Dimensional Stability of Addition Silicones - Influence of Setting Time on the Accuracy of Working Casts

[1]M. Potran, [2]B. Štrbac, [1]K. Vicko, [1]T. Puškar

[1] Department of Dentistry, Medical Faculty, University of Novi Sad, Novi Sad, Serbia
[2] Department of Production Engineering, Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia
Email: michalpotran@gmail.com

Abstract. *Addition silicones present contemporary dental impression materials with high dimensional stability. Major factor that influences the accuracy of dental impressions is setting time of the material, and as such it was adressed in this study. The master model presented a partially edentulous upper jaw with central incisors, canines and first molars. The master model was measured and corresponding data was used to create custom tray by rapid prototyping. Impressions were made with a monophasic technique, setting times were set at 3,3.5,4,4.5 and 5 minutes.Six working casts were made for each time period. Measurement of the working casts was performed 24 hours later on coordinate measuring machine. The dimensions of working casts abutments were different in comparison to the master model, especially in the interabutment regions. The precision of the working cast abutments increased in relation to prolonged setting time. In conclusion, prolonged setting time improves dimensional stability of the impression material because of the higher degree of polymerization.*

Keywords: Addition Silicones, Dimensional Stability, Setting Time, Master Model

1. Introduction

The manufacturing of indirect dental restorations includes a wide range of clinical and laboratory procedures, starting with tooth preparation and taking of dental impression. The dental impression presents a recording of intraoral tissues, and as such poses a link between the clinical and laboratory procedures. The accuracy of impression is of great importance for further compliance of these two distinct pathways.

Making of an successful dental impression depends on the properties of the material, the conditions of the oral environment and the skill of the therapist. The accuracy of dental impression is of vital importance for production of working casts, which present a reference model for manufacturing in dental laboratory. The basic requirement for impression material use is high dimensional stability. Dimensional stability is mesured through the ability of the material to withstand the biological and mechanical factors of oral surounding, maintaining its acquired dimensions. This ensures the accuracy of the recording, during and after the setting of the material. Fully set material should exhibit elastic properties, which is pronounced in presence of undercuts and in gingival sulcus [1]. Narrow areas are the source of high tensile stresses and can lead to plastic deformation and tear of the material. Larger defects are easily detected, and require repeating of impression procedure. Smaller defects, such as plastic deformation, are difficult to notice and can be easily overlooked. Dimensional stability depends on the degree of polymerization. Higher degree of polymerization improves elastic properties of the material and lowers the possibility of permanent deformation. This is called a setting time and is stated by the manufacturer. As the procedure of making of an impression is usually unpleasant to a patient, it is vital that this is conducted in the shortest time possible, while achieving the desired material's properties. In relation to this, the aim of this study was to assess the influence of setting time on the accuracy of working casts, by direct measurement of the working casts on coordinate masuring machine (CMM).

2. Subject and Methods

The master model consisted of six abutment teeth, replicating the shape of the upper incisors, canines and first molars after grinding. The dimensions and distances between abutment teeth were taken from the literature [2].

The master model was mesured five times on CMM (*Contura G2, Carl Zeiss, Germany*) with maximum permissible error with 1.9 + L/330 µm (L is length expressed in mm). The measurement results were used for construction of CAD model, a modified negativ of the master model. This was performed by enlarging the inner space around the abutments for 2 mm and contouring the outer shell of the tray to fit the dimensions of the master model (Fig. 1). The inner space enlargement of 2mm was ment to be used as reservoir for the impression material. The CAD model was transfered to a physical form by rapid prototyping (*Z310 plus, 3D Systems, USA),* thus creating the custom tray with 2 mm spacing.

The impressions were made with addition silicone, using a monophasic technique (*Elite Hd+ light body, Zhermack, Italy).* Before taking of the impressions, the master model was heated to a temperature of 37 ºC, using a waterbath. The impression material was inserted into the custom tray and the custom tray was seated on top of the master model. The working time was set to 60 sec, while setting time differed between the groups and was set to: 3, 3.30, 4, 4.30 and 5 minutes. After the immpression was taken, the working casts were poured in gypsum typ IV (*Elite rock, Zhermack, Italy*), with 30 minutes delay. Gypsum was allowed to set for 60 min, after which the custom tray and working cast were separated. Six models of working casts were made for each time interval, measurement was done 24 hours later on CMM.

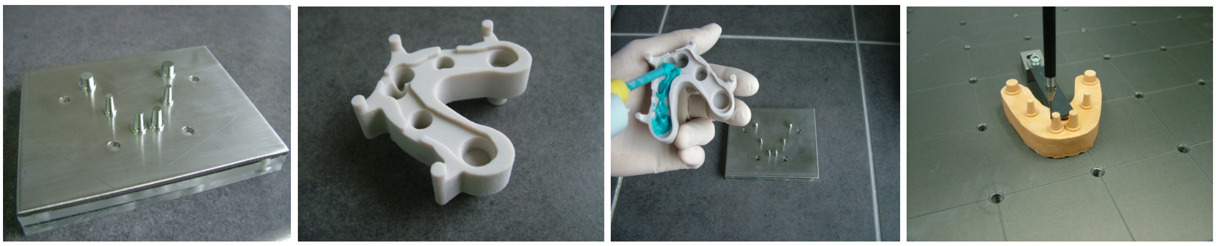

Fig. 1. The protocols of impression procedure and measurement of the working casts.

The measurement of working casts was performed using the same measurement strategy as for the master model. Inspection was conducted conformant to the new generation of product geometry specification (GPS) [3]. The measurement model consisted of geometrical features as cone, cylinder and plane. Each geometrical features was measured by discrete points, randomly distributed on the measurement surface. The measurement of abutments (cones) was made in 100 discrete points, while measurement of the chamfer (cylinder) was made in 50 discrete points. The output parameters of the measurement presented a coordinates that were mathematicaly processed to form a substitute geometry. The geometrical specifications (size, form, orientation, location) were determined by software processing. The abumtents were measured in three planes, transverzal (x1 - x3), sagittal (y1 - y6) and vertical (z1 - z6) (Fig. 2).

The comparison and analysis of the results was done by statistical analysis, with Student's T-test and One way ANOVA.

Table 1. The results of the measurement

Distance	Master [mm]	Mean [mm]					Difference/Standard deviation [µm]					t-test (p-value)					ANOVA (p-value)
		3min	3,5min	4min	4,5min	5min	3min	3,5min	4min	4,5min	5min	3min	3,5min	4min	4,5min	5min	
X_1	8.507	8.519	8.517	8.518	8.515	8.514	12 ±2	10 ±5.7	11 ±3.3	8 ±1.4	7 ±1.7	0.00	0.00	0.00	0.00	0.00	0.06
X_2	30.002	30.024	30.018	30.018	30.015	30.016	22 ±5.9	16 ±4.8	16 ±5.1	13 ±5	14 ±2.2	0.00	0.00	0.00	0.00	0.00	0.02
X_3	46.015	46.076	46.064	46.065	46.060	46.063	61 ±8.8	49 ±11	50 ±11	45 ±8.4	48 ±6	0.00	0.00	0.00	0.00	0.00	0.05
Y_1	18.144	18.162	18.157	18.154	18.154	18.153	18 ±2.5	13 ±3.9	10 ±3.7	10 ±4.9	9 ±2.6	0.00	0.00	0.00	0.00	0.00	0.00
Y_2	42.051	42.097	42.089	42.089	42.083	42.083	46 ±5	38 ±4.8	38 ±7.1	32 ±3	32 ±7.6	0.00	0.00	0.00	0.00	0.00	0.00
Y_3	24.364	24.392	24.390	24.391	24.387	24.384	28 ±3	26 ±2.1	27 ±3.4	23 ±4	20 ±2.3	0.00	0.00	0.00	0.00	0.00	0.00
Y_4	18.319	18.330	18.328	18.326	18.325	18.325	11 ±2.3	9 ±2.9	7 ±4	6 ±3.4	6 ±4	0.00	0.00	0.00	0.00	0.01	0.04
Y_5	42.149	42.196	42.193	42.189	42.186	42.184	47 ±9.7	44 ±9	40 ±10.9	37 ±9.3	35 ±9.9	0.00	0.00	0.00	0.00	0.00	0.24
Y_6	24.277	24.308	24.308	24.305	24.305	24.304	31 ±9.3	31 ±4.6	28 ±11	28 ±9.8	27 ±10	0.00	0.00	0.00	0.00	0.00	0.92
Z_1	7.506	7.514	7.515	7.511	7.514	7.508	8 ±40.7	9 ±13.2	5 ±13	8 ±8.6	2 ±8.3	0.65	0.13	0.32	0.05	0.47	0.93
Z_2	7.507	7.537	7.519	7.518	7.506	7.512	30 ±27	12 ±17	11 ±14.2	-1 ±21.4	5 ±7.5	0.04	0.14	0.11	0.95	0.13	0.09
Z_3	6.923	6.919	6.927	6.923	6.928	6.928	-4 ±22.7	4 ±18.9	0 ±6.8	5 ±13.1	5 ±7.8	0.78	0.61	0.83	0.32	0.12	0.59
Z_4	6.926	6.922	6.916	6.927	6.933	6.928	-4 ±22.6	-10 ±11.1	1 ±14.3	7 ±8	2 ±5.4	0.72	0.09	0.84	0.07	0.30	0.31
Z_5	4.5	4.506	4.499	4.493	4.497	4.499	6 ±17.2	-1 ±14.3	-7 ±6.4	-3 ±13.8	-1 ±6	0.43	0.87	0.05	0.61	0.98	0.69
Z_6	4.497	4.498	4.482	4.5	4.494	4.496	1 ±23.6	-15 ±17.2	3 ±20.4	-3 ±9.9	-1 ±12.7	0.95	0.08	0.72	0.41	0.83	0.38

3. Results

The results of the measurement are presented in Table 1. The accuracy of working casts increased with prolonged setting time.

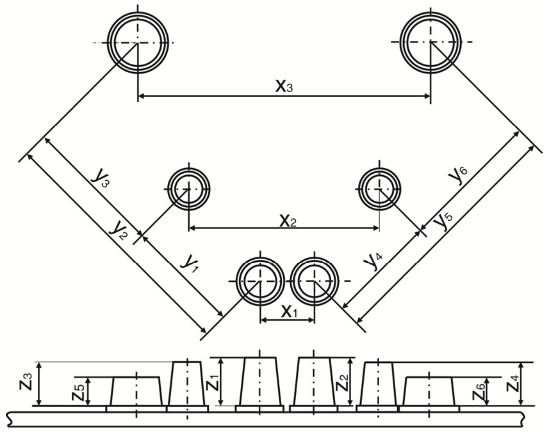

Fig. 2. The parameters of the measurement.

4. Discussion

The results presented show that extended polymerization time affects the accuracy of working casts. It can be seen that most pronounced difference is in the group with setting time of 3 minutes. The replica abutments were larger in all of the observed dimensions. The errors increased proportionally to the increase of distance between the abutments. From clinical point of view, this means that the replica abutments will be wider than that of the mouth. This is of special importance when constructing long span bridges. The future framework of dental bridges will be wider in transversal and sagittal plane, which will affect the accuracy of fit, especially in the marginal area. The marginal fit is most crucial part for longevity of dental restorations, considering the biological factors of oral environment and the increase of cement thickness, which can cause mechanical failure. While 3 minutes were considered a borderline setting time for completion of polymerization reaction, it was proven to be difficult to achieve successful impression in this time period. Some impressions made at this interval had to be discarded due to incomplete polymerization and plastic deformation of the material upon removal of the impression. This is of utmost importance for formation of elastic properties and prolonged setting time should be recommended, especially in the presence of undercuts or enclosed gingival sulcus. Within the limitations of this study, it can be concluded that prolonged setting time will increase the accuracy of working casts.

Acknowledgements

The results presented in this paper were obtained in the framework of the project entitled "Research and development of modelling methods and approaches in manufacturing of dental recoveries with the application of modern technologies and computer aided systems" – TR 35020, financed by the Ministry of Education, Science and Technological Development of the Republic of Serbia.

References

[1] Balkenhol M, Haunschild S, Erbe Ch, Wostmann B. Influence of prolonged setting time on permanent deformation of elastomeric impression materials. *J Prosthet Dent* 2010, (103): 288-294.

[2] Sched R.C, Weiss G. Woelfel's dental anatomy (8th ed.). Lippincott Williams&Wilkins, Wolters Kluwer business, Philadelphia, USA, 2012, p 41.

[3] ISO/TS 17450-1. Geometrical product specification (GPS) – General concept – Part 1: Model for geometric specification and verification. International Organization for Standardization 2002, Geneva.