A Comparison of the Accuracy of Polyether, Polyvinyl Siloxane, and Plaster Impressions for Long-Span Implant-Supported Prostheses

Vyonne J. Hoods-Moonsammy, BDS, MDent[a]/C. Peter Owen, BDS, MScDent, MChD, FICD, FCD(SA)[b]/
Dale G. Howes, BDS, MDent, FCD(SA)[c]

Purpose: The purpose of this study was to compare the capacity of different impression materials to accurately reproduce the positions of five implant analogs on a master model by comparing the resulting cast with the stainless steel master model. The study was motivated by the knowledge that distortions can occur during impression making and the pouring of casts and that this distortion may produce inaccuracies of subsequent restorations, especially long-span castings for implant superstructures. ***Materials and Methods:*** The master model was a stainless steel model with five implant analogs. The impression materials used were impression plaster (Plastogum, Harry J Bosworth), a polyether (Impregum Penta, 3M ESPE), and two polyvinyl siloxane (PVS) materials (Aquasil Monophase and Aquasil putty with light-body wash, Dentsply). Five impressions were made with each impression material and cast in die stone under strictly controlled laboratory conditions. The positions of the implants on the master model, the impression copings, and the implant analogs in the subsequent casts were measured using a coordinate measuring machine that measures within 4 μm of accuracy. ***Results:*** Statistical analyses indicated that distortion occurred in all of the impression materials, but inconsistently. The PVS monophase material reproduced the master model most accurately. Although there was no significant distortion between the impressions and the master model or between the impressions and their casts, there were distortions between the master model and the master casts, which highlighted the cumulative effects of the distortions. The polyether material proved to be the most reliable in terms of predictability. The impression plaster displayed cumulative distortion, and the PVS putty with light body showed the least reliability. ***Conclusions:*** Some of the distortions observed are of clinical significance and likely to contribute to a lack of passive fit of any superstructure. The inaccuracy of these analog materials and procedures suggested that greater predictability may lie in digital technology. *Int J Prosthodont 2014;27:433–438. doi: 10.11607/ijp.4035*

The use of dental endosseous implants to replace missing teeth in partially dentate and edentulous patients is associated with a high success rate from esthetic, functional, and psychological points of view. However, biomechanical failure does occur in long-span prostheses, which may be attributed to lack of a passive fit of the implant superstructure.

In a review of the literature it was concluded that multiple factors, including the impression, may prevent a passive fit despite accurate implant prosthodontic procedures.[1] Ultimately, the resulting inaccuracy of the fit of the implant superstructure to the implants is thought to introduce significant static and dynamic forces that remain inherent in the tightened superstructure.[2]

The consequences of dynamic forces (tensile and compressive, functional and parafunctional) existing in the presence of static forces (due to inaccuracy when an ill-fitting framework is connected) result in stresses being transferred to the entire assembly with all of its components, and these stresses remain after prosthesis placement.[3] This may lead to implant failure or metal fatigue fractures. Loosening or fractures

[a]Lecturer and Consultant, Department of Oral Rehabilitation, School of Oral Health Science, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa.
[b]Professor and Head, Department of Oral Rehabilitation, School of Oral Health Science, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa.
[c]Adjunct Professor, Department of Oral Rehabilitation, School of Oral Health Science, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa.

Correspondence to: *Dr VJ Hoods-Moonsammy, Department of Oral Rehabilitation, School of Oral Health Science, Faculty of Health Sciences, University of the Witwatersrand, 7 York Rd, Parktown, 2193, South Africa. Fax: +27-86-553-4800. Email: Vyonne.Hoods-Moonsammy@wits.ac.za*

©2014 by Quintessence Publishing Co Inc.

© 2014 BY QUINTESSENCE PUBLISHING CO, INC. PRINTING OF THIS DOCUMENT IS RESTRICTED TO PERSONAL USE ONLY. NO PART MAY BE REPRODUCED OR TRANSMITTED IN ANY FORM WITHOUT WRITTEN PERMISSION FROM THE PUBLISHER.

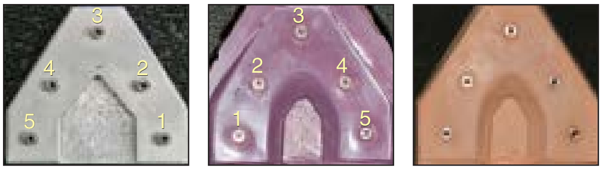

Figure 1 *(above)* The master model *(left)*, an impression *(center)* and resultant cast *(right).*

Figure 2 *(right)* Ball-probe laser scanner on master model.

of screws have, in part, been ascribed to an ill-fitting superstructure in addition to clinical stress-loading (function and parafunction).[4]

The accuracy required in the steps from impression making to the final casting contributes to achieving a passive fit of the resulting superstructure, which would lessen the inherent stresses. A misfit of 150 µm is widely regarded to be the upper limit of clinical acceptability.[2] The search for the best impression technique and material that is associated with the least amount of error is an important first step toward achieving this goal.

This study will serve as an addition to existing evidence provided by previous comparative analyses of the dimensional accuracy of various impression materials. It was an in vitro analysis to compare the accuracy of three impression materials: a polyether (Impregum Penta, Pentamix, 3M ESPE), a polyvinyl siloxane (PVS) monophase (Aquasil Ultra DECA Monophase, Dentsply), and a PVS putty and light-body wash combination (Aquasil Putty Deca and Ultra LV Regular Set, Dentsply), with a control of impression plaster (Plastogum, Harry J Bosworth).

The null hypothesis was that there would be no significant difference in the three-dimensional (3D) accuracy between the impression materials under investigation and the master model.

Materials and Methods

All of the laboratory procedures throughout this investigation were standardized, all materials were stored and used strictly according to the manufacturers' instructions, and the same batches were used for each material. A single operator performed all the tasks (making impressions, casting, and taking measurements of models). Impression materials were taken from a single batch (the same lot number) for each of the four different materials. The mixture of the materials was performed as per manufacturers' directions, keeping the consistency and temperature of the mixtures constant. The coordinate measuring machine was calibrated prior to each measurement. Excluded from the data set were any models that contained obvious distortions as a result of operator errors (eg, drag, air bubbles).

Implant components were from Southern Implants, and fitting tolerances were confirmed. A stainless steel master model was used to mimic a dental arch and contained five implant analogs. Standardized spaced (3-mm) light-cured acrylic (Megatray, Megadent) special trays were formed on duplicated stone casts poured from a single impression of Wirosil silicone material (Nova Dental).

Five impressions were made with each of the impression materials using an open-tray impression coping transfer technique, under identical conditions. The precision impression copings were torqued to 10 Ncm with the same Southern Implant torque wrench. The fit of the impression copings to the analogs of the master model and the master casts showed minimal discrepancies, which were not significant ($P < .05$) as shown by multiple t tests.

The casts were poured in a type IV dental stone (Satin Stone, Pemaco). Three-dimensional measurements of the five implant positions were made on the *(1)* master model, *(2)* each impression, and *(3)* each resulting cast (Fig 1). The calibrated portable coordinate measuring machine (PowerINSPECT, Delcam) used measures within an accuracy of 4 µm. Positional stability and consistency of the master model and analogs were confirmed by measurements taken before and after each impression made with each material. Ten interimplant distances (1–2, 1–3, 1–4, 1–5, 2–3, 2–4, 2–5, 3–4, 3–5, and 4–5) were calculated for the master model and each impression and master cast. The ball-probe laser scanner, when placed over the implant, the impression coping, or the laboratory analog, scanned the midpoint of each implant to give a 3D representation of that position (Fig 2).

Measurements made were documented on a computer via a direct link. The XYZ coordinates of each implant position were recorded, and from this information the interimplant distances were calculated for each impression, resulting master cast, and the master model. A sample size of five impressions per

© 2014 BY QUINTESSENCE PUBLISHING CO, INC. PRINTING OF THIS DOCUMENT IS RESTRICTED TO PERSONAL USE ONLY. NO PART MAY BE REPRODUCED OR TRANSMITTED IN ANY FORM WITHOUT WRITTEN PERMISSION FROM THE PUBLISHER.

Table 1 Average Interimplant Distances (mm) for the Master Model, Polyether Impression, and Resulting Casts

Interimplant pair	Master model (μ)	Data	Polyether	
			Impression	Cast
1–2	21.535	Mean (SD)	21.478 (0.022)	21.490 (0.011)
		P value	*.005	*.001
1–3	47.099	Mean (SD)	47.043 (0.083)	47.116 (0.042)
		P value	.204	.419
1–4	46.541	Mean (SD)	46.532 (0.042)	46.537 (0.024)
		P value	.655	.718
1–5	50.034	Mean (SD)	50.033 (0.111)	50.075 (0.023)
		P value	.988	*.015
2–3	26.172	Mean (SD)	26.199 (0.074)	26.253 (0.038)
		P value	.468	*.009
2–4	34.00	Mean (SD)	34.043 (0.033)	34.034 (0.032)
		P value	*.045	.077
2–5	46.486	Mean (SD)	46.549 (0.122)	46.571 (0.024)
		P value	.312	*.001
3–4	26.269	Mean (SD)	26.128 (0.064)	26.170 (0.019)
		P value	*.008	*.000
3–5	47.114	Mean (SD)	47.043 (0.079)	47.100 (0.050)
		P value	.115	.574
4–5	21.471	Mean (SD)	21.545 (0.012)	21.545 (0.039)
		P value	*.00	*.013

Mean = average 3D distance for particular interimplant position.
*Grey-shaded cells represent interimplant distances where distortion is statistically significantly different ($P \leq .05$) from the master model as per one sample, 2-tailed *t* test. Blue-shaded cells represent significant contraction. Yellow-shaded cells represent significant expansion.

Table 2 Average Interimplant Distances (mm) for the Master Model, PVS Monophase Material, and Resulting Casts

Interimplant pair	Master model (μ)	Data	Polyether	
			Impression	Cast
1–2	21.535	Mean (SD)	21.521 (0.086)	21.481 (0.060)
		P value	.734	.117
1–3	47.099	Mean (SD)	47.127 (0.093)	47.121 (0.037)
		P value	.539	.245
1–4	46.541	Mean (SD)	46.526 (0.027)	46.502 (0.032)
		P value	.278	.052
1–5	50.034	Mean (SD)	50.063 (0.043)	50.015 (0.042)
		P value	.20	.378
2–3	26.172	Mean (SD)	26.251 (0.094)	26.267 (0.056)
		P value	.133	*.019
2–4	34.00	Mean (SD)	34.031 (0.059)	34.013 (0.027)
		P value	.308	.362
2–5	46.486	Mean (SD)	46.551 (0.069)	46.520 (0.017)
		P value	.103	*.011
3–4	26.269	Mean (SD)	26.242 (0.143)	26.181 (0.028)
		P value	.698	*.002
3–5	47.114	Mean (SD)	47.144 (0.172)	47.081 (0.029)
		P value	.717	.063
4–5	21.471	Mean (SD)	21.489 (0.039)	21.512 (0.025)
		P value	.363	*.02

Mean = average 3D distance for particular interimplant position.
*Grey-shaded cells represent interimplant distances where distortion is statistically significantly different ($P \leq .05$) from the master model as per one sample, 2-tailed *t* test. Blue-shaded cells represent significant contraction. Yellow-shaded cells represent significant expansion.

material has been reported to be adequate to detect clinically relevant differences. This was shown by a number of studies in the literature that act as pilot studies, thereby providing greater statistical power to a study with a limited sample size.[5–8] It also allows contextualization of the findings within a broader framework of research of this nature.

The above data were captured in MS-Excel (Microsoft), and the information was imported into a statistical package (SPSS). Inferential statistical analysis using a one-sample, 2-tailed *t* test was used to quantify and compare the extent of the differences in distortion patterns of each impression material under investigation relative to the master model, using the 3D interimplant distances. A parametric test was selected based on similar studies mentioned above where a normal distribution of the outcomes was assumed. The analysis identified interimplant regions where expansive or contractive distortion occurred, those areas where distortion was common to the impression materials under investigation, and the identification of common patterns and frequencies of distortion within the arch.

Results

Tables 1 to 4 represent the average interimplant distances (in mm) for the master model, impression materials, and casts, highlighting those areas where distortion was significantly different from the master model. Although there are differences between the impressions and their casts, from a clinical perspective it is the difference between the final casts and the master model that is important. Table 5 represents the absolute value of the differences that exist between the average distances (x) for each cast and the master model (μ) calculated from Tables 1 to 4. It quantifies the extent to which each material deviates from the master model for each interimplant distance. It puts the null hypothesis to the test, which assumes that the sample average (x) = the test value (μ) = 0, ie, no distortion.

© 2014 BY QUINTESSENCE PUBLISHING CO, INC. PRINTING OF THIS DOCUMENT IS RESTRICTED TO PERSONAL USE ONLY.
NO PART MAY BE REPRODUCED OR TRANSMITTED IN ANY FORM WITHOUT WRITTEN PERMISSION FROM THE PUBLISHER.

Table 3 Average Interimplant Distances (mm) for the Master Model, PVS Putty with Light-Body Wash, and Resulting Casts

Interimplant pair	Master model (μ)	Data	Aquasil putty with light-body wash: Impression	Cast
1–2	21.535	Mean (SD)	21.434 (0.427)	20.420 (2.018)
		P value	.625	.284
1–3	47.099	Mean (SD)	47.442 (0.931)	46.144 (1.015)
		P value	.456	.103
1–4	46.541	Mean (SD)	47.624 (0.345)	45.912 (1.096)
		P value	*.002	.269
1–5	50.034	Mean (SD)	50.958 (0.260)	49.438 (0.542)
		P value	*.001	.070
2–3	26.172	Mean (SD)	26.578 (0.850)	26.426 (1.381)
		P value	.346	.702
2–4	34.00	Mean (SD)	33.848 (0.302)	34.142 (0.556)
		P value	.324	.598
2–5	46.486	Mean (SD)	45.948 (0.413)	46.456 (1.296)
		P value	*.043	.691
3–4	26.269	Mean (SD)	25.880 (0.520)	25.574 (1.515)
		P value	.170	.363
3–5	47.114	Mean (SD)	46.974 (0.743)	46.710 (1.673)
		P value	.695	.618
4–5	21.471	Mean (SD)	21.672 (0.427)	21.846 (0.107)
		P value	.352	*.001

Mean = average 3D distance for particular interimplant position.
*Grey-shaded cells represent interimplant distances where distortion is statistically significantly different ($P \leq .05$) from the master model as per one sample, 2-tailed *t* test. Yellow-shaded cells represent significant expansion.

Table 4 Average Interimplant Distances (mm) for the Master Model, Impression Plaster, and Resulting Casts

Interimplant pair	Master model (μ)	Data	Impression plaster: Impression	Cast
1–2	21.535	Mean (SD)	21.968 (0.491)	21.776 (0.788)
		P value	.120	.531
1–3	47.099	Mean (SD)	47.642 (0.595)	46.908 (0.922)
		P value	.111	.667
1–4	46.541	Mean (SD)	46.542 (0.674)	45.908 (0.586)
		P value	.998	.073
1–5	50.034	Mean (SD)	49.834 (0.473)	49.562 (0.624)
		P value	.398	.166
2–3	26.172	Mean (SD)	26.338 (0.487)	26.028 (0.756)
		P value	.488	.692
2–4	34.00	Mean (SD)	34.080 (0.660)	34.258 (0.131)
		P value	.800	*.012
2–5	46.486	Mean (SD)	46.616 (0.622)	47.314 (0.335)
		P value	.664	*.005
3–4	26.269	Mean (SD)	26.776 (0.516)	26.466 (0.118)
		P value	.170	*.02
3–5	47.114	Mean (SD)	47.626 (0.905)	47.704 (0.321)
		P value	.275	*.015
4–5	21.471	Mean (SD)	21.470 (0.506)	21.838 (0.294)
		P value	.997	*.049

Mean = average 3D distance for particular interimplant position.
*Grey-shaded cells represent interimplant distances where distortion is statistically significantly different ($P \leq .05$) from the master model as per one sample, 2-tailed *t* test. Yellow-shaded cells represent significant expansion.

Table 5 Absolute Value (mm) of the Deviation of the Sample Averages x* Relative to the Baseline†

	Absolute values of the differences								
	Impressions					Casts			
Groups	Master model (Test value)	Polyether	PVS monophase	PVS putty and light-body wash	Polyether	From polyether	From PVS monophase	From PVS putty and light-body wash	From polyether
1–2	0.00	0.057	0.014	0.101	0.433	0.045	0.054	1.115	0.241
1–3	0.00	0.056	0.028	0.343	0.543	0.017	0.022	0.955	0.191
1–4	0.00	0.009	0.015	1.083	0.001	0.004	0.039	0.629	0.633
1–5	0.00	0.001	0.029	0.924	0.200	0.041	0.019	0.596	0.472
2–3	0.00	0.027	0.079	0.406	0.166	0.081	0.095	0.254	0.144
2–4	0.00	0.043	0.031	0.152	0.080	0.034	0.013	0.142	0.258
2–5	0.00	0.063	0.065	0.538	0.130	0.085	0.034	0.030	0.828
3–4	0.00	0.141	0.027	0.389	0.507	0.099	0.088	0.695	0.197
3–5	0.00	0.071	0.030	0.140	0.512	0.014	0.033	0.404	0.590
4–5	0.00	0.074	0.018	0.201	0.001	0.074	0.041	0.375	0.367

*For each of the impression materials and their respective casts.
† Indicating the master model where μ = 0.

Discussion

Under the strict conditions of this in vitro study, the results have shown that distortion is inevitable and displays a random pattern. Other studies have reinforced these findings[5,6] (Von Berg G, unpublished data, 2007). In general, the outcomes of this investigation reflect variability between and within test

© 2014 BY QUINTESSENCE PUBLISHING CO, INC. PRINTING OF THIS DOCUMENT IS RESTRICTED TO PERSONAL USE ONLY. NO PART MAY BE REPRODUCED OR TRANSMITTED IN ANY FORM WITHOUT WRITTEN PERMISSION FROM THE PUBLISHER.

samples. No statistically significant differences were found between the PVS monophase impression material and the master model, or between these impressions and their resultant casts, but there were differences between those casts and the master model (in four instances). This also was the case for the impression plaster, with five instances of significant differences. These results highlight the cumulative effect of distortions, which were present but not significant in the preceding steps but which ultimately yielded master casts with significant interimplant distortions. Similarly, for the polyether, the cumulative nature of distortion ultimately yielded six instances of distortion between the master cast and master model that were statistically significant.

PVS putty with light-body wash was the only material that displayed distortion during the impression stage, which later seemed to be "reversed" so that the significant distortions that previously existed were no longer significant. It is possible that an initial expansive distortion was negated by a contractive distortion in the master cast, as is evident in instances for distances 1–4 and 1–5, and vice versa for distance 2–5 (see Table 3).

In terms of overall performance, the PVS monophase and polyether materials displayed the least distortion. A study comparing PVS with polyether showed no significant differences under dry conditions, but polyether showed improved dimensional stability under moist conditions.[6] This finding may explain its wide usage. Investigations under moist conditions do not provide conclusive evidence for the behavior of impression materials as they do not simulate the oral environment where blood and saliva are responsible for the moisture.

The PVS putty with light-body material showed the greatest deviation relative to the monophase materials. This is reinforced in a study where the PVS monophase material showed less distortion under wet and dry conditions.[6]

Random error (random variation) is inherent in any methodology that involves human manipulation despite its high internal consistency. This random nature of distortion makes the prediction as to its cause, and at which point during the procedures it occurs, difficult to establish.

With small sample sizes, random errors can become inflated as these have an inversely proportional relationship. In this case, a single outlier has a 20% representation and influences the outcomes greatly compared with larger sample sizes where its effect could be negligible. The selected sample size was in part dictated by financial constraints, which highlights the importance of drawing information from similar studies in the literature.

The variability within the samples measured (reflected by the SD) played a great role in dictating the significances observed in Tables 1 to 4. Assuming an unknown variance initially, the following test statistic was used to investigate significance:

$$\frac{t = \bar{x} - \mu_0}{s/\sqrt{n}}$$

where t is the t-statistic, $\bar{x}$ is the average sample distances for each material being investigated, μ is the master model, s is the standard deviation of the distance measurements, and n is the sample size for each material being investigated.

This equation highlights the dependence of significance on the variability of the samples investigated. The greater the SD for each test statistic, the greater the probability of failing to reject the null hypothesis (ie, no significant differences relative to the master model), which also provides an explanation for the unexpected outcomes observed. Assuming that the sample averages follow a normal distribution and that a 2-tailed test needs to be used (because distortion was either expansive or contractive) with four degrees of freedom (n–1), an exact P value is derived from the table of the t distribution. In clinical or practical terms, the statistical significance may not be totally applicable or useful when deciding on the material with the least distortion.

However, what is useful about the results obtained from inferential statistics is that they highlighted the 3D changes that occurred, which are of concern considering that these impressions and their casts were made under very strict laboratory conditions. It is, thus, highly probable that under clinical conditions the differences observed would be greater.

Another positive contribution of this line of investigation is the quantification of the variability that exists for the different materials by way of SD measurements and the range of each data set. These data indicate that the polyether generally had the lowest degree of variability, followed by the PVS monophase, PVS putty with light-body wash, and, last, the impression plaster at the impression stage. The latter was shown to be the least reliable as an impression material and polyether the most reliable in a previous study (Von Berg G, unpublished data, 2007) in which impression plaster also showed less reliability compared with polyether.

The above findings indicate the importance of a correct interpretation of pure statistics. The finding of statistical significance does not always explain the clinical or practical significance of the behavior of materials. Therefore, the descriptive data need to be viewed together with the inferential statistical data.

© 2014 BY QUINTESSENCE PUBLISHING CO, INC. PRINTING OF THIS DOCUMENT IS RESTRICTED TO PERSONAL USE ONLY.
NO PART MAY BE REPRODUCED OR TRANSMITTED IN ANY FORM WITHOUT WRITTEN PERMISSION FROM THE PUBLISHER.

This was achieved by examining the absolute values of the differences between the impression materials and their master casts relative to the master model and also among the materials themselves (Table 5). A quantification of the deviation from the master model at the impression and the master cast level spread over the various interpositional distances showed the greatest deviation from PVS putty with light-body wash, followed by impression plaster, polyether, and PVS monophase material, which, interestingly, is associated with the least distortion. If the absolute value of the differences between samples and test values observed is divided by the standard deviation, a ratio of differences is obtained. This ratio influences statistical significance in that the larger the ratio, the higher the probability of rejection of the null hypothesis (ie, the higher the probability of finding statistically significant results). This adds to the explanation of such findings as, for example, in the case of polyether, which had the lowest SD and therefore a larger ratio compared with PVS putty with light-body wash and impression plaster, which had much larger standard deviation values (increased variability and a greater range of results) and a smaller ratio.

Overall, then, the inevitability, the random pattern, and cumulative nature of distortion raise concern, particularly as procedures were performed under very strict laboratory conditions. It is thus highly probable that under clinical conditions the differences observed would be greater.

Given this unpredictability, other means of registration of implant position need to be provided to the laboratory for prosthesis fabrication, such as the use of digital technology, which could bypass the need for impressions and casts.

Conclusions

Under the conditions of this study, the PVS monophase impression material reproduced the master model most accurately, and the polyether proved to be the most reliable. However, all the materials displayed unpredictable distortion, which, in light of the absolute values observed, could be clinically significant. It is likely that these distortions will contribute to lack of passivity of fit of superstructures. If this is considered together with the evidence that one-piece castings also display unpredictable and inevitable 3D distortion,[9] this may mean that the need for impressions and casts should perhaps be bypassed by using digital technology.

Acknowledgments

Thanks to Leigh Spamer (Dentsply), Christina Stydom (3M ESPE), and Vic Young (Nova Dental) for donation of materials; Chris Boschoff (Bostech Laboratory) and Alfonso Ferrara and Tommy Sylvester (D'Eurodental Laboratory) for their assistance with laboratory work; and Shailen Nagesar and staff (AZ technology), who assisted with the portable coordinate measuring machine. The authors reported no conflicts of interest related to this study.

References

1. Wee AG, Aquilino SA, Schneider RL. Strategies to achieve fit in implant prosthodontics: A review of the literature. Int J Prosthodont 1999;12:167–178.
2. Jemt T. Failures and complications in 391 consecutively inserted fixed prostheses supported by Brånemark implants in the edentulous jaw: A study of treatment from the time of prosthesis placement to the first annual check-up. Int J Oral and Maxillofac Implants 1991;6:270–276.
3. Jemt T, Lekholm U. Measurements of bone and frame-work deformations induced by misfit of implant superstructures. A pilot study in rabbits. Clin Oral Implants Res 1998;9:272–280.
4. Zarb GA, Schmitt A. The longitudinal clinical effectiveness of osseointegrated dental implants: The Toronto study. Part III: Problems and complications encountered. J Prosthet Dent 1990;64:185–194.
5. Stober T, Johnson GH, Schmitter M. Accuracy of the newly formulated vinyl siloxanether elastomeric impression material. J Prosthet Dent 2010;103:228–329.
6. Johnson GH, Lepe X, Aw TC. The effect of surface moisture on detail reproduction of elastomeric impressions. J Prosthet Dent 2003;90:354–364.
7. Kronström MH, Johnson GH, Hompesch RW. Accuracy of a new ring-opening metathesis elastomeric dental impression material with spray and immersion disinfection. J Prosthet Dent 2010;103:23–30.
8. Wadhwani CP, Johnson GH, Lepe X, Raigrodski AJ. Accuracy of newly formulated fast-setting elastomeric impression materials. J Prosthet Dent 2005;93:530–539.
9. Mitha T, Owen CP, Howes DG. The three-dimensional casting distortion of five-fixture supported implant frameworks. Int J Prosthodont 2009;22:248–250.

© 2014 BY QUINTESSENCE PUBLISHING CO, INC. PRINTING OF THIS DOCUMENT IS RESTRICTED TO PERSONAL USE ONLY. NO PART MAY BE REPRODUCED OR TRANSMITTED IN ANY FORM WITHOUT WRITTEN PERMISSION FROM THE PUBLISHER.

Copyright of International Journal of Prosthodontics is the property of Quintessence Publishing Company Inc. and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.