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The Dimensional Changes of Clasp Arm in Removable Partial Denture Frameworks Fabricated Through DMLS and Conventional Lost Wax Technique: An In Vitro Study

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Abstract

AIM: *The aim of the present study is to evaluate the effect of CAD designing on the dimensions of the clasp arm.* ***METHODOLOGY:*** *A Kennedy Class III mod I cast was selected as the reference cast. Samples were divided into 2 groups, Group I with DMLS and Group II with Conventional lost wax technique. Three reference points were selected on the clasp arm and the vertical dimensions were measured in the digital design and compared it with the dimensions at the same points in the final framework.* ***RESULTS:*** *There was slight expansion in group 1 (p-value > 0.05) with mean of -0.035 and standard deviation 0.088. And there was decrease in dimensions in the clasp arm in group 2 (p-value < 0.05) with mean of 0.1741 and standard deviation 0.081.* ***CONCLUSION:*** *From the present study, it was concluded that the dimensions of the clasp arm of DMLS framework increased slightly, whereas the there was significant decrease in the clasp arm dimensions in the framework produced through conventional lost wax technique. Both the frameworks had clinically acceptable fit.*

Keywords: clasparm, DMLS, dimensional changes, cast partial denture

Introduction:

Technology is rapidly taking over everything in the world and dentistry is no exception. Prosthodontics uses digital dentistry for a number of treatments, including implant planning, surgical implant placement, and CAD/CAM restorations, to mention a few[1]. Digitalization has been used in the production of removable partial dentures and complete dentures in removable prosthodontics[2, 3][4]. Traditionally, wax patterns are used to create cast partial dentures, which are then cast using the lost wax technique[5][6]. For many years, this has served as the gold standard. Due to the numerous advantages, it provides, additive manufacturing has currently overtaken traditional techniques[7]. The process of fabricating a cast partial denture is cumbersome and involves multiple steps.The components of CPDs can now be manufactured on 3D virtual models utilizing designing tools that provide significantly improved precision. thanks to the development of newer technological aids[8]. They reduce the number of laboratory steps, which might result in improved accuracy from fewer manufacturing mistakes. Because the input is a 3D digital geometric model created through direct scanning or manufacturing in a commercial CAD application, additive technologies reduce the setup time. Examples of additive manufacturing techniques include 3D printing, DMLS, and SLM (selective laser melting and sintering). The method that is used the most commonly out of all of them is the selective laser melting and sintering of metal powder particles[9, 10].

A high-power laser is used in direct metal laser sintering (DMLS), a type of additive manufacturing, to sinter thin metal powders while being directed by a 3D CAD model. Theoretically, direct printing using CAD technology, especially selective laser melting (SLM) technology, has the potential to be more accurate than conventional framework manufacturing because it requires fewer steps and may reduce fabrication errors[11]. SLM is an additive continuous layered construction method that uses laser melting immediately after deposition of elemental metal or alloy powder to produce a completed shape under computer control. Time, labour and expenses are reduced with this procedure[12].

There are a lot of studies comparing and evaluating the accuracy and fit of the cast partial denture framework fabricated using conventional and digital methods. Methods which have been used in recent publications include using different disclosing materials, sectioning the RPD, taking precise measurements of the spaces between the prosthesis and the master casts, and digitally superimposing models[13]. However, to our knowledge, there are no articles evaluating the dimensional changes of the framework printed through DMLS compared to the initial design. This study is done to evaluate the effect of CAD designing on dimensions of clasp arm.

Two null hypotheses were set:

1. There is no statistically significant difference in vertical dimensions of a clasp fabricated through DMLS compared to initial digital design planned.
2. There is no statistically significant difference in vertical dimensions of a clasp fabricated through conventional lost wax method compared to initial wax-up of the CPD framework.

Materials and Methods

This was an in vitro study done in the Department of Prosthodontics after getting Institutional approval by Saveetha Dental College and Hospitals, Chennai, India

Sample size was calculated to be 10 using G*Power software version 3.1.97 keeping the p value < 0.05 and power 80% using data from a similar study done previously. (Soltanzadeh et al)(15)

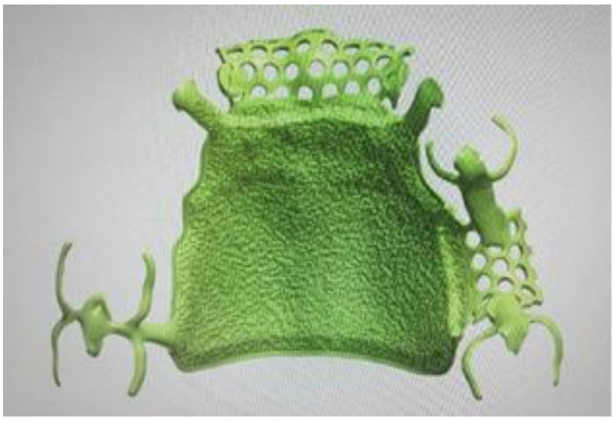
Sample preparation:

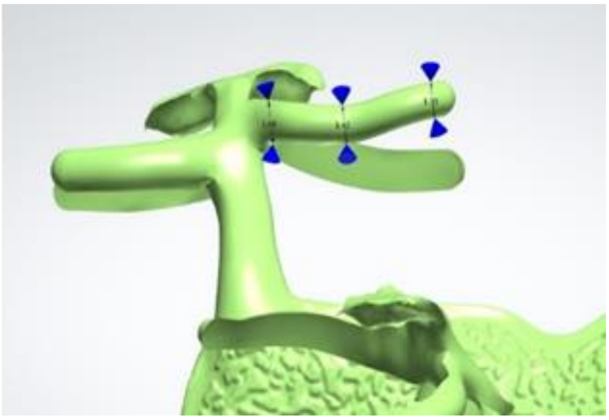
A silicon based pre-clinical mould with Kennedy's class III modification 1 was used to pour a cast. A total of 6 rest seats were prepared on the abutment teeth (mesial to 17, distal to 16, lingual rests for 13 and 23, distal to 24 and mesial to 27). The cast was surveyed and modified to ensure parallel guiding planes. This cast served as a reference model throughout the study. All RPD frameworks were fabricated using Co-Cr alloy.

Group I – CAD designing

Reference cast was scanned using a desktop scanner (3 shape, E4 extra oral scanner), and the STL file generated was used as the reference data set. After the scans were done, the denture design frameworks were designed and the STL files were sent for DMLS printing. After finishing and polishing, the frameworks were checked for dimensions of clasp arm. They were checked in the digital design by using the inbuilt measuring option in the software.

clasp arm in the printed and conventional dentures were measured using digital calipers. Data were analysed using independent t-test





(a)

(b)

Figure 1. Image showing framework design and measurement of clasp arm (a)
Image showing clasp assembly post printing (b)

Group II – Conventional fabrication using Lost wax technique

In order to create five casts utilizing a type IV dental stone (Kalabhai Kal (Green) Stone), the reference model was reproduced using a silicone-based duplicating substance after the rest seat preparation. For increased consistency and standardization among the casts, the amount of powder and water was metered by a liquid dispenser and combined using a programmable vacuum mixing apparatus (Silfradent, Italy). The entire batch of samples was poured on one day and stored in a dry, dark environment for 24 hours.In the edentulous spaces, a wax (Hindusthan) spacer with tissue stops was adapted. On all 5 casts, pattern wax and sprues were applied. Frameworks for cast partial dentures were made from Co-Cr alloy (Bego). To eliminate operator bias, the same technician completed all of the fabrications

(a)

(b)

Figure 2. Image showing conventional wax-up (a)
Image showing casted framework post processing (b)

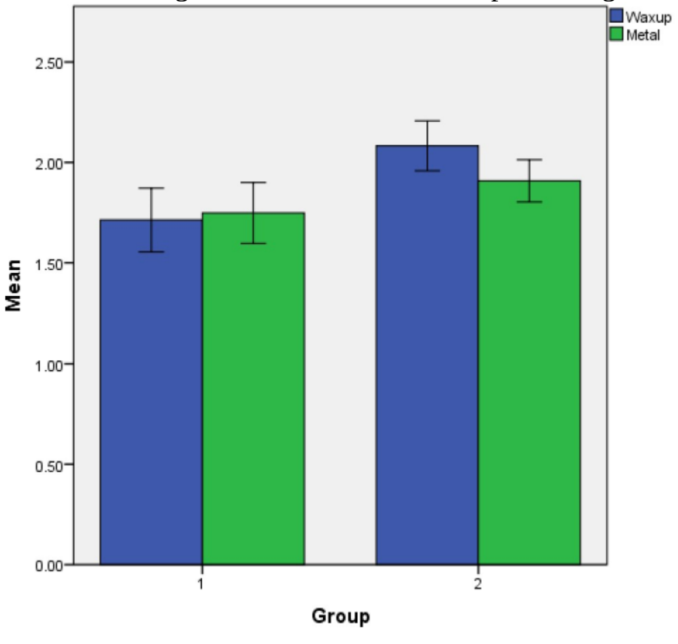
Finishing And Polishing:
At a pressure of 3 bar, 250-micron Al2O3 airborne particles were utilized to abrade the RPD metal frameworks. All RPD metal frameworks were finished using carbide burs. Then, they were air-abraded with 125 Al2O3 at a pressure of 3 bar. Finally, the frameworks were polished using polishing paste by a dental technician with more than three years of experience in the field of removable prosthodontics.

Statistical Analysis:
Statistical analysis was done using IBM SPSS software 23.0. As per tests of normality, p value was >0.05, and hence analysis was done using paired t-test and the results were tabulated.

Results and Discussion

Normality testing was done, P value was found to be > 0.05, hence parametric test (student t-test) was performed.
Group 1 - Digital wax-up and DMLS fabricated framework
Group 2 - manual wax up and manual casting.

The bar chart showing dimensional changes in the framework after processing



The bar chart shows slight expansion in group 1 and shrinkage in group 2 post processing.

Paired Samples Test

Group			Paired Differences					t	df	Sig. (2-tailed)
			Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
						Lower	Upper			
1	Pair 1	Waxup - Metal	-.03500	.08816	.02545	-.09102	.02102	-1.375	11	.196
2	Pair 1	Waxup - Metal	.17417	.08140	.02350	.12245	.22589	7.412	11	.000

Table1. Table showing the results of paired sample t-test

There was slight expansion in group 1 (p-value > 0.05) with mean of -0.035 and standard deviation 0.088. There was a decrease in dimensions in the clasp arm in group 2 (p-value < 0.05) with mean of 0.1741 and standard deviation 0.081, With confidence interval of 95%.

Discussion:
This study was undertaken in order to evaluate the dimensional changes in the clasp arm of RPD metal frameworks produced using conventional lost-wax casting technique and Direct metal laser sintering (DMLS) after the finishing and polishing. From a clinical perspective, the accuracy of the clasp arm of RPD frameworks is an essential parameter in order to decrease plaque accumulation, food impaction, patient comfort, covering the alveolar ridge which had been an interest of research in removable prosthodontics[14]. If the clasp arm is dimensionally inaccurate it can produce leverage forces on the tooth and can lead to destruction of supporting

tissues. Hence, it is absolutely essential that the clasp arm dimensions are not affected by any of the processing methods, be it digital or conventional. In the present study, we have compared the dimensions of the clasp arm of initial digital and wax-up design to the printed and casted models. There are numerous studies comparing the accuracy and fit of removable partial denture frameworks produced by conventional and digital methods. But to our knowledge, there was no study specifically comparing the dimensions of the clasp arm of the final framework to the initial design. Here, in this study, three points were selected as reference for measuring the dimensions of clasp arm[15, 16]. One point at the shoulder of the clasp, one at the centre of body and the other at the tip of the retentive arm. The measurements were taken after initial design and after final processing and finishing of the metal framework at the same points. It was observed that the dimensions of the DMLS framework increased from the initial design. Whereas, the dimensions of framework produced from conventional casting showed decrease in size. The dimensional changes of DMLS framework could be attributed to a lot of reasons.

Some metal alloys used in DMLS may unexpectedly expand during the sintering process[17]. This might happen if the material hasn't been correctly described or if anything is causing it to behave differently than it should, like contaminants or uneven powder distribution[18]. Dimensional differences may result from inaccurate calibration or settings in the DMLS machine, including laser power, scan speed, or layer thickness. The printed part can end up being larger than intended if these settings are not updated on regular basis[19].The consistency and dimensions of the finished product might be impacted by the sintering layer's thickness, according to a study that was recently published. Beyond a specific thickness, sintering layer thickness decreases process accuracy and degrades surface finish, whereas layer thickness increases process accuracy and enhances surface finish when decreased by up to 20 m[20]. On the other hand, lowering the layer thickness to less than 20 m might result in the structure being more porous, and doing so often lengthens the production process[21, 22]. The fabrication of a stone cast using an impression as a basis and subsequently scanning it to design and create 3D-printed frameworks had no discernible impact on the fit correctness of frameworks created using an STL file model[23]. This result is in accordance with Soltanzadeh et al [24]. The fit of the prosthesis may be positively or negatively impacted by the finishing and polishing of the intaglio surfaces. This process was based on research by Brudvik and Reimers, who found that after finishing and polishing Co-Cr frameworks, an average of 127 m of metal was lost from the surface[25]. The dimensional changes in group 2 could be due to increased storage time of the wax pattern. This is in accordance with a recently published study where they said that the framework accuracy decreases with increase in storage time of wax up. Highest accuracy was shown in patterns which were immediately invested[17, 26].

The dimensions of the clasp arm in group 1 increased slightly but was not significant statistically, whereas the dimension in group 2 decreased significantly. Hence, null hypothesis 1 was accepted and null hypothesis 2 was rejected. Only vertical height of the clasp was considered, width of the clasp was not considered. Conventional and digital frameworks were fabricated from different labs, hence, there can be inter-operator bias. So, we recommend future studies to evaluate dimensional changes using different manufacturers and correlate it clinically.

Conclusion:

From the present study, the following points can be concluded.

1. The dimensions of the clasp arm of DMLS fabricated framework increased slightly compared to initial design, but is clinically acceptable.
2. The dimensions of the clasp arm of conventionally fabricated framework significantly decreased when compared to initial design.
3. The dimensional changes did not affect the fit of the framework

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