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EFFECT OF DIFFERENT FABRICATION TECHNIQUE ON THE ACCURACY OF MAXILLARY KENNEDY CLASS II CASES

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ABSTRACT

Aim of this study: The aim of this study was to evaluate the accuracy of two different fabrication techniques (direct milling and indirect printing of castable resin then casted by lost wax technique) of Co-Cr frameworks using Geomagic software.

Material and methods: This in vitro study was applied on a ready-made (Kennedy class II modification 1) maxillary stone model used for educational purposes. After alteration, the cast was scanned, and a digital removable partial denture framework was created. Twelve frameworks were constructed and divided into two groups were defined: Group A: Six frameworks were printed with castable resin, then casted by the lost wax technique into Co-Cr frameworks; Group B: Six frameworks were milled directly from co-cr blank. Using the Geomagic Control X programme, comparative 3D analysis was conducted to evaluate the precision of the manufactured frameworks. Student's t-test was used for comparing data. P value ≤ .05 was considered statistically significant.

Results: The accuracy of the occlusal rests was much higher in group B (milled) than in group A (printed). The same results were found regarding the 3D comparison of the overall accuracy, in which group B was significantly more accurate than group A.

Conclusion: Within the limitation of this study, it could be concluded that: Cobalt Chromium partial denture frameworks fabricated by direct milling technique are more accurate than frameworks fabricated by indirect 3D printing of resin framework then casted by lost wax technique.

KEYWORDS: Removable partial denture, milling, printing, accuracy

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INTRODUCTION

Removable partial denture (RPD) is easy and non-expensive prosthesis used to restore the lost teeth in partially edentulous patient, and thus improving their longtivity. [1] RPD framework is most commonly made of cobalt chromium (Co-Cr) alloys because of their suitable cost, mechanical properties, and their excellent corrosion resistance and biocompatibility. It's traditionally fabricated using casting technique which used in this field for more than a century. [1]

The main chief complain for the conventional technique is ill fitting denture. Lately there are different ways for fabricating RPD's frameworks without casting have shown up. Technology is constantly evolving, enabling the production of RPD frameworks using numerous CAD/CAM systems, resulting in precise prostheses, while also enabling the usage of multiple systems with an accurate fit and correct morphology as designed by the software. [2, 3]

Sometimes the traditional lost wax method is mixed with the digital approach. You can produce RPD frameworks using additive or subtractive manufacturing. Depending on the manufacturing process, a definitive prosthesis can be made directly from the digital design or indirectly from a resin pattern which is subsequently casted. [4]

A The use of digital fabrication techniques has a number of benefits over traditional ones. In particular, digital surveying performed in the virtual space, On the basis of the scan data, it is possible to figure out the undercut amount and manage the insertion and removal paths in a way that is simpler and more precise than traditional surveying. Eliminating some operations, such as cast duplication and investment cast production, also significantly cuts down on the overall time required for prosthesis fabrication. Additionally, many prosthesis patterns may be created at once in a short amount of time. These advantages highlight the benefits of the digital over the conventional method. [5, 6]

Accuracy and adaptation ensure the proper functions of every component of the removable partial denture as planned and designed by the prosthodontist in terms of retention, support and stability. Color code maps have been applied to quantify accuracy by 3D superimposing different scans using different digital software as Geomagic control X. [7, 8]

So, this study was conducted to evaluate the accuracy of RPD frameworks constructed indirectly from printed castable resin patterns and directly from milled CoCr blank.

MATERIAL AND METHODS

This in vitro study was applied on a ready-made (Kennedy class II modification 1) maxillary stone model used for educational purposes. The abutment was the canine on free end saddle side, while on the bounded side the abutments were first premolar and the second molar.

A total of 12 frameworks (six in each group) were constructed by two different techniques. The two groups were defined as following:

Group A: Six Co-Cr frameworks were constructed by printing the resin pattern then converted to metal using lost wax technique.

Group B: Six Co-Cr frameworks were constructed by directly milling Co-Cr blanks

Model preparation

Model preparation was done as the following: A- res seat preparation B- Beading

Midline was drawn on the cast to bisect it into two equal halves. Anteriorly incisive papilla was used as a guide to determine the midline and a point measured midway between the two hamular notches that represents the midline posteriorly.

For rest seat preparation canine extension arm seat was done on the palatal surface of the canine. The rest was prepared to be inverted V-shaped. While occlusal rest seat preparations were made in the near zone of the edentulous area in the first premolar and second molar. The rest seat was prepared spoon shaped following the anatomy of the triangular fossa.

Beading was done by Scraping a shallow groove of 0.5 mm width and depth along the anterior and posterior borders of the major connector. It was done with a small spoon excavator.

The final prepared model was duplicated using silicone material to form a silicone index for pouring of six identical refractory models (for group A)

Scanning the model

After model preparation the cast was scanned using desktop scanner (Identica Hybrid, Medit, Seoul,). Data was saved as a Standard Tessellation Language (STL) file then the file imported to start the designing step.

Designing of the framework

Designing of the model was done using Exocad software (EXO; exocad GmbH, Darmstadt, Germany) by the following steps:

A digital survey tool was used to automatically determine the path of insertion. All undercuts were blocked out except that needed for retention. Relief was done under denture base in the free end saddle area. Meshwork was chosen at free end saddle area while solid with beads at bounded area. Denture base was extended 2mm both buccally and palatally following the contour of the ridge and 1mm away from the abutment mesiodistally. A notch was made on the buccal side at its middle as a reference point.

Middle palatal strap was chosen with 8 mm width. Anterior and posterior notches made at the middle of the major connector which were used as reference points. A clasp assembly retainer was properly designed, where RPI clasp assembly was chosen at free end saddle side while an aker clasp was chosen on bounded side.

External finish line was added at the junction between the denture base and the major connector. It was inverted so it faces occlusally. The design was finalized using the sculpt tool by smoothing of the rough parts to avoid any sharp undesirable area. The STL file of the RPD design was produced by the software which then will be used for construction of the RPD framework.

Construction of partial denture frameworks

For group A: the design of STL file was printed from castable resin (3D printing UV sensitive resin, China) and then the printed resin pattern was converted into Co-Cr by the lost wax technique The STL file of the same design imported to another software (Chitubox Pro; CBD Ltd., Guangdong, China) to create 75% support structure creating a new STL file. Supporting arm were oriented to the outer surface. The new STL file was imported to the 3D printing machine (ANYCUBIC Photon Mono X, China), then a post- printing treatment was pursued by 10 min of isopropyl alcohol rinsing, drying, and then curing in ultraviolet unit by ultraviolet light for 20 min in the post-curing chamber.). After the process had been completed the framework was separated using handpiece to cut the supporting arms. The printed resin pattern was then sprued to get ready for the investment step. The assembly was invested with special phosphate bonded investment material. The ring was preheated in the oven (between 630°C and 850°C) for the resin elimination. The melting procedure for the Co-Cr alloy was done at 500 °C [8] for the completed pressing process then it is converted into Co-Cr framework by the conventional method. The final framework was then finished and polished. These steps were applied to all the six frameworks of this group. (Fig 1, 2)

For group B: Twenty mm Co-Cr blank (Cobalt Chrome Scheftner Disc MoguCera, Germany) was milled after installing the STL file on the 5- axis milling machine (Imes Icore 350i 5 axis milling machine, USA) to produce the final form of the RPD framework. The framework design was oriented in the blank directing the contact with supporting arms at the outer surface and 10 supporting arms were added. The wet milling of the blank lasted for nine hours using four different diameters burs with special cutting flutes. (Fig. 3) The framework was removed from the milled blank. The supporting arms were separated and the frameworks finished with rubber finishing wheels. These steps were applied to all the six frameworks of this group.

Evaluation of the accuracy of the framework

Partial denture frameworks of each group were sprayed with scannable spray (Renfert-Scanspray, Renfert GmbH, Hilzingen, Germany) and scanned by 3 Shape desktop scanner then STL file of each framework was obtained. After that the STL file of the scanned framework was superimposed over the STL file of the initial digitally designed partial denture framework then accuracy was measured using computer matching system (Geomagic control X, 3D systems, USA). Measurement of the fit between the two data was done at three axes X, Y and Z. Difference was recorded and tabulated for statistical analysis. (Fig. 4)

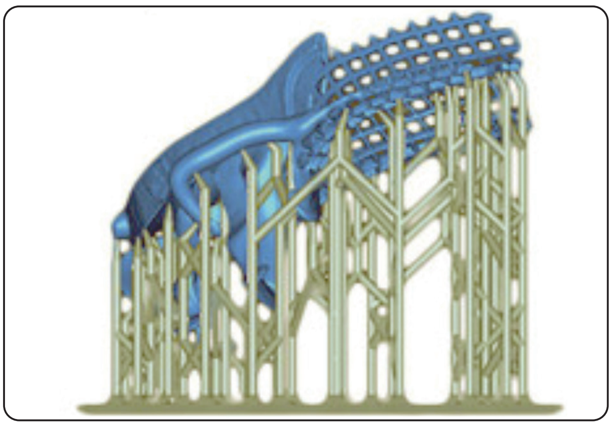

Fig. (1) Framework with the supporting arms

Fig. (2) The printed resin pattern

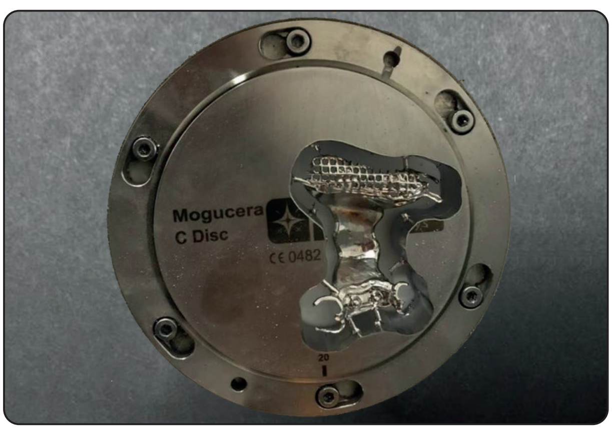

Fig. (3) Milled framework from polished surface

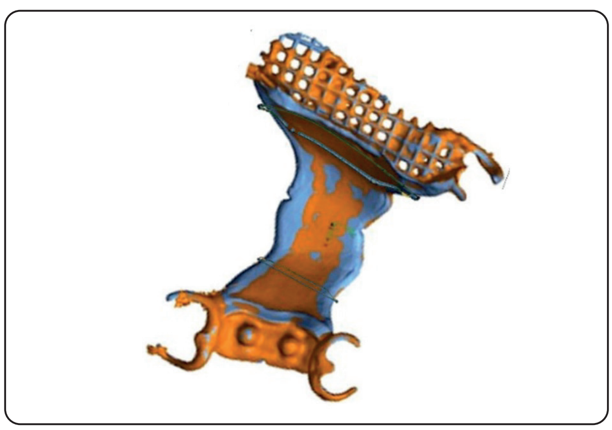

Fig. (4) 3D comparison

RESULTS

Data were presented as mean and standard deviation (SD) values for both group A (a framework was printed into resin then casted into CoCr by lost wax technique) and group B (framework was directly milled from CoCr disc).

I - Comparison between conventional and milled frameworks regarding accuracy of fit of the occlusal rests of partial denture frameworks.

The data showed that group B (Direct milling) has the least deviation and highest accuracy compared to group A (Indirect printing) which has the highest deviation and the least accuracy at occlusal rest and the results were statistically significant.

II) 2D and 3D Comparison between Conventional Frameworks and Milled Frameworks regarding the accuracy.

The data showed that group B (Direct milling) has the least deviation and highest accuracy compared to group A (Indirect printing) which has the highest deviation and the least accuracy on all the axes and also in 3D compare. Student's t test showed that difference was statistically significant.

TABLE (1): Mean, Standard deviation, and P value of student's t-test for the comparison of the deviation of the frameworks between the two groups.

	Group A (n=6)	Group B (n=6)	Test value	p-value
Mean±SD	2.3357± 0.1022	1.4827± 0.0154	20.2161	<0.0001

TABLE (2): Mean, Standard deviation, and P value of student's t-test for the comparison of the deviation of the frameworks between the two groups.

3D compare	Group A (n=6)	Group B (n=6)	Test value	p-value
x-axis	2.3355± 0.0958	1.4896 ± 0.0224	21.0606	<0.0001
y-axis	2.2471±0.0969	1.4563± 0.0198	7.9958	<0.0001
z-axis	2.1865± 0.0986	1.4791±0.0209	7.0185	<0.0001
3D	0.5000± 2.4413	0.0341.5523±	6.3530	<0.0001

DISCUSSION

In this study, frameworks were digitally made by different fabrication techniques. Depending on the manufacturing process, they were made either directly by direct milling from CO-Cr blank or indirectly by creation of resin pattern which then converted into metal by conventional method. The accuracy of the two manufacturing processes differed noticeably.

The inaccuracies caused by wax distortion are avoided by casting the digitally designed and built resin patterns instead of the traditional waxing up of the refractory casts. Replacing manual waxing of the framework by digitally planned and manufactured wax or resin patterns showed improvement in the accuracy of the casted framework This method was used in several studies to avoid the dimensional changes of refractory casts and to streamline the production process. [9, 10]

Milling eliminates waxing, investing and casting of the prosthesis which is assumed to improve the overall precision. They require minimal adjusting, finishing, and polishing after completion of the milling process. Also, it produces complex designs and smooth external surface was a motive to use this milling machine as it reduces fabrication flaws in dental prosthesis by relying more on the tighter quality control processing of the material manufacturer rather than commercial laboratory. (11)

Accuracy of the partial denture framework was evaluated using geomagic control X software by using best-fit alignment. The visual representation of the colored 3D surface deviation maps. The average deviation was measured in microns as a basis for overall trueness evaluation which is more accurate than traditional methods of measurements. Geomagic Control X provides 3D inspection that is simple to use and understand in any industrial workflow. Accurate measurement and fast analysis were done. (12)

The use of unpolymerized polymers for printing the castable patterns may be responsible for these outcomes. Polymerization shrinkage during the 3D printing process is theoretically possible since the patterns are not fully polymerized. To finish the procedure, one more light-polymerization step is necessary. (13)

This result coincides with another study obtained by Snosi et al. who studied the accuracy of the occlusal rest of partial denture framework fabricated by direct milling and indirectly by printing. The study showed that frameworks fabricated by direct milling showed more accuracy than those fabricated indirectly. (14)

Arnold et al. discovered similar results when they investigated why the clasp assemblies of fast prototyping-made frameworks displayed more imperfections than those of directly or indirectly machined frameworks. (15 An investigation by Örtorp et al. showed that frameworks fabricated by the conventional lost wax technique had higher values of distortion than those casted from milled patterns using the conventional lost wax technique. (16)

CONCLUSION

Within the limitation of this study, it could be concluded that Co-Cr partial denture frameworks fabricated by direct milling technique are more accurate than frameworks fabricated by indirect 3D printing of resin framework then casted by lost wax technique.

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