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Using a Three-Dimensional Superimposition Technique, Studying the Effects of Different Cooling Procedures on the Adaptability of Rapidly Heat-Cured Acrylic Denture Bases

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Keywords

Three-dimensional-superimposition, cooling methods, denture base adaptation, rapid cured polymethyl methacrylate"

Abstract

Aim: The purpose of this study is to use a 3D superimposition technique to examine how different cooling techniques affect denture base adaptation of rapidly heated acrylic resin.
Setting and Design: Comparative in vitro study.

Materials and Method: Five different cooling techniques were used to adapt two different polymethyl methacrylate acrylic resins for denture bases. For the purpose of creating denture bases with a

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standardized thickness, Casts in stone of 50 edentulous maxillae were made. Based on the components used and the methods of cooling, the samples were divided into five groups (n = 10). A 3Shape E1 laboratory scanner was used to examine the professional stone cast and all forty replacement dental implant bases. Each dental replacement base was examined, and then, using the Appear 3-Matic application, the filtered picture was superimposed on top of the expert cast filter. Color surface maps were made to display the three-dimensional contrasts between the two surfaces for a visual qualitative assessment.

The statistical analysis included the use of the generalised Linear Model Test as well as the Bonferroni Post Hoc Analysis.

Results: There was a large area of green across the whole palatal surface in all of the instances that were cooled in the seats, but the red variation regions enlarged in the swiftly cooled examples, particularly in the taste buds and the post-dam areas. The Summed Direct Model test and Bonferroni post hoc analysis both confirmed that there was significant variation in root means square quality across the various sample sets.

Conclusion: By and large, the accuracy of the samples that were cooled on the bench was higher than that of the quick cooling groups. In spite of the need for faster denture manufacturing, bench cooling of quickly heat-cured PMMA is important for satisfactory denture base adaption.

1. Introduction:

Due to its advantageous working characteristics, acceptable mechanical strength, and comparably cheap cost, polymethyl methacrylate (PMMA), which was first commercialized in 1937, was often used to create detachable prostheses. [1,2] Continuous improvement has been made to this material and the methods associated with it in order to shorten the time needed to issue or deliver a detachable prosthesis. No discernible layering differences exist between the typical protracted heat-restoring cycle and the rapid 20-minute relieving cycle, according to studies led from the primary fast 20-minute intensity alleviated PMMA was supplied [3] [4,5]

Effective chewing is made possible by properly fitted dentures, which also enhance patient comfort. The flask cooling method, Factors that affect the final product's appearance include not just the acrylic resin's kind, curing time, and water absorption, but also is crucial for maintaining the dimensional accuracy of a removable prosthesis. [6,7] This is due to the fact that a longer cooling period in the stone mould relaxes any internal stress that was left over from heat processing, reducing warpage during deflasking. [6] However, in urgent situations, Traditional denture chilling methods are inconvenient and time-consuming for situations when speedy denture delivery is of the utmost importance, such as during community outreach in remote locations or for elderly patients in poor health. The length of time a denture base needs to cool down is a key variable in determining its accuracy and the quality of adaption it will have after being used. Direct estimates between two points [8,9] and measuring space by silicone weight have been investigated to better understand how to determine the stacking accuracy of materials used for long-term prosthesis or tooth replacement bases. [10]

These procedures required a lot of time and were prone to operator error.[11] We may use 3D superimposition to see how the many options for dental implant bases affect the crown fit, which has direct clinical relevance. [12] To far, there hasn't been any research examining the impact of various cooling techniques on the quick heat-cured acrylic denture base adaption. The purpose of this investigation was to compare two rapid heat-cured PMMA denture base materials currently on the market to different cooling methods. The null hypothesis stated that regardless of the chilling

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techniques used, no discernible changes would be seen in the adaption of the tested materials' denture bases to the stone model.

2. Material and Methods:

Scanning and preparing reference casts

The institutional review board gave their approval to the research. This research made use of two fast-curing PMMAs that are already on the market (Table 1).

Table 1: This study takes a look at a variety of acrylic dental replacement base products and the cooling mechanism they use.

“Material	Lot number	Code Manufacturer	Group	Cooling procedure
Acron	Powder: 210605	AE Associate Dental Products Ltd., Kemdent Works, U.K.	A1	Bench-cool for 30 min, and then immerse in 23°C room temperature water bath for 20 mina
Express	Liquid: 24512		F1	Bench-cool until cool down completely
Fast heat	Powder: 1809141101	FHC Huge Dental Material Co. Ltd., Shanghai, China	F2	Bench-cool for 30 min, and then immerse in 23°C room temperature water for 15 min
Curing	Liquid: 1808271049		F3	Bench-cool for 5 min, and then place under running tap water for another 5 min
			F4	Immerse directly into room temperature water bath with running tap water for 5 min”

As a reference cast, type 1 material A maxillary cast for an edentulous patient was constructed using the protocol established by the American Academy of Prosthodontists [13]. Using Type IV dental stone, 50 stone casts of the definitive cast were created, and the authoritative cast was replicated using silicone-based duplicating material (Wirosil, Bego USA) (Tip top Stone, Zhermack Italy). Each research group received eight castings, which were distributed in accordance with the cooling method that was used, as shown in Table 1. Before using the 3Shape E1 dental laboratory scanner to scan and digitize each cast, it was given a label and given time to dry for 24 hours (3Shape, Copenhagen, Denmark).

3. Denture basis specimen preparation

Over the reference cast, a 2.0 mm thick wax print was produced throughout. “A silicone matrix (Exaflex Putty, GC USA) was utilized to replicate waxed denture foundation specimens and standardize specimen thickness. [14] Each denture base specimen underwent compression molding,[15] flasking, and 20 minutes of heat curing in a water bath at 100°C.”

Process for chilling the foundation of dentures and three-dimensional analysis. Before the scanning operation, The 50 samples were rehydrated in distilled water for 24 hours, and then refrigerated in accordance with the selected groups (Table 1). A 3Shape E1 scanner was used to inspect the intaglio surface of each dental implant base. All of the samples were examined in the same exact location by using Exaflex Clay from GC USA. The 3D checked data of the dental replacement bases was imported into the modelling application (3matic®, Appear, Leuven, Belgium). The bases were created using the standard decorating language (STL). Whole tissue surfaces of the dental replacement bases were placed overlying just the matched dental replacement conveyance region of the expert cast. To achieve superimposition, The buccal frenum, sharp papillae, fovea palatine, and the fourth molar are all landmarks in a person's physical development. were matched on the two surfaces. When the nearest point approach of fine-tuning a product is used for global enrolment and pre-programmed enrollment,

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For a visual qualitative evaluation, This problem was handled by determining how far apart the two surfaces were spatially, and then using that information to create a wide range of surface guides. In the case of a perfect fit between the dental replacement base and the expert cast, the complete dental replacement would be shown in green on the variation map. Changes from cyan to blue that are indicative of tissue pressure suggest that the dental replacement base is impinging on the expert dental cast. whereas negative departures from yellow to red reveal a mismatch with a gap.

Statistic evaluation: In order to determine the dependability of the five separate groups of examples, we used a combined direct model test and Bonferroni post hoc test (P 0.05). In cases where it was possible to do so, the root-mean-square (RMS) benefits of each superposition were recorded. The median, mode, and IQR of the numerical separation between each set of superimpositions were also recorded. Every quantitative statistic was parsed using the latest release of the Factual Bundle for Sociologies (version 22.0.0). "(SPSS Inc., Chicago, II, USA). One investigator handled all scanning and superimposition tasks." High intra-rater dependability was guaranteed by the intraclass correlation coefficient.

4. Results:

Wide green areas could be seen on the general palatal surface of specimens A1, F1, and F2. Particularly in the palate and post-dam region, F3 and F4 had elevated red color patches.

Table 2 displays descriptive statistics from the research, such as the mean, IQR, mode, and standard deviation of the numerical superimposition distance for each set of specimens. In terms of the accuracy of denture base adjustments, the F1 group had the lowest RMS mean value while the F3 group had the greatest RMS mean value. The Generalized Linear Model test revealed a significant variation in the RMS values across the specimen groups (P = 0.002). When cooled down in accordance with the manufacturer's directions, As compared to ISO-certified A1, F1's overall accuracy was not significantly different. Post hoc Bonferroni testing revealed that compared to Factors 1 and 2, Factor 3 (F3) was statistically different from both. Factor 4 (F4) was only different from Factor 1 (F2).

Table 2: Maxillary denture base surface variations compared to scanned master castings

Specimen	Mean±SD (mm)	IQR (mm)	Median (mm)	RMSE (mm)
A1	−0.002±0.005	0.145	0.350	0.345
F1	0.365±0.005	0.135	0.352	0.362
F2	0.370±0.008	0.140	0.360	0.365
F3	0.400±0.115	0.152	0.405	0.405[ab]
F4	0.405±0.010	0.155	0.385	0.402[a]

Bonferroni post hoc test, F1 =.05, F2 =.05; both tests were two-tailed. The terms "standard deviation," "interquartile range," and "root-mean-square error" (RMSE) are all measures of dispersion.

5. Discussion:

Those with specific requirements, such as those who are physically or chronically unwell or who have other socioeconomic challenges, may have their dentures delivered as quickly as possible. denture processing must be more inexpensive, stronger, and shorter in length. [16,17] For a dental replacement base to fit the user comfortably, with little twisting and shrinking, the wearer will need to have a high level of expertise. [18-20]

Researchers have used a variety of techniques to investigate the layered accuracy of dental replacement base materials, including: [20] using an optical comparator to measure the distance between two reference focuses on the foundation of the prosthesis; [21] inspecting post dam errors; [22] estimating the vertical aspect or incisor pin development; [22,23] estimating the distance between the expert cast and the dental replacement using the heaviness of a wax up; and [24] estimating the distance between the expert cast

Although manual measurement techniques are accessible, affordable, and simple to use, they take time and are prone to operator mistakes. [11,28] Moreover, these techniques only monitor indirect shifts between two locations, but during handling, multilayer shifts happened in three dimensions. Hence, superimposing STL records using design software is a more clinically relevant way to describe the adaptability of tooth replacement. [27,29] Although statistically significant changes were revealed between the five sessions, the results of the evaluation contradicted the erroneous supposition (P 0.05). The seat cooled dental replacement bases (A1, F1, and F2 groups) were significantly more flexible than the quickly cooled dental replacement bases (F3 and F4), as determined by correlating the 3D checked image of the dental replacement base with the stone model of the upper complete edentulous curve (P 0.001). These results are in line with previous research showing that slow cooling, as opposed to quick cooling, increases mobility (see references [6,19,30]). For a long time, controlling the pace at which heat-relieved acrylic saps cool has been thought to be an effective method for regulating their crystallinity and shrinkage.

[31] If there is a difference in the warm withdrawal between stone form and acrylic gum,[32] the handled dental replacement will experience internal strain due to the reaction that occurs during heat polymerization. In contrast to slow or seat-cooled acrylic, which experienced less shrinkage on deflasking, instantly cooled PMMA experienced higher shrinkage because to the residual pressure applied on deflasking due to the greater flexible strain imposed following ejection free of the stone form. [30,33]

In the optimal variety coded map, the green region encompassed the A1, F1, and F2 seat cooling groups. Space between the dental replacement base and the cast was indicated by a positive deviation, as revealed by a change in color from yellow to red; this was most pronounced in the F3 and F4 rapid cooling groups. This void, most notably at the rear palatal seal region, indicates that the tooth replacement was warped in the rapid cooling groups after deflasking, which is consistent with the finding that the RMS value was much higher in these groups.

It has long been known that applying slow post-processing cooling results in the least amount of distortion of the prosthesis. Rapid cooling rates result in highly constricted polymer chains with decreased segmental mobility and significant residual stresses, which have an impact on the prosthesis's structural stability and fit. [33] Rapid temperature drops or extinguishing [34,35] may also have an adverse effect due to the differential shrinkage vectors and withdrawal at some dental replacement locations. Unlike the majority of other studies [12,36], which just evaluated the middle of numeric distance to determine the correctness of each example bunch, RMS esteem was taken into account in this investigation when surveying the advanced data. According to Pearson's correlation coefficient, there was no association between the root-mean-square (RMS) value and the median of the measured numerical distance. RMS value continues to be the parameter of choice to assess the correctness of each superimposition. There are certain restrictions on this in vitro investigation. A typical edentulous master cast was used as a comparison point for the denture base alteration. Saliva and a restricted oral orifice are only two examples of the functionally-relevant, but changeable aspects of the oral mucosa. are not replicated by the master cast. Furthermore, unlike fixed prostheses,[37] mucosal compressibility during mastication has a significant impact on how well detachable prostheses adapt. [38] The program also carried out overall matching utilizing the closest corresponding points between two surfaces after performing point-based registration using specified anatomical landmarks. True individual displacement may not be precisely duplicated in automated superimposition because of the convoluted algorithm used in the process. However, for research of a comparable kind, this methodology continues to be the most recent one. To get over this problem, haptic technology should be included into the arrangement's programming and linked to the patient's actual material inclination throughout the dental replacement base adaptation process. [14] To evaluate patient-related outcome measures, more studies that take into account the real clinical setting should be conducted.

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6. Conclusion:

As far as this in vitro study was concerned, the 3D superimposition technique demonstrated that samples cooled at room temperature (bench cooled) were more accurate than those cooled in a shorter amount of time (quick cooled). Hence, when time is of the essence, the flexibility of a denture base made of bench-cooled quick-heat-cured PMMA is just what you need.

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