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RESEARCH ARTICLE

The retention difference between cobalt chromium and zirconia coping in different angulations on telescopic overdenture

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ABSTRACT

Telescopic overdenture is one type of removable denture that uses dual coping system that consists of primary and secondary coping. Retention of telescopic overdenture is obtained from the friction between primary and secondary coping, which is mainly influenced by the type of material and coping angulation. The purpose of this study is to determine the retention differences between CoCr and zirconia coping with 0Â°, 1Â°, and 2Â° angulations. Twenty four pairs of telescopic overdenture coping samples with 6 mm length were divided into 6 groups (n = 4), CoCr 0°, CoCr 1°, CoCr 2°, zirconia 0°, zirconia 1°, and zirconia 2°. Measurement of retention between coping is done by pull-off test using universal testing machine (UTM) and data were analyzed by two way ANOVA. The results showed that the largest average retention was found in zirconia coping with 0° angulation group (22.48 N), while the smallest average retention was found in CoCr coping with 2° angulation group (10.28 N). Two way ANOVA revealed that there were significant differences among groups ($p<0.05$). LSD tests showed that there were significant differences among all of groups. This study concludes that zirconia coping has higher retention than CoCr coping and coping with 0° angulation has the highest retention.

Keywords: angulation; cobalt-chronium; telescopic overdenture; zirkonia

INTRODUCTION

Telescopic overdenture is one type of removable denture that usess a dual coping system, primary coping that is cemented to the abutment tooth and secondary coping which is united with denture frame. Telescopic overdenture is also known as denture overlay, prosthesis overlay, or superimposed prosthesis.[1,2]

Telescopic overdenture can be used as an alternative treatment for dentures. Use of remaining teeth as an abutment for denture support provides a better function because it can prevent the resorption of alveolar bone, increase the strength and efficiency of mastication, make movement of the mandible more controlled, provide proprioceptive and better stability and retent the denture.[3,4]

In order to obtain retention between copings, primary and secondary coping must be made with the utmost precision using the right materials to obtain optimal retention.[5] Materials that are widely used for primary and secondary coping are alloys, specifically cobalt-chromium (CoCr). However, over time, the biocompatibility of CoCr as primary coping has become debatable. Many studies suggest that CoCr has poor biocompatibility and can affect tissue health. The research conducted by Kim et al. (2016) stated that CoCr cytotoxic for cells and increases free radicals that can induce tissue inflammation. This has lead to many new materials being developed as substitutes for CoCr.[6,7]

Zirconia or zirconium dioxide (ZrO2), known as ceramic steel, is a metal oxide formed by the chemical reaction between Zr and $O_{2,}$ which is currently highly developed and is widely used in the field of dentistry, especially in prosthodontics as a substitute for CoCr. Zirconia has more

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advantages than other materials. This material has good aesthetics and mechanical strength, can be made very precisely with a digital system, and has excellent biocompatibility. A research conducted for more than 10 years revealed that zirconia has very high stability and biocompatibility and thus is very suitable for various types of dentures, such as implants, crowns, inlays, onlays, veneers, and coping.[7,8]

Retention of telescopic overdenture was obtained from friction between primary coping and secondary coping. The use of zirconia as coping is expected to provide better friction than CoCr because coping with zirconia can be very well polished so that it can generate very low surface roughness. The surface roughness (Ra) of zirconia is 0.02 µm, while the surface roughness (Ra) of CoCr is of 0.35 µm.[9] With lower surface roughness, the distance between primary and secondary coping becomes smaller and primary coping has wider area contact to secondary coping so that it can increase friction between coping.[7,9] In addition, the low surface roughness makes zirconia free from plaque buildup and biofilm accumulation, and thus leading to the gingival tissue around coping which is healthy, stable, and free from inflammation. The use of zirconia as coping does not result in a low bleeding on probing (BOP), a low probing depth, and gingival recession around the coping. In addition, the low accumulation of plaque and biofilm in zirconia coping has increased retention between coping.[7,10] Based on these factors, the use of zirconia as a telescopic coping overdenture is expected to have better retention than CoCr.

The purpose of this study is to determine the retention differences between CoCr and zirconia coping with 0°, 1°, and 2° angulations. Computer-aided-design and computer aided-manufacturing (CAD/CAM) dentistry is a field of dentistry and prosthodontics using CAD/CAM to improve the design and creation of dental restorations especially dental prostheses, including crowns, veneers, inlays, and onlays, fixed dental prostheses bridges, dental implant supported restorations, dentures (removable or fixed), and orthodontic appliances. CAD/CAM technology allows the delivery of a well-fitting, aesthetic, and a durable prothesis.

MATERIALS AND METHODS

This research is a laboratory experimental study conducted at the Materials Laboratory of the Faculty of Mechanical and Industrial Engineering, Universitas Gadjah Mada, Yogyakarta. The study was conducted with the management of ethical research information obtained from the Research Ethics Commission of Faculty of Dentistry Universitas Gadjah Mada No.001602/KKEP/FKG-UGM/ EC / 2018. It used the following ingredients: cobalt chromium (ceramill sintron, ammangirrbach), zirconia blanks (ceramill ZI, ammangirrbach), artificial saliva, and cement resin (relyx unicem 2, 3M ESPE). The following tools were used for the experiment: ceramill map 300, ammangirrbach (scanner), ceramill mind software, ammangirrbach, ceramil motion of 2 systems, ammangirrbach (milling machine), ceramil argotherm, ammangirrbach, ceramil therm, ammangirrbach, universal testing device (zwick 1445, zwick, ulm, Germany), and pull off holder system. CAD/CAM has improved the quality and standardized the production process. It has also increased productivity and improved the level of accuracy.

This study divided the research samples into 6 treatment groups, each of which consisted of 4 primary and secondary coping pairs. The first treatment group was primary coping and secondary CoCr with 0° angulation (Group 1), followed by primary coping and secondary CoCr with1° angulation (Group 2) and 2° angulation (Group 3). The fourth, fifth and sixth groups were composed of primary coping and secondary zirconia with angulations of 0°.1°, and 2°, respectively.

The retention between coping with pull-off tests was measured using universal testing machine (UTM). The primary coping was cemented to the abutment using cement resin (Relyx Unicem 2, 3M ESPE) then fixed on the UTM. Secondary coping was installed with a hook, then moistened with artificial saliva, inserted into primary coping, and pull-off test at a speed of 50 mm/minute.

The process obtained ratio scale data, which were analyzed by using two-way ANOVA with a significance level of 95%. ANOVA test results showed significant differences. Then, the procedure continued with the LSD Post Hoc test to find out which groups had a significant difference in mean.

RESULTS

Table 1. Mean and standard deviation of different retention between CoCr coping and zirconia coping telescopic overdenture with 0°, 1°, and 2° angulation (N)

	0° angulation	1° angulation	2° angulation
CoCr	18.25 ± 0.83 (Group 1)	13.98 ± 0.40 (Group 2)	10.28 ± 0.51 (Group 3)
Zirconia	22.48 ± 1.12 (Group 4)	19.28 ± 0.50 (Group 5)	15.35 ± 0.53 (Group 6)

Table 2. Shapiro-Wilk normality test result and Levene's homogeneity test result on difference retention between CoCr and zirconia coping telescopic overdenture

Types of material	p value Shapiro-Wilk	p value Levene's test
CoCr	0.168	0.735
Zirconia	0.388	

Table 3. Shapiro-Wilk normality test result and Levene's homogeneity test result on difference retention between coping telescopic overdenture with 0°, 1°, and 2° angulation

Angulation	p value Shapiro-Wilk	p value Levene's test
0°	0.477	
1°	0.210	0.236
2°	0.350	

Table 1 shows the highest retention average in group 4 (zirconia primary and secondary coping with 0° angulation) 22.48 N. The mean retention was the lowest in group 3 (CoCr primary and secondary coping with 2° angulation) which is 10.28 N.

The mean retention value between CoCr coping and zirconia coping telescopic overdenture with 0°, 1°, and 2° angulation in each group were analyzed using the two-way ANOVA test. Before the two-way ANOVA test were carried out, the normality test using Shapiro-Wilk were done to determine the distribution of existing data and Levene test to find out homogeneity data.

Tables 2 and 3 presents the value of the Shapiro-Wilk test in each treatment group $p>0.05$. It shows that the data were normally distributed. The p value on Levene's test >0.05 indicates that the variants of all treatment groups do not have significant differences or are said to be homogeneous data. The data of the next study were analyzed by a two-way ANOVA test to determine the difference in retention between CoCr coping and zirconia telescopic overdenture coping with 0°, 1°, and 2° angulations (Table 4).

The results of the two-way ANOVA test showed that there were significant differences between CoCr and zirconia coping telescopic overdenture retention ($p<0.05$). There was a significant difference between telescopic overdenture coping retention with 0°, 1° and 2° angulation ($p<0.05$), but there were no significant differences in the interaction of material types and angulations on telescopic overdenture coping ($p>0.05$).

The data were then tested using the least significant difference (LSD) test to determine the significance of differences between treatment groups, with the results presented in Table 5.

The conclusion of the results of the LSD post hoc test in Table 5 shows that there are significant retention differences ($p<0.05$) between all groups. CAD/CAM has improved the quality and standardized the production process. It has increased productivity and increases the level of accuracy.

DISCUSSION

In this study, the highest retention results were obtained in zirconia coping groups with an angulation of 0° which was equal to 22.48 N. Angulation of 0° coping with parallel walls will result in complete contact between primary

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Table 4. Two-way ANOVA test result difference retention between CoCr and zirconia coping Telescopic overdenture with 0°, 1°, dan 2° angulation

Variables	Number of squares df	df	Average squares	F	p value
Types of materials	142.107	1	142.107	293.003	0.000*
Angulation	228.018	2	114.009	235.070	0.000*
types of material and angulation	1.286	2	0.643	1.326	0.290
Total	6993.580	24			

Table 5. LSD test result on difference retention between cocr and zirconia coping telescopic overdenture with 0°, 1°, and 2° angulation

LSD	1	2	3	4	5	6
1	-	4.27*	7.97*	-4.22*	-1.02*	2.90*
2	-	-	3.70*	-8.50*	-5.30*	-1.37*
3	-	-	-	-12.20*	-9*	-5.07*
4	-	-	-	-	3.20*	7.12*
5	-	-	-	-	-	3.92*
6	-	-	-	-	-	-

and secondary coping walls that makes greater retention. Coping with an angle of 0° has a piston-cylinder effect that can produce greater retention between copings than coping with angulation of more than 0°. The cylinder effect piston is the effect of contact that occurs in all areas of primary polishing surface coping with all areas of secondary surface coping because primary and secondary coping has parallel walls.[11] Zirconia coping can be very well polished so that the contact area between coping becomes wider and can produce higher retention. This is in accordance with the previous research, which stated that the contact area between primary and secondary coping polishing surface will result in greater retention.[9]

The smallest retention rate was found in the CoCr coping group with angulation of 2° which is equal to 10.28 N. The angulation coping of 2° will result in smaller retention because not the entire surface of the wall between coping is in contact. This is consistent with the research of Guven et al. (2017) which stated that coping with angulation of more than 0° does not have a piston-cylinder effect, but rather has a wedging effect which results in smaller retention between copings. Wedging effect is generated from the contact between primary polishing surface coping and secondary internal surface coping that occurs only when secondary coping is at the final position against primary coping and not all surfaces of coping walls are in contact.[11] CoCr coping has a higher surface roughness than zirconia coping. The higher surface roughness allows CoCr coping to have a contact area between primary polishing surface coping and secondary internal surface coping, which will produce smaller retention than zirconia coping.

The two-way ANOVA test results showed significant retention differences between zirconia coping telescopic overdenture groups and CoCr coping telescopic overdenture groups with angles of 0°, 1°, and 2° ($p<0.05$). These results are due to differences in coping angulations that affect retention between telescopic overdenture coping

because a more upright coping wall produces greater retention between coping, and vice versa. This is in accordance with Brand research, et al., (2016), which stated that the amount of retention is strongly influenced by coping angulation. Coping with smaller angulations will have a greater retention and maximum coping angulation at 2° is required to obtain optimal retention.[7] In addition to angulation, the type of material also affects retention between coping. Zirconia coping has lower surface roughness than CoCr coping so zirconia coping has a wider contact area or dry friction. This is consistent with the study of Bevington and Robinson. (2003), which stated the amount of retention or friction between primary coping and coping of secondary telescopic overdenture is the total results of dry friction (FD), lubricated friction (FL), and boundary friction (FB). All of these frictions can occur when secondary internal surface coping moves into the loose direction of primary polishing surface coping. Dry friction (FD) is resulted from the contact area between primary polishing surface coping and secondary internal surface coping, which rubs against each other. Lubricated friction (FL) is obtained from saliva between primary polishing surface coping and secondary internal surface coping that is not in contact. Boundary friction (FB) occurs between polishing surface primary coping and secondary internal surface coping, which is almost in contact and limited by saliva. Out of the three frictions, dry friction (FD) has the most influence because wider area contact between copings will result in greater retention.[12]

The results of the two-way ANOVA test showed no significant differences in the interaction of material types and the large angulation of telescopic overdenture coping ($p>0.05$). Interaction will arise when there is no uniformity between the states of variation with one another. In this study, the use of CAD/CAM methods in making telescopic overdenture coping in all treatment groups caused uniformity/equality between treatment groups. As a consequence, there is no statistically significant different interaction between the types of materials and the large angulation of telescopic overdenture coping. CAD/CAM dentistry is a field of dentistry and prosthodontics using CAD/CAM to improve the design and creation of dental restorations especially dental prostheses, including crowns, veneers, inlays, and onlays, fixed dental prostheses bridges, dental implant supported restorations, dentures (removable or fixed), and orthodontic appliances. CAD/CAM technology allows the delivery of a well-fitting, aesthetic, and a durable prosthesis.

This result is in accordance with Pietruski's research, et al. (2013), which stated that the interaction between the type of material and angulation of telescopic overdenture coping does not increase retention between primary coping and secondary telescopic overdenture.[13] Retention between copings can be improved by using CAD/CAM methods for coping because the CAD/CAM method can improve dimensional accuracy and increase the level of precision of each telescopic overdenture coping. The use of CAD/CAM methods in coping all treatment groups caused interactions between the types of materials, while angulation of telescopic overdenture coping did not lead to a statistically significant different results.

CONCLUSION

Zirconia coping of telescopic overdenture has greater retention than CoCr coping of telescopic overdenture. Coping of telescopic overdenture with 0° angulation has greater retention than the coping of telescopic overdenture with angulation of 1° and 2°.

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