Al-Rafidain Dental Journal, Vol. 23, Issue No.1, 2023 (180-186)

Al-Rafidain Dental Journal

rden.mosuljournals.com

The Comparison of Retention Between Overdenture Copings Manufactured by DMLS, CAD and Conventional Casting Techniques

Yaman Aahed Alhamamy [1*], Ahmed Asim Al-Ali [2]

Department of Prosthetic Dentistry College of Dentistry, University of Mosul

Article information

Received: July 17, 2021
Accepted: September 5, 2021
Available online: March 25, 2023

Keywords
Over denture
DMLS
CAD- CAM

***Correspondence:**

E-mail:
yamanalhamamy@gmail.com

Abstract

Aims: To compare the retention of copings produced by Direct Metal Laser Sintering (DMLS), Hard metal CAM (Computer Assisted Milling) and conventional casting techniques. **Materials and Methods**: An implant abutment was used as an ideal model which was scanned by 3D scanner and 8 copings of each group were fabricated from a single STL file. Each specimen was seated, luted, and mounted on a vertical column universal testing machine for a pull-off test. Dislodgement readings were recorded and statistically analyzed with ANOVA test and Duncan's multiple range test. **Results**: Significant difference was found between the studied groups in retention. The laser-sintered group showed the highest force required for dislodgement followed by conventional casting group then by the hard metal milling group. **Conclusions**: within the limitations of this study, Laser sintered group has the superior retention above the other two groups

الخلاصة

الاهداف: تهدف الدراسة الى مقارنة ثبات الأغطية التي ينتجها تكليس المعادن بالليزر المباشر (DMLS)، وتفريز المعادن الصلبة (النحت بمساعدة الكمبيوتر)، وتقنيات الصب التقليدية. **المواد وطرائق العمل**: تم استخدام دعامة زرعة سنية كنموذج مثالي تم مسحه ضوئيًا بواسطة الماسح الضوئي ثلاثي الأبعاد وتم تصنيع 8 أغطية لكل مجموعة من ملف STL واحد. تم الصاق كل عينة وتثبيتها على آلة اختبار، وتم تسجيل قراءات الخلع وتحليلها إحصائيًا باستخدام اختبار ANOVA واختبار Duncan متعدد المدى. **النتائج**: تم العثور على اختلاف كبير بين المجموعات في الثبات. أظهرت المجموعة الملبدة بالليزر أعلى قوة مطلوبة للإزالة، يليها الصب التقليدي، ثم مجموعة طحن المعادن الصلبة. **الاستنتاجات**: ضمن حدود هذه الدراسة، تتمتع المجموعة الملبدة بالليزر بالثبات المتفوق على المجموعتين الأخريين.

DOI: 10.33899/rdenj.2021.130871.1120

INTRODUCTION

The use of cobalt-chromium (Co-Cr) alloys in the fabrication of crowns and fixed dental prostheses have increased largely because of their superior mechanical properties and their decreased cost compared to those using high-noble alloys (1).

However, some drawbacks with casting in the conventional manufacturing process are known. Although casting shrinkage has largely been overcome, still the accuracy may be compromised; also, the increased hardness of the alloy makes finishing process difficult (1-3).

Recently developed production techniques using computer-aided design and computer-aided manufacturing (CAD-CAM) provides better standardization and promises better results (4,5). Besides, the working environment for dental laboratory staff may be improved when production using base metal alloys with potential unhealthy effects developing into under-control procedures with little exposure to the vapor and airborne particles (6,7).

The production costs for CAD-CAM were high at first. The machines are costly and subtractive technique systems are associated with increased material waste.[4] Nevertheless, this difficulty is overcome by the fact that CAD-CAM techniques are better in time efficiency (4,5).

A few CAM techniques are currently available commercially, including milling (M), Direct laser-sintering (DLS), and milled wax/lost wax (LW) (4).

Milling has an important advantage in that restorations are produced from optimal quality blocks of restoration materials. However, drawbacks exist in the shape and fit of the restorations as these depend on factors such as the number of milling axes and the size of the milling burs. Another drawback is the higher waste materials. As for Laser sintering, which is an additive technique, there is not much waste material, and left-over powder may be reused. Laser sintering, thus, may provide advantages such as better material economy, possible better fit, and unlimited complexity of the shape of the restorations (4,5).

It is suggested that fabrication procedures influence a restoration's surface roughness, fit, and retention (5,8,9)

Poor quality of the produced prosthesis or crown may result in a poor fit and higher risk of complications such as dental caries and loss of retention, the two common reasons for the clinical failure of crowns or copings (7).

Not enough data are currently available to provide clinicians with definite guidelines regarding which of the techniques to choose to achieve the best possible retention. Therefore, the purpose of this study was to compare the retention of milling, a subtractive CAD-CAM technique, with those of laser sintering, an additive CAD-CAM technique. A form of a manual technique, milled wax/lost wax, was included for comparison.

MATERIALS AND METHODS

An Implant Abutment (Dual Abutment, Dentium, South Korea) was chosen to be used as the standard abutments for the copings in this experiment.

The abutment was fixed on top of a block of self-curing acrylic resin where the center of the abutment coincides with the center of the block, which is a geometrical principle.

A plastic container was used to take an impression of the aforementioned abutment, the material used was addition silicone duplication material (Shera Duosil H, SHERA Werkstoff Technologie, Germany). The material was mixed according to the manufacturer's instructions to obtain a homogenous mixture, then the addition silicone was poured in the container into which the abutment and the block were placed, a vibrator was used to ensure getting rid of all the trapped air bubbles.

The impression was left for 30 minutes (according to product's use instructions) until full setting had occurred, the block (with attached abutment) was removed, and epoxy resin material (Sikadur, Skia, Switzerland) were mixed according to manufacturer's instructions and poured into the impression to produce an epoxy resin replica of the abutment. The epoxy resin material was left 24 hours to set, which is the ideal setting time stated by the manufacturer.

Another impression of the abutment was taken with the same procedure mentioned above, also using the addition silicone, but this time the impression was poured with type IV dental stone (Elite Stone, Zhermack, Italy). The produced stone model was scanned by 3D scanner (S600 ARTI, Zirconzahn , Germany) using the Zirconzahn scanning software , and the 3D model was transferred to CAD software to design a standardized coping that is going to be used in manufacturing all of the copings used in this study [10].

This technique facilitates comparison as it allows for standardized coping shapes as the wax copings are milled from the same original master file used for the CAD-CAM and Laser sintering techniques.

The design properties were set to have a minimum metal thickness of 0.5 mm, with a cement gap of 0.050 µm, the cement gap was set to decline to zero on the margins of the copings, this is also a standardization method to obtain uniform thickness and design of all the studied specimens.

The fabrication techniques for the samples to be studied in this research are the following:

- Milled Wax technique: The conventional casting of milled wax patterns
- Pre-sintered Metal Milling: direct subtractive milling of hard metal
- Direct Metal Laser Sintering: direct additive printing of metal powder into the designed shape

An STL file of the finalized 3D design was sent to the laboratory to produce the 3 groups of samples, each of the aforementioned techniques were used to produce 8 copings.

All of the copings were subjected to sandblasting by fine Aluminum Oxide particles on the external surface only, the inner surfaces of the copings were left untouched to avoid any possible discrepancy [4,10]

Twenty-four impressions of the master (Epoxy Resin) cast were taken with a 3D printed resin box that was used as a customized container to take the impressions and in which the impressions were poured using epoxy resin to obtain the 24 duplications of the master cast. Addition silicone was used for the duplications.

The retention of the samples was measured by using a pull-out test, the samples were seated and luted on the abutments, and the abutment-coping pair was mounted in a universal testing machine, a pulling force is subjected trying to dislodge the coping from the abutment, the peak force at which the separations took place was recorded and put into a table.

Eight copings from each group were seated and looted to the epoxy resin abutments, the luting process was done using eugenol free luting cement (T Cem NE, Nexobio , UK), a micro brush was used to spread the luting material evenly on the internal surface of each coping [9,10].

Each coping was seated with equal pressure (10 N) for an equal amount of time (90 seconds), which was sufficient for the luting cement to reach its initial setting time as stated by the product leaflet. The pressure was controlled and standardized by utilizing an orthodontic bracket seating instrument (orthodontic force gauge).

After completion of setting of the luting cement, the 24 samples (8 from each group) were mounted on the universal testing machine [9,11] , one by one, and the pulling off test was done where the abutment was held in place and the coping was clamped and pulled off , the peak force was recorded as the copings separated and the results were recorded , making 24 results, 8 from each group of samples.

The results were statistically analyzed using SPSS on Microsoft Windows 10.

RESULTS

The readings were analyzed statistically to find which set of readings has significance over the others (means of the values are showed in Table 2), this was accomplished by first testing the obtained results for normality, the results showed normal distribution Shapiro-Wilk test. This test is used to check the normality of the results obtained from a given test, and to show their relative closeness to the normal distribution curve (See Table 1).

Table 1: Test of Normality

Retention	Shapiro-Wilk		
	Statistic	df	Sig.
Casting	.875	8	.167
Milling	.912	8	.371
DLS	.931	8	.524

a. Lilliefors Significance Correction
*. This is a lower bound of the true significance.

The results also showed significantly higher retention values for copings produced by the Direct Laser Sintering technique in comparison with the direct milling and milled wax casting (See Table 3).
Duncan's multiple range test was used to test the significance in the results, significant value was set to 0.05, as shown in (Figure 1).
DLS (Direct Laser Sintering) group shows the significantly highest retention. Significant difference also presents between milling and casting group.

Table 2: Means and SD of values of the force needed to dislodge copings. Each value represents the mean of tensile retention test.

Groups	Mean in Newton	N	Std. Deviation
Casting Group	22.7375 B	8	3.00900
Milling Group	19.6375 C	8	2.50368
DLS Group	34.4125 A	8	2.87573
Total	25.5958	24	7.02910

Table 3: One – Way analysis of variance (ANOVA) of the retention (pull-off) test

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	971.243	2	485.622	61.752	.000
Within Groups	165.146	21	7.864		
Total	1136.390	23			

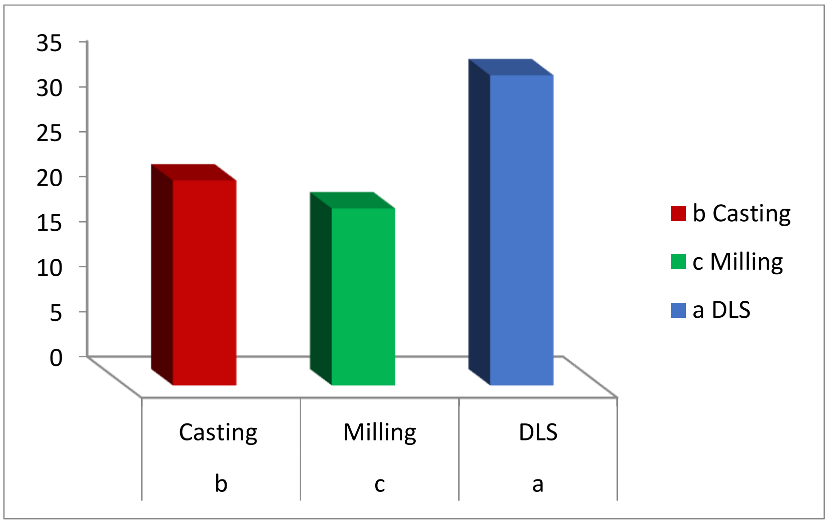

Figure 1: Duncan's Multiple range test for retention values

DISCUSSION:

Many studies comparing the retention values of implant-supported restorations have focused on the effect of cement type, changes in abutment surface topography in addition to the height and taper features of the abutment. However, studies of new techniques such as laser-sintered crowns are scarce.

The results this research found are that there is a significantly higher retention with copings produced by DLS compared to the copings prepared by the other two techniques.

This research disagrees with Lövgren *et al.* who found no significant difference in retention of the studied specimens, however, they suggested an increase in retention in the direct laser sintering category [10].

The increase in retention in DLS specimens could be explained by the increase of surface roughness of the copings, when compared with the other techniques. This was proven by Lövgren *et al.* after analyzing the surfaces microscopically. Juvantee & Millstien already proved the effect of increased surface roughness of crowns on retention [11].

However, this research agrees with Kilicarslan & Ozkan who found specimens produced by DLS to have a significantly higher retention and recommended their use in situations where higher retention is needed [8]. This result was also explained by the increase in the surface roughness of copings prepared by direct laser sintering.

In the laser sintered copings, there was an evident adhesion failure to abutment rather than the opposite in the other two groups, this also suggests an increase in cement retention to coping due to increased surface roughness.

“When the internal surface of a restoration is very smooth, retentive failure occurs not through the cement but rather at the cement restoration interface.” [12]

A clinical research carried out by Chaar et al. suggested similar mechanical properties of copings produced by DLS to those produced by the conventional methods, as they showed similar survival and retention rates. This cannot be conclusive in supporting the current research directly, but it further establishes the reliability of this new technique in terms of retention [13].

CONCLUSION

Retention of copings produced by DMLS was fount to be higher than those produced by conventional casting and hard metal milling.

REFERENCES:

1. Svanborg P, Längström L, Lundh RM, Bjerkstig G, Örtorp A. A 5-Year Retrospective Study of Cobalt-Chromium–Based Fixed Dental Prostheses. Int J Prosthodont. 2013;26(4):343–9.

2. Herø H. Effects of casting temperature on some properties of co-cr-mo dental casting alloys. Acta Odontol Scand. 1984;42(6):371–7.
3. Thompson GA, Luo Q, Hefti A. Analysis of four dental alloys following torch/centrifugal and induction/ vacuum-pressure casting procedures. J Prosthet Dent. 2013;110(6):471–80.
4. Örtorp A, Jönsson D, Mouhsen A, Vult Von Steyern P. The fit of cobalt-chromium three-unit fixed dental prostheses fabricated with four different techniques: A comparative in vitro study. Dent Mater. 2011;27(4):356–63.
5. Koutsoukis T, Zinelis S, Eliades G, Al-Wazzan K, Rifaiy M Al, Al Jabbari YS. Selective Laser Melting Technique of Co-Cr Dental Alloys: A Review of Structure and Properties and Comparative Analysis with Other Available Techniques. J Prosthodont. 2015;24(4):303–12.
6. Seldén AI, Persson B, Bomberger-Dankvardt SI, Winstróm LE, Bodin LS. Exposure to cobalt chromium dust and lung disorders in dental technicians. Thorax. 1995;50(7):769–72.
7. Geurtsen W. Biocompatibility of dental casting alloys. Crit Rev Oral Biol Med. 2002;13(1):71–84.
8. Kilicarslan MA, Ozkan P. Evaluation of Retention of Cemented Laser-Sintered Crowns on Unmodified Straight Narrow Implant Abutments. Int J Oral Maxillofac Implants. 2013;28(2):381–7.
9. Heintze SD. Crown pull-off test (crown retention test) to evaluate the bonding effectiveness of luting agents. Dent Mater. 2010;26(3):193–206.
10. Lövgren N, Roxner R, Klemendz S, Larsson C. Effect of production method on surface roughness, marginal and internal fit, and retention of cobalt-chromium single crowns. J Prosthet Dent. 2017;118(1):95–101.
11. Juntavee N, Millstein PL. Effect of surface roughness and cement space on crown retention. J Prosthet Dent. 1992;68(3):482–6.
12. Narula S, Punia V, Khandelwal M, Sharma V, & Pamecha S. Retention in conventional fixed partial dentures: A review. J of Clin and Diag Res. 2011;5(5), 1128–1133
13. Chaar MS, Passia N, Kern M. Long-term clinical outcome of posterior metal-ceramic crowns fabricated with direct metal laser-sintering technology. J Prosthodont Res. 2020;64(3):354–7.