypsum product producing smooth dense, bubble-free dies or models, excellent shelf-life and pleasant taste.

CONCLUSION

Because of above-mentioned qualities, group II impression material may be the choice of many clinician over group III impression material. Group I (Alginate) impression material, though very cost-effective and easy to handle, may not able to produce an accurate results as in case of groups II and III impression materials. An *in vivo* study is suggested to verify

the results of the present *in vitro* study which has its own limitations.

CLINICAL SIGNIFICANCE

The study gives overview of the best impression material that can be used clinically. Laminated hydrocolloid technique can be the technique of choice.

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