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ORIGINAL ARTICLE

Evaluation of Dimensional Stability and Accuracy of Autoclavable Polyvinyl Siloxane Impression Material

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Abstract Dimensionally stable autoclavable impressions will be effective in controlling the cross-infection and contamination caused by patient's saliva and other oral secretions. The accuracy of newly introduced autoclavable polyvinyl siloxane impression material was assessed for its dimensional stability and accuracy. A standard metal model (Dentoform, U-501, Columbia) was customised for impression making. The impressions were made using the newly introduced polyvinyl siloxane impression materials (AFFINIS, Coltene/Whaledent AG, 9450 Alstalten, Switzerland). Fifty impressions were made and were divided into two groups A and B of 25 each. Group A was the control sample (non-autoclaved impressions) and group B was the test sample (autoclaved impressions), which was subjected to the steam autoclave procedure at 134 °C for 18 min, casts were poured in type IV gypsum products. The customised metal model, casts obtained from control and test group were subjected to laboratory evaluation with help of a travelling microscope (×10 magnification), and digital vernier calliper (0.01 mm/10 μm accuracy). Data analysis was done using one-way ANOVA and One-Sample *t* test to evaluate the overall accuracy ($P < 0.005$). As a result, there was an average reduction of 0.016 μm in overall dimension between the test and the control group when compared with the master model, which is not statistically or clinically significant. The newly introduced polyvinyl siloxane impression material is accurate and dimensional stable for clinical use when steam autoclaved at 134 °C for 18 min.

Keywords Autoclavable impressions · Polyvinyl siloxane · Sterilization of impression

Introduction

Infections may be transmitted in the dental office and laboratory through direct contact with blood, saliva, and other secretions, indirect contact with operatory equipment, or environmental surfaces, and contact with aerosol when using air/water sprays or high speed or ultrasonic equipment [1]. A set of infection-control strategies common to all health-care delivery settings should reduce the risk of transmission of infectious diseases and standard precautions must be followed routinely [2].

The principal potential route of infection transmission from the patient to dental clinician is through contaminated impressions, casts and prosthesis. Disinfection of dental impression materials can be carried out by immersion in or spraying with a disinfectant. When disinfecting impressions, its antibacterial efficacy and its effect on the dimensional stability of impression materials are important [3]. However, impression disinfection is less effective on pathogens than any type of sterilization because it intends to kill disease-producing microorganisms but not bacterial spores [4]. The steam autoclave sterilization is claimed to be effective in controlling the cross-infection and contamination by dreaded microorganisms. Sterilization of impressions by routine method may also affect the physical properties of the impression materials. Water imbibing materials do not lend themselves to prolonged immersion, nor can it be sterilized by autoclaving and other high

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temperature methods, since their physical properties and linear dimensions can be affected by such procedures.

With the advent of new materials and technologies in concern with hygiene and infection control, a polyvinyl siloxane impression material has been developed capable of steam autoclaving at 134 °C for 18 min at 2.0 psi. In this study the clinical feasibility and overall dimensional stability of this autoclavable impression material was checked.

Materials and Methods

The accuracy of newly introduced autoclavable polyvinyl siloxane addition cured impression material was assessed by measuring various dimensions of gypsum cast obtained from impressions made from the master model. A metal master model (Dentoform, U-501, Columbia), representing maxillary edentulous alveolar ridge, attached with three customised abutments were used for this study [5–7]. The three customised abutments A, B, C were machined to simulate full veneer crown preparations with six degrees total occlusal convergence and shoulder finish line with 1 mm width. The customised abutments were positioned one in the anterior region and one in the posterior region of each quadrant at the first molar region (Fig. 1). The centre of the preparations was indicated by cross hair reference points on the occlusal aspect (Figs. 2, 3) and reference marks were placed on the buccal and lingual surface in the cervical portion of each abutment to facilitate future measurement.

The impressions were made using the newly introduced addition cure polyvinyl siloxane impression materials (AFFINIS, Coltene/Whaledent AG, 9450 Alstalten, Switzerland, Lot. No.: C10833) using perforated rim-lock stock metal trays (SUPREME, SS rim-lock perforated trays). A polysiloxane tray adhesive was used from the same manufacturer (Coltene adhesive, Lot. No.: 0109371).

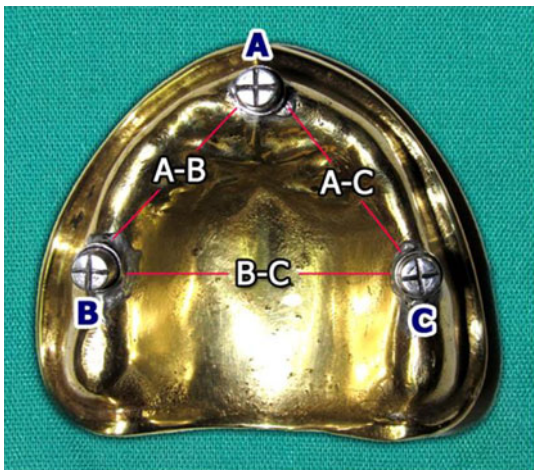


Fig. 1 Master model

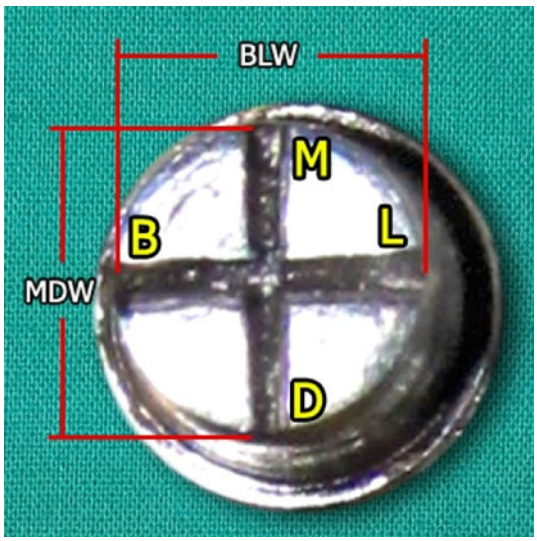
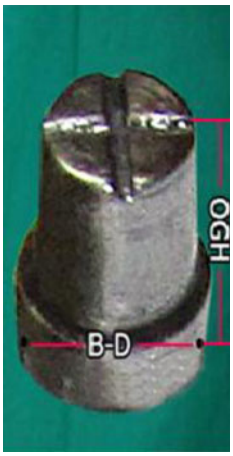


Fig. 2 Occlusal view of the customised abutment

Fig. 3 Axial view of the customised abutment



To standardize the impression procedure, an impression apparatus (Fig. 4), similar to the one used by Alex Hoyos et al. [5] and Holtan et al. [7] was customized. Spacer was fabricated with a 2 mm thick plastic pressure/vacuum-formed template placed over the abutments of the metal master model. A polysiloxane tray adhesive (Coltene/Whaledent) was applied evenly over the inner surface of the tray and extended approximately 3 mm onto the outer surface of the tray along the periphery. The adhesive was allowed to dry for 15 min before the impression was made [8]. The impressions were made with PVS impression material at viscosities of putty super soft and light body. All impressions were made by a single operator.

A total of 50 impressions were made and divided into two groups A and B of 25 each. Group A was the control sample (non-autoclaved impressions) and group B was the test sample (autoclaved impressions). The test specimens were subjected to the steam autoclave procedure at 134 °C for

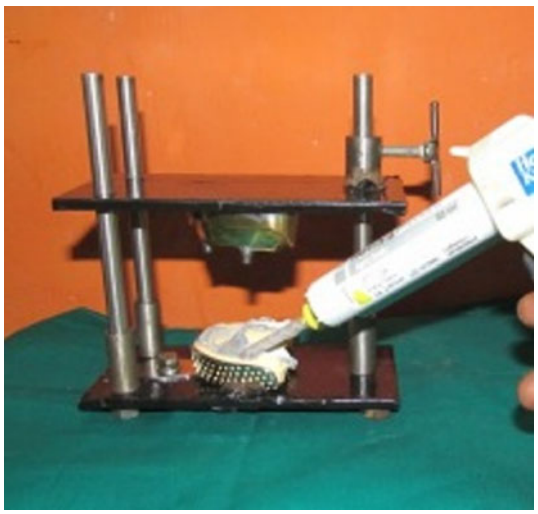


Fig. 4 Impression jig housing the master model and impression tray

18 min at 2.0 psi and with a drying time of 12 min (Unique clave C79 B, Confident equipments Pvt. Ltd.). Control group and test specimen impressions were poured with type IV low expansion (0.10 % max, Kalrock, Kalabhai Karlson Pvt. Ltd., Batch No.: 110203) gypsum products.

The dimensions measured on the master model (MM), casts obtained from control sample (CS) and test sample (TS) were (1) antero-posterior dimensions (APD) i.e. the distance between the junction of cross hairlines of abutment A to B, (2) cross-arch dimensions (CAD) i.e. the distance between the junction of cross hairlines of abutment B to C, (3) base width (BW) of abutment A was measured across the reference marks on the cervical aspect in the bucco-lingual direction, (4) occluso-gingival heights (OGH) was measured between the buccal end of the cross hairline and the cervical reference mark on buccal side of abutment A, (5) bucco-lingual width (BLW) on the occlusal aspect was measured between the buccal and lingual ends of hairline on the occlusal aspect for abutment A, (6) mesio-distal width (MDW) on the occlusal aspect was measured between the mesial and distal ends of hairline on the occlusal aspect for abutment A.

The APD and CAD were measured using a travelling microscope capable of measuring to 10 μm accuracy and the diameter of the base and the height of the abutment were measured using a hand-held digital electronic vernier calliper capable of measuring to 0.001 mm/10 μm accuracy [7, 9].

Statistical Analysis

Data analysis was done using one-way ANOVA and One-Sample *t* test to evaluate the overall accuracy of cast obtained from the autoclaved impression material and the control group when compared with the MM ($P < 0.005$).

Results

The *t* test comparisons of the various dimensions of the MM, with CS and TS showed an average reduction of 0.016 μm in dimensions of TS when compared with the CS. APD of TS showed an increase in dimension of 0.00837 μm from the CS. The CAD of TS showed a reduction in dimension of 0.0080 μm from the CS. BW, OGH, BLW, and MDW of TS being 0.0036, 0.00120, and 0.00141 μm more in dimension than CS respectively. No statistically or clinically significant variation was observed between the samples of control and test groups from the MM ($P < 0.005$, for confidence interval of 99 %) Table 1.

Discussion

The widespread use of addition reaction silicone impression materials, also known as vinyl polysiloxane (VPS) materials, used in fixed and removable Prosthodontics is attributed to their dimensional accuracy, excellent elastic recovery, ease of handling, stability, and ability to produce multiple casts from an single impression, and good detail reproducibility [9]. Impressions are to be disinfected with the chemical disinfectants or to be sterilized to avoid risk of cross contamination and potential transfer of infectious disease from patients to dental professionals and vice versa. There is no general consensus about the necessity and method of disinfection or sterilization of dental impressions. Polyvinyl siloxane materials are the only materials currently available that may tolerate the procedures necessary for sterilization [7]. Johansen [1] reported, polyvinyl siloxane immersed in glutaraldehyde for 16 h materials was highly stable. Holtan et al. [7] sterilized PVS impressions using ethylene oxide gas rather than steam sterilization.

This study subjected a newly introduced autoclavable PVS material to sterilization using a conventional steam autoclave at 134 °C for 18 min at 2 psi, and evaluated the accuracy of the type IV gypsum cast obtained from it. The measurements made on the MM and casts obtained from test and CS were the APD, and CAD, BW, MDW and BLW and the OGH of abutment A.

The observed inference was that the dimensions of casts obtained from the TS were dimensionally smaller than the MM. The cause could be the net polymerization shrinkage of the addition cured silicone impression material. Thomas Stober [10] reported that the tray with adhesive near the occlusal preparation may control the magnitude of polymerization shrinkage. The tendency of the hydrophilic additives in the PVS impression material to absorb water and swell in contact with the type IV improved stone could have resulted in smaller dimension.

Table 1 The recorded dimensional values of the master model (MM), control samples (CS) and test samples (TS)

Sl. no.	Variables	Mean	SD	T	*df*	Sig. level at 1 %
1	Antero-posterior dimension (APD)					
	MM	27.5033	0.00577	378.057	2	0.000
	CS	27.4923	0.01079	377.616	2	0.000
	TS	27.4943	0.01916	377.441	2	0.000
2	Cross-arch dimension (CAD)					
	MM	40.03	0	801.200	2	0.000
	CS	40.0175	0.01128	800.248	2	0.000
	TS	40.0255	0.00711	800.735	2	0.001
3	Base width (BW)					
	MM	6.5833	0.00577	21.631	2	0.001
	CS	6.5651	0.01584	21.446	2	0.000
	TS	6.5687	0.01166	21.497	2	0.000
4	Occluso-gingival height (OGH)					
	MM	6.5433	0.005	21.374	2	0.001
	CS	6.5391	0.00643	21.337	2	0.001
	TS	6.5399	0.00763	21.335	2	0.001
5	Bucco-lingual width (BLW)					
	MM	5.08	0	12.903	2	0.001
	CS	5.0711	0.06347	12.538	2	0.000
	TS	5.0719	0.00816	12.820	2	0.001
6	Mesio-distal width (MDW)					
	MM	5.08	0	12.903	2	0.001
	CS	5.0707	0.01037	12.803	2	0.001
	TS	5.0715	0.01178	12.800	2	0.001

This result is in agreement with report of Stackhouse [11] on hydrophilic polyether. Holtan [7] reported the decrease in dimensions was due to shrinkage of the impression material, but his values were greater in magnitude ranging from 58 to 129 μm. Idris [6], Nissan [12] and Sergio Caputi [13] assessed the accuracy of PVS impression materials in which gypsum dies were shorter in the occluso-gingival dimension. Stackhouse [11] reported that the height of the stone model was shorter than the standard model because of the vertical component of contraction is in a direction towards the occlusal portion of the preparation where impression adheres to the tray. Nissan [12] reported a shorter model will produce a casting that is short at the margins. Grajower [14] in his study concluded that a slight increase in dimension (0.04 mm) of the working die (height and diameter) would be helpful to facilitate cementation.

Measurements made on the stone cast could be potentially affected not only by the impression material and the tray type, but also by the linear setting expansion of the dental stone used. So, another possible factor may be the use of the low expansion (0.1 %) type IV improved dental stone in this study which would have a positive effect on the slightly undersized dimensions of the cast produced. Jaganmohan Reddy [15] reported similar findings where low expansion improved dental stone was used and also quoted that use of a higher expansion dental stone of 0.28 % would have increased the measurements. The maximum decrease in diameter for CS casts was 10 μm and for autoclaved sample casts was 15 μm. Tjan [16] stated that a difference of approximately 50 μm was acceptable.

The results of the present study shows a maximum difference of 15 μm from the MM for the casts both from control and autoclaved samples. Thus, it is unlikely that the differences observed for the dimension in this study would have any clinical impact on the fit of fixed prostheses. The results implies that the newly introduced PVS material autoclaved at 134 °C for 18 min at 2 psi will not affect the accuracy or the dimensional stability of the set impression material and this material can be recommended for short-span multi-unit restorations rather than when planning for a complete arch fixed restorations, to avoid framework distortion and misfit.

Conclusion

The dimensions measured for the variables studied was slight smaller in overall dimension when comparing the control and test group samples with the MM with no

statistically or clinically significance. Thus the newly introduced polyvinyl siloxane impression material is accurate and dimensional stable for clinical use when steam autoclaved at 134 °C for 18 min.

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