Accuracy of working casts and dies produced by fast-setting polyvinyl siloxane impressions

Mona El-Agroudi MD DDS[1] and Eman Essam, MD DDS[2]

[1] Assistant professor of Fixed Prosthodontics, Faculty of Oral and Dental Medicine, Cairo University. , Egypt.
[2] Lecturer of Fixed Prosthodontics, Faculty of Oral and Dental Medicine, Al Azhar University. , Egypt.

Abstract: Purpose: This study aimed to evaluate the effect of spacer on the accuracy of working casts and dies produced from fast-setting polyvinyl siloxane impressions.
Materials and Methods: Twenty Impressions of the mandibular arch of a modified Dentoform master model incorporating a stainless steel circular crown preparation were made, using a fast-set Polyvinyl siloxane (Affinis perfect impressions Coltene/Whaladent AG) using 2/step impression technique with and without a spacer. Gypsum working casts and dies were produced from the poured impressions. Measurements of the master model and working casts were carried out including anteroposterior (AP) and cross-arch (CA) dimensions. The stainless steel circular crown preparation incorporated within the master model was also measured in buccolingual (BL), mesiodistal (MD), and occlusogingival (OG) dimensions and compared to measurements from recovered gypsum dies. Linear measurements were made using a measuring stereomicroscope. Results: Double impression technique without spacer showed statistically significant higher mean percent relative change than double impression technique with spacer. With each technique, the means percent relative change in die measurements showed statistically significant higher mean values than cast measurements. There was no statistically significant difference between means percent relative change in the BL and MD dimensions which showed the statistically significant highest mean values. The means percent relative change in the OG dimension showed the statistically significant lowest mean value. Conclusion: Accuracy of fast-setting polyvinyl siloxane impression material was favorably affected with the use of spacer, as the space resulted from contraction of the putty material was not enough to produce accurate detail reproduction by the light material. The working dies; from the fast- setting polyvinyl siloxane impression material without spacer demonstrated an increase in (mesio-distal and bucco-lingual) dimensions, while for cast dimensions, there was no difference between the two techniques. [Journal of American Science. 2010;6(11):284-292]. (ISSN: 1545-1003).

Keywords: dies; fast-setting; polyvinyl siloxane

1. Introduction

Understanding accuracy of impression materials is required. Impressions register and reproduce the prepared tooth form and the surrounding oral tissues[1].Elastomers were developed as a replacement of natural rubbers during world war II then they were modified chemically and physically for dental use. At first Polysulfide rubbers existed exclusively followed by condensation silicones, Polyether, and then Polyvinyl siloxane. It is relative to clinical[2, 3] and laboratory factors[4, 5]. Elastomers are subjected to dimensional changes. Polymerization involving cross linking of the polymer chain can result in reduction of the spatial volume[5]. The reaction continues for some time after the final set clinically[5]. Effect of temperature is another variable[6].

Impression techniques have been categorized as monophase and dual phase. Techniques using monophase materials are made in a single step using a medium viscosity material. Techniques that use dual phase materials such as putty and light body wash method may be accomplished in 1-step or in 2-step (1-step and 2-step putty/light body techniques). In the one step technique the putty and wash material are mixed in the same time. The light body material is syringed around the prepared teeth and the tray containing the putty is seated and stabilized with minimal pressure until the impression materials are set and polymerized. In the 2-step putty/light body technique a stock tray is painted with adhesive and the putty material produces a tray similar to that of acrylic resin. One precaution is to select a tray closely fitting the arch form thus reducing the amount of impression material and facilitate seating of the loaded tray intraorally. Another method is to make a preliminary putty impression intraorally and selectively relieve the putty and details are recorded by the light body only.

There is a potential difficulty with this technique as it is practically impossible to control the bulk and even amount of wash material. Moreover, further modifications to this technique include the use

of polyethylene spacer. The addition type silicones have been reported to be the most accurate and dimensionally stable[7, 8]. Some authors claim that the impression materials has improved to such an extent that accuracy can be controlled by the technique rather than the material itself.[9, 10] Others report that the technique does not affect accuracy.[11, 12] Several techniques have been proposed. The Putty/wash 1 step technique, Putty/ wash 2 step and the Putty/wash with polyethylene spacer [13-15] or a resin spacer[16].Nissan et al reported that the polyvinyl siloxane 2 step Putty/wash impression technique is the most accurate, as a uniform cross sectional bulk of 2mm is provided.[13] Nissan et al [13]and Lee et al[17] used different quantitative analysis, moreover in the 1/step and the2/step the light body should cover the entire preparation but this cannot be accomplished clinically[11]. The 2/step technique has been reported to be more accurate than the 1/step technique[13]. With the 2/step technique the impression with the light body is made after the putty has polymerized and contracted therefore any further contraction in the light body results in minimal dimensional change[13].The 1/step putty/light body technique has been criticized because of the uncontrolled bulk of the light body material[14], by diminishing the volume of the polymerizing material at each stage the final contraction will be reduced and the accuracy of the impression can be improved .The impression techniques and the different protocols used to asses the accuracy of Impression materials explain the contradictory results reported in the literature.

When clinical circumstances necessitate the use of fast-setting elastomeric impression materials; patients, practitioners, and dental office staff can benefit from the shorter setting times, [18] as time saving usually relates to reduced costs and increased patient comfort. Also, impression making is generally an uncomfortable procedure, and for some patients with a strong gag reflex, it presents a severe problem. Reducing the time the impression material remains intraorally is an improvement from the patient's perspective. The purpose of this study was to assess the effect of vacuum-formed resin sheet spacer on the accuracy of fast-setting polyvinyl siloxane impression material. Impressions were taken with and without spacer. Different methods of accuracy assessment were also used and compared. Thus, the research hypotheses were that no differences existed in accuracy among the two techniques which are with and without spacer, and secondly, no differences were existed between the two assessments.

2. Material and Methods

This study evaluated the accuracy of a polyvinyl siloxane rubber base impression material (Affinis perfect impressions Coltene/Whaladent AG), indirectly through recovered gypsum casts from impressions made on a master model. The tested variables included the use of double impression technique with a spacer and double impression technique without a spacer. (Table 1). The master model utilized was similar to that used in previous studies, [18-20] consisting of a Dentoform mandibular arch (Model 1362; Columbia Dentoform, Long Island City, NY) with some modifications. It contained a removable stainless steel complete crown preparation in the position of the mandibular right first molar (Figure 1). The complete crown preparation was machined with 12-degree angle of convergence with a gingival shoulder finish line. In addition two stainless steel inserts were placed, one on the central fossa of the occlusal surface of the left first molar, and one on the lingual surface of the mandibular left central incisor to provide reference points for measuring cross-arch(CA) and anteroposterior(AP) dimensions. Thus, reference mark 1 is placed on the lingual surface of the mandibular left central incisor; reference mark 2 on the central fossa of the left first molar; and reference mark 3 on the center of diameter of the stainless steel prepared crown representing the mandibular right first molar.

Table [1]: Variables tested

Tested variables	
Group 1	Double impression technique with spacer [n=10]
Group 2	Double impression technique without spacer[n=10]

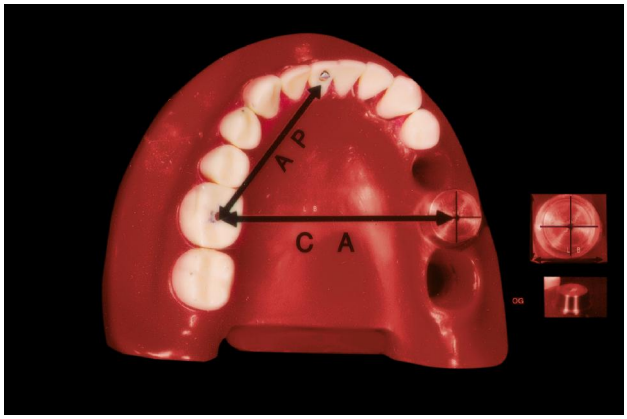


Figure 1: Dentoform mandibular arch with removable stainless steel complete crown preparation

Figure 2: Spacer pressed onto the model

A total of twenty impressions were taken, and divided into two equal groups according to the selected variables, each consisting of 10 impressions.

Group 1: Ten casts were made from individual impressions of the master arch form, using the double step impression technique. A large, mandibular, disposable plastic impression tray (President Disposable Impression Tray; Coltene Whaledent, Cuyahoga Falls, Ohio) was used for all impressions. This was a rigid, perforated tray with the ability to resist distortion expected during seating and removal of the tray. A soft clear ethyl vinyl acetate spacer of thickness 1mm (Pro-Form; Dental Resources Inc, Delano, Minn) was pressed onto the master model using vacuum formed machine (Figure 2). For retention of the impression material the tray adhesive provided by the manufacturer was painted in the fitting surface of the tray. To standardize the seating position and centering of the tray during impression making on the master model, positioning guides were constructed with light polymerized acrylic resin material (Triad Tru Tray, VLC; Dentsply Intl, York, Pa). [Table 2] The type I high viscosity polyvinyl siloxane impression material [Affinis perfect impressions] was used according to manufacture instructions to make the impressions. The trays were loaded with the material then seated over the master model , centered according to the positioning guides, and left to polymerize [for 2.20 minutes at 37 0c in 100% humidity]. After the putty impression material is completely polymerized, the impression and the spacer were removed from the cast, and then the spacer was removed from the putty impression. The light body polyvinyl siloxane material [Affinis fast light body] was then injected onto the complete crown preparation and occlusal reference points, and Syringed into the impressions evenly and the tray was reseated over the master model again and left for polymerization. Once removed, the impression was visually inspected to determine the reproduction of the details, rinsed for 10 seconds under running water to simulate the removal of saliva and other contaminants and then air dried. To form the working casts, type IV stone (Prima-Rock; Whip mix, Louisville, Ky) in the form of 70 gm packages was used. The stone was mixed using 14 ml of distilled water, first by hand for 15 seconds, and then vacuum-mixed for an additional 30 seconds (Combi-Mix; Whip mix). The stone was vibrated into the impression, filled to the level of the tray borders, and the excess material utilized to provide mechanical retention. The cast was allowed to set at room temperature in air for 60 minutes. To enable ease of separation of the stone working die, a stone separator (Super-Sep; Kerr Lab, Orange, Calif) was painted over the site. The cast was boxed and then a base was added using a type III dental stone (Microstone; Whip Mix). The base was allowed to bench set for one hour. The recorded stone cast with base was separated from the impression and left to set for 24 hours in ambient air for measurement.

Group 2: Ten casts were produced from individual impressions of the master model using the double step impression technique without a spacer, following the previously mentioned steps.

Measurements of casts' accuracy:

The master model and each recovered cast were measured in an ordered sequence, namely dimension A, the distance between reference marks 1 and 2; dimension B, the distance between reference marks 1 and 3; and dimension C, the distance between reference marks 2 and 3. The A, B, and C dimension measurements were made using a binocular measuring microscope (Nikon Measurescope 20; Nikon, Tokyo, Japan) capable of measuring to 0.001 mm. These measurements were repeated three times to determine the mean for each dimension. All measurements were made by the same investigator. The measurements were carried out at ambient room temperature and humidity (22.1° 0± 0.2° C and 60% -10 %).

Measurements of dies accuracy:

The stainless steel and working dies were positioned on a custom fabricated stainless steel device, to assess the BL, MD, and OG dimensions The cross-arch (CA) dimension was assessed by measuring the distance from the mandibular left first molar to the mandibular right first molar, the

anteroposterior (AP) distance from mandibular left first molar to central incisor; the mesiodistal (MD) and buccolingual (BL) dimension across the gingival shoulder of the simulated complete crown preparation and the occlusogingival (OG) measurement of the preparation from the gingival shoulder to the occlusal surface. The same five dimensions were measured on working casts and die retrieved from impressions of the master model. Specimens were examined on a Zeiss stereomicroscope and pictures were taken using an Olympus Camedia C-5060 digital camera fitted on the microscope using a fixed magnification of x6.3.

Table [2]: Impression material tested: Morphometric measurements were done on an IBM compatible personal computer (PC). The image analysis software used was the "Image Tool for Windows version 3". A graph paper was photographed using the same magnification of x6.3, for the purpose of calibrating the image analysis software, after the software is calibrated. The data obtained were then subjected to statistical analysis.

Product	Type	Working/Setting time (min:sec)	Batch no.	Manufacturer
Affinis perfect impressions	Polyvinyl Siloxane Rubber base material (Addition type) Putty Soft Fast base, Fast catalyst	Affinis fast regular body/ fast light body Mixing time (15 ml): 0:15 min Total working time: 1:15 min Oral setting time: 1:20 min	putty consistency ISO 4823, type 0 light consistency ISO 4823:2000	Coltene/Whaladent AG

Statistical analysis

Data were presented as mean and standard deviation (SD) values. ANOVA test was used to compare between master model and experimental models. Tukey's post-hoc test was used for pair-wise comparison between the means when ANOVA test is significant. Mann-Whiney U test was used to compare between the differences and percent relative changes from master model of the two groups. The significance level was set at $P \leq 0.05$. Statistical analysis was performed with SPSS 15.0® (Statistical Package for Scientific Studies) for Windows

3. Results

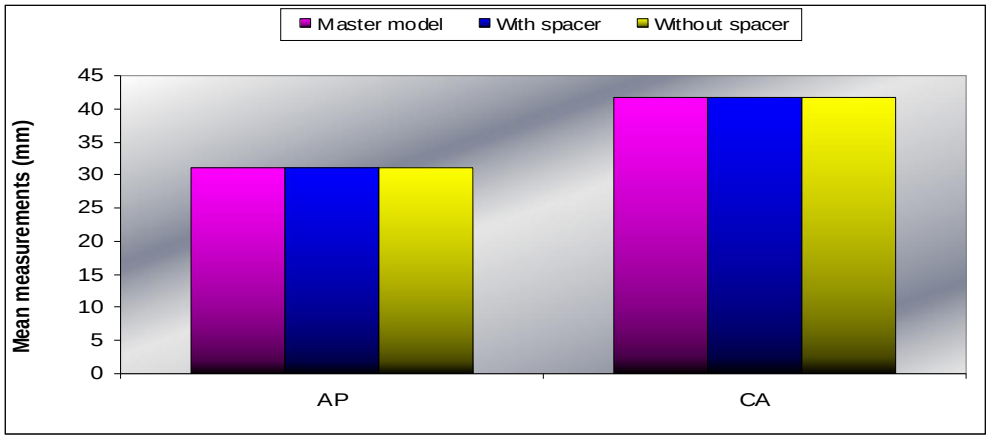
Comparison between cast and die measurements in the two techniques and master model

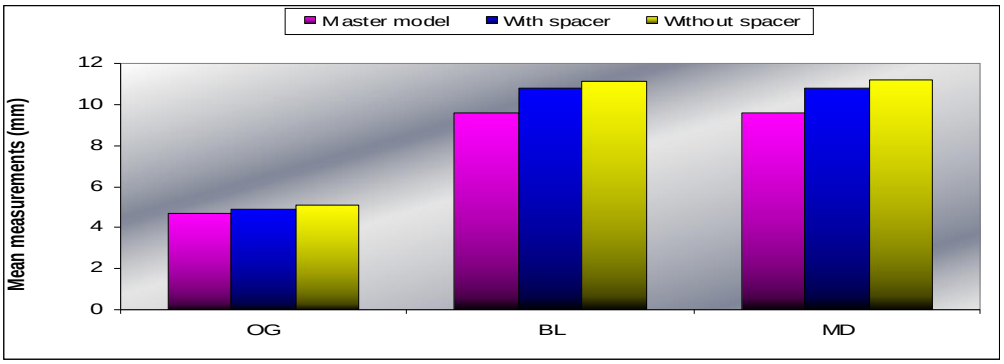
	Dimension	Master model		With spacer		Without spacer		P-value
		Mean	SD	Mean	SD	Mean	SD	
Cast	AP	31.1	0.1	31.1	0.1	31.1	0.2	0.966
	CA	41.8	0.1	41.8	0.2	41.8	0.2	0.882
Die	OG	4.7 [c]	0.05	4.9 [b]	0.06	5.1 [a]	0.07	<0.001*
	BL	9.6 [c]	0.03	10.8 [b]	0.03	11.1 [a]	0.08	<0.001*
	MD	9.6 [c]	0.03	10.8 [b]	0.04	11.2 [a]	0.1	<0.001*

*: Significant at $P \leq 0.05$, Means with different letters are statistically significantly different according to Tukey's test

As regards cast measurements, there was no statistically significant difference between double impression with spacer, without spacer and master model dimensions.

As regards die measurements in all dimensions, both techniques showed significant difference from master model measurements. Double impression without spacer showed statistically significantly higher mean measurement than double impression with spacer technique.





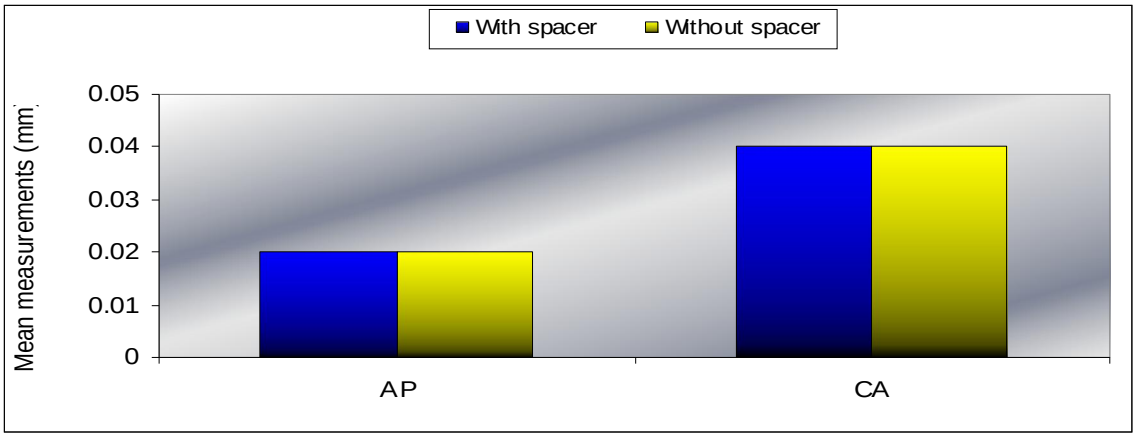
Comparison between differences from master model in cast and dies measurements

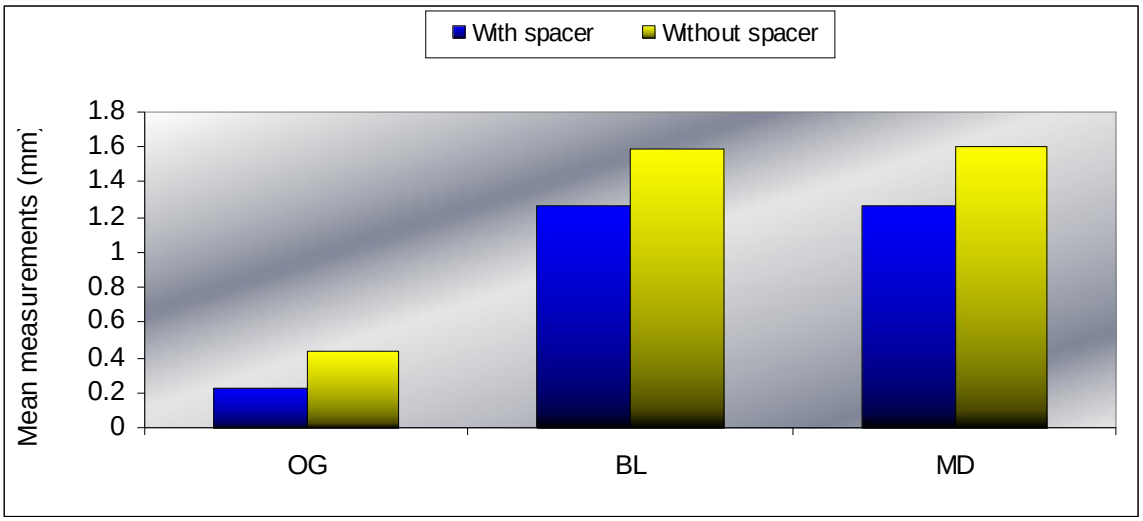
	Dimension	With spacer		Without spacer		P-value
		Mean	SD	Mean	SD	
Cast	AP	0.02	0.03	0.02	0.04	1.000
	CA	0.04	0.09	0.04	0.11	1.000
Die	OG	0.22	0.10	0.44	0.11	0.028*
	BL	1.26	0.05	1.59	0.06	0.009*
	MD	1.26	0.05	1.61	0.08	0.009*

*: Significant at $P \leq 0.05$

As regards cast measurements, there was no statistically significant difference between double impression with spacer and double impression without spacer.

As regards die measurements in all dimensions, double impression without spacer showed statistically significantly higher mean difference than double impression with spacer technique.





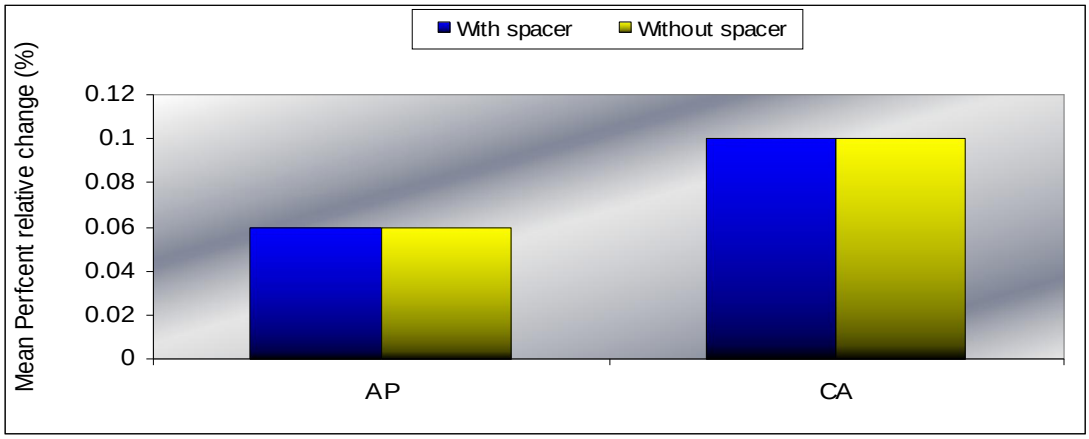
Comparison between percent relative changes from master model in cast and dies measurements

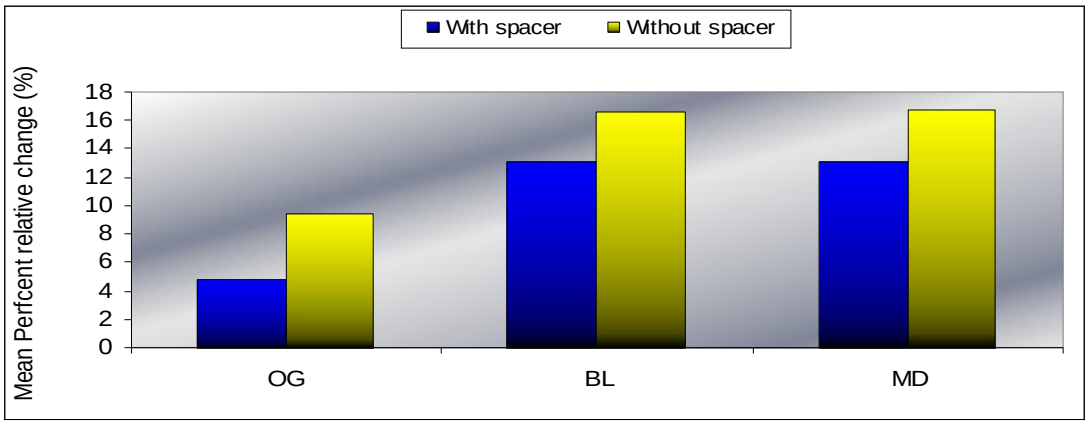
	Dimension	With spacer		Without spacer		P-value
		Mean	SD	Mean	SD	
Cast	AP	0.06	0.12	0.06	0.14	1.000
	CA	0.10	0.21	0.10	0.27	1.000
Die	OG	4.8	2.2	9.4	2.4	0.028*
	BL	13.1	0.5	16.6	0.6	0.009*
	MD	13.1	0.6	16.8	0.8	0.009*

*: Significant at $P \leq 0.05$

As regards cast measurements, there was no statistically significant difference between double impression with spacer and double impression without spacer.

As regards die measurements in all dimensions, double impression without spacer showed statistically significantly higher mean percent relative changes than double impression with spacer technique.





There was no statistically significant difference between means percent relative change in the BL and MD dimensions which showed the statistically significant highest mean values. The means percent relative change in the OG dimension showed the statistically significant lowest mean value.

4. Discussions

Distortion is a 3-dimensional problem that is inherent in all of the steps involved in fabricating an indirect dental restoration. Dimensional accuracy when making impressions is crucial to the quality of fixed prosthodontic treatment, and the impression technique is a critical factor affecting this accuracy [21]. As elastomeric impression materials have been reformulated to achieve a faster set, the accuracy of fast-setting elastomeric impression materials should be confirmed [18]. Accuracy of impression resulting from the 1-step putty-wash technique is controversial [15]. Some authors found that there was no difference in accuracy between techniques, [11'12] while others criticized several potential disadvantages with this approach [15]. These disadvantages include lack of control of the bulk of wash material and the high risk of capturing portions of the prepared margin in putty material rather than lower viscosity material [22]. Most putty viscosity materials have inadequate fine detail reproduction for this purpose. In our study, it seems that this was the primary reason for the discrepancies in die dimensions resulted from double impression technique without spacer rather than double impression technique with spacer. An advantage of the 2-step double impression technique is that the impression of the teeth can be captured with the wash material [11]. The 2-step putty / light-body technique has been reported to be more accurate than the one-step putty/ light body technique [11]. With the 2-step technique, the impression with the light-body material is made after the putty has polymerized and contracted. Therefore, any further contraction of the light-body material results in minimal dimensional change [13].This is in agreement with our study, where there was no statistically significant difference between the two techniques in accordance to cast dimensions. The 1-step putty/light-body technique

has also been criticized because of the uncontrolled bulk of the light-body material[14]. By diminishing the volume of the polymerizing material at each stage, the final contraction will also be reduced, and the accuracy of the impression can be improved [23]. Therefore, careful control of the bulk of the light-body impression material has been advocated because it affects the accuracies of the stone cast's [24].The distortion of the die in a mesiodistal, buccolingual, and occlusogingival direction was investigated in this study. The machined stainless steel standard used in this investigation provided certain advantages in obtaining the measurements over that of a prepared plastic typodont tooth. The well-defined line angles of the stainless steel standard were clearly observed under the microscope, thereby reducing measurement error. The circular nature of the standard allowed observation of the relationship between the change in buccolingual and mesiodistal dimensions of the gypsum dies[26]. Dental elastomeric impression materials are subject to several factors that can result in dimensional changes [18]. For example, the process of polymerization, which involves cross-linking of the polymer chains, can result in a reduction of spatial volume [5]. Polymerization reactions have been shown to continue for a considerable period of time, beyond the achievement of what is considered a final clinical set, and continue after removal of the impression from the mouth [5,6].Moreover, the lower viscosity of the material, the greater the contraction after polymerization [12].

In the current study, the space resulted from contraction of the fast-setting putty material, was not enough to produce accurate detail reproduction by the light material. This ensures the necessity of using a spacer to provide enough room for the light-body to record fine details. The direction of dimensional change of impression materials has been reported to be dependent upon the bonding of the material to the impression tray [8,25].Also; more rigid trays reduce the possibility of distortion in the impression [26]. In our study, a large mandibular disposable plastic impression tray was used for all impressions. This was a rigid, perforated tray with the ability to resist distortion expected during seating and removal of the tray. With a rigid tray and good adhesion to the tray; the material shrinks toward the tray, producing a larger die [5]. While when bonding to the tray may not be sufficient to constrain the material, shrinkage causes movement away from the tray and results in smaller dies. Eames et al [25] reported that the material may adhere to the adhesive of the tray, causing the negative image of the master die (the prepared tooth) to enlarge. In our study, the means percent relative changes in die measurements have also shown statistically significant higher mean values than cast measurements. Nissan et al [13] studied the accuracy of three polyvinyl siloxane putty-wash impression techniques. When stone casts and the master model were compared, it was found that changes in the vertical dimension were greater than the horizontal. This phenomenon was attributed to the contraction of the impression toward the tray walls, making the stone dies wider in the horizontal aspect and shorter in the vertical one. In another study, Nissan et al [14] attributed the changes in the vertical dimensions (occlusogingival) to the same reason. It was concluded that wash thickness of 1 to 2 mm are most accurate for fabricating stone dies, when using polyvinyl siloxane impression materials with the 2-step putty/wash impression technique. Contrary, in the present study, there was no statistically significant difference between means percent relative change in the bucco-lingual and mesio-distal dimensions which showed the statistically significant highest mean values, while the means percent relative changes in the occluso-gingival dimension showed the statistically significant lowest mean values. This may be attributed to the fact that the amount of impression contraction on the expense of the horizontal aspect (mesio-distal and bucco-lingual), was not high enough to result in changes in the vertical (occlusogingival) direction. Hense, fast setting impression contraction has been greatly compensated for by the use of double step impression technique together with the use of a suitable spacer.

5. Conclusion

Within the conditions of this study, it was found that:

- Accuracy of fast-setting polyvinyl siloxane impression material was favorably affected with the use of spacer, as the space resulted from contraction of the putty material was not enough to produce accurate detail reproduction by the light material.
- The working dies; from the fast- setting polyvinyl siloxane impression material without spacer demonstrated an increase in (mesio-distal and bucco-lingual) dimensions, while for cast dimensions there was no difference between the two techniques.

References

1. Craig RG, Powers JM Restorative Dental Materials 11th ed St Louis El Sevier. 2002 p:330,431
2. GatesGN, Nicholls JL. Evaluation of mandibular width change J Prosthet Dent;1981:46:385-392
3. Hellie GM, Charbeneau GI, Craig RG, Brandeau HE Quantitative Evaluation of proximal tooth

movement effected by wedging a Pilot study J Prosthet Dent; 1985:53:335-341
4. Baily JH, Donovan TE, Preston JD The dimensional accuracy of improved dental stone, Silver plated and Epoxy resin die materials J Prosthet Dent;1988;59:307-310
5. Marcinak CF, Young FA, Draughin RA, Fleming RW, Linear dimensional changes in elastomeric impression materials J Dent Res;1980:59:1152-1155
6. Berg JC, Johnson GH, Lepe X, Adan Plaza S. Temperature effects on Current Polyethers and Polyvinyl Siloxane materials during Setting J Prosthet Dent ;2003;90:150- 161
7. Phillips RW Skinners Science of Dental materials 9 th ed Philadelphia, PA WB Saunders Co 1991 pp; 145-156
8. Lacy AM, Fukui H, Belleman T, Jendersen MD.Time Dependant Accuracy of elastomeric Impression materials PartII: Polyethers, Polysulfides, and Polyvinyl siloxanes J Prosthet Dent;1981; 45: 329-333
9. Morgano SM, Milot P, Ducharm F, Rose L Ability of various impression materials to produce duplicate dies from successive impressions. J Prosthet Dent;1995; 73: 333-340
10. CheeWW, Donovan TE. Polyvinyl Siloxane Impression materials: a review of properties and techniques J Prosthet Dent.1992;68:728-732
11. Hung SH, Purk JH, Tira DE, Eick JD. Accuracy of 1-step versus 2-step putty wash addition silicone impression technique J Prosthet Dent; 1992;67:583-589
12. Idris B, Houston F, Claffey N, Comparison of the dimensional accuracy of 1-step and 2- step technique with the use of putty/wash addition silicone impression materials J Prosthet Dent .1995;74 :535-541
13. Nissan J, Laufer BZ, BroshT, Assif D. Accuracy of three polyvinyl siloxane putty/wash impression materials. J Prosthet. Dent. 2000;83:161-165
14. Nissan J, Gross M, Shifman A, Assif D. Effect of wash bulk on accuracy of polyvinyl siloxane putty/ wash impressions J Oral Rehabil 2002;29:357-361
15. Wu AY, Donovan TE. A modified one-step putty-wash impression technique. J Prosthet Dent.2007;98:245-246
16. Wu AY, Donovan TE. The Use Of Vacuum-formed resin sheets as spacers for putty-wash impressions. J Prosthet Dent.2007;97:54-55
17. Lee I K, DelongR , Pintado MR, Malek R. Evaluation of factors affecting accuracy of impressions using quantitave surface analysis. Oper. Dent.1995;20:246-252
18. Wadhwani CPK, Johnson GH, Lepe X, Raigrodski AJ. Accuracy of newly formulated fast-setting elastomeric impression materials. J Prosthet Dent.2005;93:530-539
19. Lepe X, Johnson GH. Accuracy of polyether and addition silicone after long-term immersion disinfection. J Prosthet Dent. 1997;78:245-249
20. Johnson GH, Chellis KD, Gordon GE, Lepe X. Dimensional Stability and detail reproduction of irreversible hydrocolloid and elastomeric impressions disinfected by immersion. J Prosthet Dent. 1998;79:446-453
21. Caputi S, Varvara G. Dimensional accuracy of resultant casts made by a Monophase, one-step and two-step, and a novel two-step putty/light-body impression Technique: An in Vitro study. J Prosthet Dent.2008;99:274-281
22. Donovan TE,Chee WW. A review of Contemporary impression materials and techniques. Dent clin north Am;2004;48:445-470
23. Lewenstein I, The ratio between the vertical and the horizontal changes of impressions J Oral Rehabil 1993;20:107-114
24. de Araujo PA, Jorgensen KD. Effect of material bulk and undercuts on accuracy of impression materials J Prosthet. Dent.1985;54:791-794
25. Eames WB, Sieweke C, Wallace SW, Rogers LB. Elastomeric impression materials effect of bulk on accuracy. J Prosthet Dent.1979;41:304-307
26. Ceyhan JA, Johnson GH,Lepe X. The effect of tray selection, viscosity of impression material, and sequence of pour on the accuracy of dies made from dual-arch impressions. J Proset. Dent. 2003;90:143-149

6/3/2010