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Comparison of Retention and Seating of Implant-Supported Hard and Soft Metal Copings

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A B S T R A C T

Objectives: Implant-supported restorations are generally used for the replacement of the lost teeth. Stability against masticatory forces and proper retention are critical for optimal durability of restorations. The aim of this experimental study was to compare the retention of cobalt-chromium (Co-Cr) copings made by different techniques.

Materials and Methods: Twenty-four solid abutment analogs were mounted and scanned with a desktop scanner. They were divided into two groups (n=12) and received metal copings fabricated by either soft or hard Co-Cr alloy. Soft Ceramill Sintron Co-Cr patterns were milled and sintered. Hard Co-Cr blocks were milled in a milling machine. The copings were sandblasted, polished, adjusted, and placed on the respective abutments. The frequency of adjustments was recorded for each abutment. The copings were cemented with zinc phosphate cement and underwent tensile test by a universal testing machine. The Mann-Whitney test and t-test were used to compare the two groups ($\alpha=0.05$).

Results: There was no significant difference in retention of copings between the experimental groups. The mean retentive force was 559.58±115.66 N and 557.13 ±130.48 N for the soft and hard metal groups, respectively (P=0.96). Considering the non-normal distribution of adjustment frequency data, the Mann-Whitney test showed that the frequency of adjustments was significantly higher in the hard metal group than the soft metal group (9.5 versus 0.1667; P<0.001).

Conclusion: Although hard metal copings required more adjustments, retention of soft and hard Co-Cr copings was not significantly different.

Keywords: Computer-Aided Design; Dental Implants; Dental Prosthesis Retention; Hard Metal

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INTRODUCTION

Fabrication of dental implant restorations is among the most challenging aspects of implant dentistry. Biological, functional, and esthetic aspects are among the important parameters that need to be considered in fabrication of implant abutments and restorations. Therefore, biocompatible materials with optimal mechanical properties should be used to fabricate implant abutments and restorations [1]. Moreover, restorations should be carefully and passively fit on their mating implants to avoid complications such as fixture loosening, bone loss, and abutment fracture during function [2]. Retention is a critical factor for clinical longevity of restorations [3]. The preparation design and optimal adaptation of components are among the important factors that affect retention [4]. Factors such as increasing the surface area by macro- and micro-scale surface treatments, increasing the occluso-gingival preparation height, and optimal taper can increase retention [5-9]. The technique of fabrication of the coping is another important factor that affects retention. In the past decade, the application of novel fabrication techniques based on the computer-aided design/ computer-aided manufacturing (CAD/CAM) technology has greatly increased for the fabrication of dental restorations [10-12]. Several recent studies have compared the effects of different manufacturing techniques such as CAD/CAM milling, laser-sintering, and traditional casting on the marginal fit, internal fit, and retention of cobalt-chromium (Co-Cr) copings [3,13-17].

Nowadays, different materials are available for the fabrication of implant restorations. Since the 1980s, base-metal alloys are more commonly used considering the high cost of noble metals. Co-Cr alloys are amongst the most popular base-metal alloys in dentistry, and have several promising clinical applications. Co-Cr alloys have high strength, high modulus of elasticity, and favorable resistance to wear, corrosion, and tarnish. They are heat-resistant and non-magnetic [18] alloys with excellent biocompatibility [19]. The aforementioned characteristics have made Co-Cr alloys a suitable option for restorative purposes [20].

There are two types of Co-Cr alloys in the market that are used for the fabrication of copings by milling machines, namely the hard and soft Co-Cr alloys. Dry milling of soft Co-Cr blanks, which is a new advancement in production of Co-Cr restorations, decreases the fabrication time and expenses by fine dispersion of the alloy powder in a binder material that can be burned-out [21,22]. High-temperature sintering furnace is needed for sintering of the milled reconstruction. This is done under an argon protective gas atmosphere at approximately 1300˚C [22,23]. The hard alloy is milled as the final coping, and does not require sintering. However, milling of such hard materials could damage the milling machine. The aim of this experimental study was to compare the retention and seating of Co-Cr copings milled by a CAD/CAM system from soft and hard Co-Cr alloys. The null hypothesis was that no significant difference would be found in the retention or adjustment frequency between the hard and soft milled Co-Cr copings.

MATERIALS AND METHODS

Twenty-four abutment analogs (Solid abutment; Ufit Dental implant system, Gimhae, South Korea) with 5.5 mm height and 6° taper were mounted in acrylic blocks (cold-cure acrylic for repair; Acropars, Tehran, Iran) using a surveyor (Ney Dental International, Bloomfield, CT, USA) perpendicular to the horizontal axis. The abutments were sprayed (Scanspray; Renfertp GmbH, Hilzingen, Germany) and scanned by a laser scanner (3Shape D810; 3Shape, Copenhagen, Denmark).

Data were transmitted to a software program (3Shape CAD Design software; 3Shape, Copenhagen, Denmark). One trained and skilled technician implemented all the laboratory procedures to eliminate inter-operator errors. The cement space was considered to be 30 µm starting at 0.5 mm from the margin. The anatomical patterns were designed and milled using two different materials of soft and hard Cr-Co alloys. Soft Cr-Co patterns (Ceramill Sintron; Amann Girrbach AG, Koblach Austria) were milled by Amann Girrbach CAM system (Ceramill motion 2; Amann Girrbach AG, Koblach, Austria) using drill no. 760605 with 2.5 mm diameter, and sintered at 1300°C in a vacuum oven (Argovent; Amann Girrbach AG, Koblach, Austria) for 30 min.

Hard Cr-Co blocks were milled in a milling machine (CORiTEC 450i; Imes-icore GmbH, Eiterfeld, Germany) using a T40 drill with 2.5 mm diameter. The internal surfaces of the copings were air-abraded with 50 µm aluminum oxide particles (Basic master; Renfert GmbH, Hilzingen, Germany) under 0.3 MPa pressure.

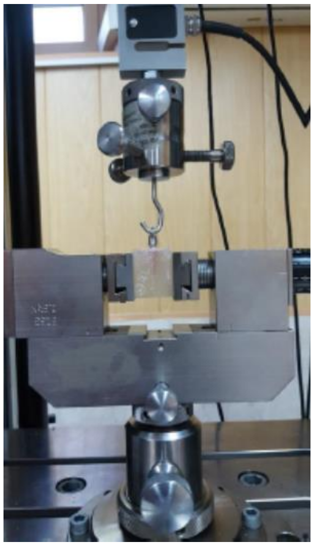

Fig 1. Tensile test to measure the retention of copings

The internal surface of each coping was evaluated by a binocular loupe (HEINE HR-C 2.5x; HEINE, Herrsching, Germany), and visible macro-nodules were removed with a tungsten carbide bur (H71EF; Brasseler GmbH.KG, Komet, Siegel, Germany). Invisible nodules, irregularities, or pressure points were disclosed using a disclosing agent (Occlude indicator spray; Pascal International Inc., Seattle, WA, USA), and adjusted by a round bur (Teezkavan; Tehran, Iran) for complete passive seating on the abutments up to the point that complete seating was confirmed by two prosthodontists blinded to the materials/methods used for the fabrication of specimens.

The frequency of adjustments was recorded for both groups. The frameworks were designed in anatomical shape with minimum thickness of 0.5 mm. A loop with an internal diameter of 5 mm was designed on the occlusal surface of each pattern to attach the copings to the universal testing machine (Pro Line Z050; Zwick/Roell, Berlin, Germany). The copings were cemented on the abutment analogs using zinc phosphate cement (Hoffmann GmbH, Berlin, Germany) under finger pressure for 10 min [13].

The cemented specimens were placed in an incubator (Model 2; Precision Scientific Co., Columbus, OH, USA) at 37°C for 24 h, and thermocycled (TC-300; Vafaei industrial, Tehran, Iran) for 5000 cycles at 5±1°C-55±1°C with a dwell time of 30 s, and a transfer time of 10 s. Each specimen was attached to the universal testing machine by the loop on the occlusal surface, and retention was measured by the tensile test at a crosshead speed of 0.5 mm/min.

The dislodging force was applied in vertical direction to the center of the occlusal surface of the samples (Fig. 1). The t-test was used to compare retention, and the Mann-Whitney test was applied to compare the frequency of adjustments. Level of significance was set at $\alpha=0.05$.

RESULTS

Statistical analysis showed a significant difference in the adjustment frequency between the groups ($P<0.001$). The hard metal copings required significantly more adjustments compared with soft metal copings. None of the soft metal copings required any adjustment, except one that needed adjustment twice. The mean number of adjustments required by the soft metal copings was 0.1667. On the other hand, all hard metal copings required adjustments, with a mean number of 9.5 times. There were no significant differences in the mean retentive forces of the soft metal (559.58±115.66 N) and hard metal (557.13±130.48 N) groups (P=0.96, Table 1).

DISCUSSION

Introduction of CAD/CAM technology enabled the automatization of several steps in the fabrication of prostheses to minimize errors. The CAD/CAM technology also provides the possibility of using a wide variety of materials such as metals and ceramics.

The present study compared the retention and seating of implant copings fabricated from two types of Co-Cr alloys as indicators of technical accuracy. In order to attribute the results to the materials used, the present study tried to standardize all other confounders affecting the retention.

The null hypothesis was partially rejected. The mean retention of soft metal copings was 559.58±115.66 N, which was not significantly

Table 1. Mean retentive force and frequency of adjustments for the soft and hard metal copings

Groups	Retentive force			Frequency of adjustments			
	Mean	Standard deviation	P-value	Median	Minimum	Maximum	P-value
Hard Metal	557.13	130.48	0.96	9.5	6	13	<0.001
Soft Metal	559.58	115.66		0	0	2	

different from that of hard metal copings (557.13±130.48 N). However, the mean adjustment frequency of hard metal copings (9.5) was significantly higher than that of soft metal copings (0.16), which reflects the difficulty and time-consuming nature of clinical adjustment procedure, especially for hard metal alloys.

The milling of metal blocks has disadvantages of expensive milling tools, long process, and wear of the milling machine. The soft Co-Cr alloy (Ceramill Sintron; Amann Girrbach AG) may overcome these disadvantages. While the hard Co-Cr alloy sustained only computer-assisted milling, soft pre-sintered alloy was milled in a CAD/CAM system, followed by sintering that results in 8-10% of dimensional shrinkage. However, this dimensional change appears not to affect the accuracy and retention of soft metal copings, and even facilitates the adjustment procedure. Mai et al, [24] reported that the Ceramill Sintron metals showed significant horizontal and angular discrepancies, which could result in greater internal gaps. These internal gaps may be the reason for easy seating of Ceramill Sintron metals. However, the results showed that these internal gaps were not large enough to decrease retention. The cement space was considered to be 30 µm in the present study; increasing the thickness of die-spacer could decrease the adjustment frequency. Furthermore, according to Olivera and Saito [25], and Torabi and Azarian [26], increasing the spacer thickness up to 40 µm would not cause a significant change in the retention of copings. However, further investigations are required to evaluate the effect of increased cement space on the retention and stability of restorations.

Zinc phosphate cement has been the most popular luting agent for fixed partial dentures for almost a century due to its excellent clinical performance, which can be attributed to its high fatigue strength, despite its disadvantages such as high solubility and lack of adhesion [27]. The reason for not using resin cement in this study was because of its self-adhesion properties, which could interfere with the results of comparing the two materials and the fabrication methods. Moreover, clinicians usually prefer to cement implant restorations with cements that allow easier retrieval.

Several factors such as the abutment height and width, surface topography, cement type, fabrication method, cementation technique, in vitro environment, and methodology can affect the retention of restorations [28,29]. The present study tried to standardize the testing conditions as much as possible to achieve accurate results in comparing the effects of materials and the fabrication method on retention and seating. In the present study, one path of removal was studied; whereas, in the clinical setting, restorations may be retrieved in more than one path. In vitro models could not exactly simulate all the forces and the clinical conditions present in the oral environment.

As soft milling reduces the cost, time, and instrument wear, the results of the present study could confirm the application of soft alloys considering the optimal retention and ease of seating. However, further studies are required to evaluate other mechanical, clinical, and biological characteristics of this type of base metal alloy prior to suggesting its application in routine clinical practice.

CONCLUSION

The present study compared the retention and adjustment frequency of CAD/CAM Co-Cr copings, milled from soft and hard Co-Cr alloys. Within the limitations of this study, there was no significant difference in retention of the two groups. However, hard metal copings required significantly more adjustments compared with soft metal copings.

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CONFLICT OF INTEREST STATEMENT

None declared.

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