Efficacy of Co-Cr-Mo UCLA Abutment for Internal Tapered Implant

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Efficacy of Co-Cr-Mo UCLA Abutment for Internal Tapered Implant

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마지막으로 항상 저를 지켜봐 주시는 부모님과 장인어른, 장모님께 감사드리며, 제가 하는 일에 전념할 수 있도록 세심하게 배려해준 아내와 저에게 더 큰 힘이 되는 은해, 민강, 형원에게도 고마움과 사랑을 전하며 이 기쁨을 나누고자 합니다.

2013년 12월

조영성 드림

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Efficacy of Co-Cr-Mo UCLA Abutment for Internal Tapered Implant

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(Directed by Prof. Keun-Woo Lee, D.D.S.,M.S.D.,Ph.D.)

Introduction & Purpose: There are various abutment materials for the dental implant restoration. Although gold alloy has been the choice of material, titanium and zirconia has been used widely for abutment materials of cement type restorations due to substantial gold price increase. For screw type restorations, plastic abutment that can be cast with Ni-Cr or Co-Cr alloy has been introduced. However, casting procedure might cause roughness and irregularities that can influence the stability of restoration. Recently, many implant companies have brought out premachined UCLA abutment with Co-Cr-Mo alloy on the market. Co-Cr-Mo alloy has been used in orthopedic implant for a long time due to excellent biocompatibility. Nevertheless casting and firing procedure for fabricating the porcelain fused metal crown can change the properties of Co-Cr-Mo alloy. To date there have been limited studies on the Co-Cr-Mo UCLA abutment (CCM abutment). The purpose of present study is to evaluate the efficacy of CCM abutment by investigating the surface change and surface roughness of abutment after casting and firing procedure for porcelain fused crown fabrication and by examining the removal torque value and wear pattern on the interface between abutment and fixture after functional loading by chewing simulator.

Materials & Methods: I. Examination of abutment surface after casting & firing procedure: Six gold abutments and six CCM abutments were used. Three of six gold UCLA abutments were untreated (Group A) and the remaining three were cast with type III gold (Group B). Three of six CCM abutments were untreated (Group C) and the remaining three were cast with Ni-Cr alloy (Group D). Cast abutments have undergone porcelain firing cycle and bead blasting (CCM Only). The SEM photograph was taken to examine the surface change and surface roughness value of R_a was measured. II. Analysis of removal torque value and wear pattern after chewing simulation. Sixteen internal tapered implant fixtures were divided into 2 groups (CCM and gold group). Screw-retained prostheses were made using CCM abutment and gold UCLA abutment and they were connected to implant fixture to 30 Ncm torque. Thermocyclic functional loading of 5 kg was applied in wet condition by chewing simulator. A target of 1.0 x 10^6 cycles was defined. After cyclic loading, removal torque values were recorded. Interface between implant fixture and abutment was evaluated by scanning electronic microscopy (SEM).

Results: After casting procedure, irregularities or deformation was not found on all specimens. Mean surface roughness value R_a for groups A, B, C, D were 0.119 ㎛, 0.320 ㎛, 0.094 ㎛, and 0.212 ㎛ respectively. After thermocyclic functional loading, mean removal torque value of gold group and CCM group were 14.88 ± 3.66 Ncm and 14.66 ± 3.58 Ncm respectively. In SEM analysis, remarkable wear patterns were observed at the interface of abutment in gold group, but there were no remarkable wear patterns at the interface of fixture in gold group and at the interface of fixture and abutment in CCM group.

Conclusion: 1. Surface roughness value of CCM group after firing and bead blasting procedure was smaller than that of gold group after firing procedure. 2. After chewing simulation, there was no statistically significant difference in removal torque value between both groups. 3. On SEM photographs, wear patterns were observed only at the interface of abutment in gold group. Based on limited present study, CCM abutment can be alternative to gold abutment for internal tapered implant. However, consideration on biological aspect and long-term clinical study is needed in the future

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Key Words: Co-Cr-Mo abutment, internal tapered implant, chewing simulation, oxide layer, reverse torque, wear pattern

Efficacy of Co-Cr-Mo UCLA Abutment for Internal Tapered Implant

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Introduction

Dental implant has been highly successful rehabilitation method to treat edentulous area. As dental implant has become more frequently rendered treatments, larger part of expenses are being spent for materials and components used to make implant prosthesis.

While making implant prosthesis, various abutments can be used in case where sufficient interarch distance is available. Although gold alloy has been the choice of material, titanium and zirconia are used widely as the abutment materials for the cement type restoration due to dramatic increase in gold price.

However, when insufficient interarch distance with retrievability of prosthesis is taken into account, UCLA abutment can be utilized as screw retained form. When considering bone resorption pattern and the position of opposing dentition, UCLA abutment has been used directly connected to the implant fixture. This method has an advantage in forming the emergence profile[1)]. When the UCLA abutment was introduced in 1980's, it was plastic pattern used to develop the wax pattern for the final restoration. Because of the irregularities and roughness of contacting surface after casting procedure, premachined UCLA abutment is recommended. Despite that gold UCLA abutment (gold abutment) is the choice of material, recently Co-Cr-Mo UCLA abutment (CCM abutment) is now emerging as an alternative due to better economic advantage.

Co-Cr-Mo alloys have been commonly used for orthopedic implants because of their high strength, superior corrosion resistance, non-magnetic behavior, and biocompatibility. Material properties for various compositions and processing routes are covered by a number of ASTM specifications. Co-28Cr-6Mo (66 % Cobalt, 28 % Chromium, 6 % Molybdenum) is a common composition and can be cast (ASTM F75), wrought (ASTM F1537), or forged (ASTM F799). Due to the shape complexity of the orthopedic implants, casting is often the selected processing route. Also, cast Co-Cr-Mo alloys called vitallium have been widely used for removable partial denture frameworks because of their excellent strength, corrosion resistance, and castability. F777 is the material forged after casting F75 under 800 °C to improve the yield strength, tensile strength and fatigue endurance limit. F799 has nearly double the amount talents of F75. CCM abutment available on the market is made with F779 in turning process.

Internal connection implant system has biomechanical advantages such as a better force distribution, higher stability and higher resistance to lateral loads than external connection system. Consequently the demand for CCM abutment for internal tapered implant is increasing. Nevertheless CCM abutment has the property to form thicker oxidized layer because that it is cast with base metal alloy like Ni-Cr or Co-Cr alloy at higher temperature. Casting and firing procedure for fabricating the porcelain fused metal crown can change the properties of Co-Cr-Mo alloy. To minimize the release of corrosion products from metal surfaces into the patient's tissues, it is important to evaluate the effects of the porcelain firing process on the corrosion behavior of base metal alloys . The difference of surface hardness between the Co-Cr-Mo alloy for the abutment and titanium alloy for the implant fixture may cause the wear on interface of them. The wear might put the implant/abutment interface at risk for undesirable mechanical changes in the wall of the implant and could eventually lead to abutment loosening or fracture. The galvanic corrosion between Co-Cr-Mo alloy and titanium might cause the damage on the each component in oral environment. To date there have been few studies on the CCM abutment for implant dentistry.

The purpose of this study is to evaluate the efficacy of CCM abutment by examining the surface change and the surface roughness of abutment after casting and firing procedure for porcelain fused crown fabrication and measure the removal torque value and examine the wear pattern on the interface of abutment and fixture after functional loading by chewing simulator.

Materials & Methods

1. Examination of surface change and surface roughness after casting & porcelain firing procedure

Six internal gold abutments (Goldcast abutment, Osstem Co., Seoul, Korea) and six internal CCM abutments (NP cast abutment, Osstem Co., Seoul, Korea) were used. Group A specimens were three untreated gold abutment and group B specimens were three gold abutments cast with type III gold. Group C specimens were untreated three CCM abutments. Group D specimens were three CCM abutments cast with Ni-Cr alloy. In case of group C, D, firing cycle was performed to simulate process in making the PFM crown as table 1. In case of group D, the oxidized layer was removed using 50㎛ glass bead under pressure about 4 ~ 6 bars and then was polished using cotton wheel by the manufacture's recommendation. SEM photograph was taken on the connection portion of the one abutment in each group to examine the surface change. Surface roughness of specimens in each group was measured using a surface analyzing instrument (XE-Bio, Park Systems, Suwon, Korea). Table 2 shows the alloy used in present study.

Table 1. Porcelain firing cycle

Firing cycle	Initial temperature (℃)	Final temperature(℃)	Heating rate(℃/min)	Vacuum
Base opaque	500	940~960	50~60	Y
Shade opaque	500	920~940	50~60	Y
Dentin, enamel	650	900~920	50~60	Y
Glaze	650	880~900	50~60	N

Table 2. Dental alloy used in present study

Metal	Composition	Brand name & Manufacture
Type III Gold	Au 46%, Pd 4%, Ag 38%	Myeso, Yesbiogold Co., Seoul, Korea
Ni-Cr alloy	Ni 61%, Cr 26%, Mo 11%	4 All, Ivoclar Vivadent Inc., Amherst, USA

2. Analysis of removal torque value and wear pattern after chewing simulation

a. Implant fixture

16 internal tapered implants (TS II, Osstem Co., Seoul, Korea) with diameter of 4.1 mm, length of 11.5 mm were used and divided into 2 groups (Gold and CCM group).

b. Fabrication of superstructure

In gold group, using the induction centrifugal casting machine (Millennium, Manfredi S.r.l. Pinerolo, Italy), gold abutment was cast with gold alloy for the crown after wax pattern with 7 mm diameter and 8 mm height was made (Figure 1, 2). The melting temperature was 980 ℃. A total of eight specimens were fabricated for this group.

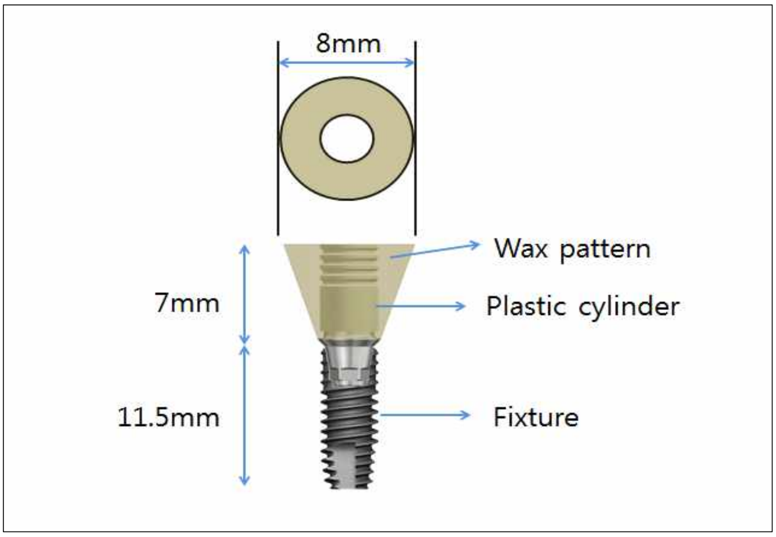

Figure 1. Schematic diagram of wax pattern of crown

Figure 2. Fabrication of superstructure

In CCM group, using the same method, CCM abutment was cast with Ni-Cr alloy. The melting temperature was 1460 ℃. To simulate the process of making PFM crown, the prosthesis was burned out as Table 1. After casting and final firing procedure, the oxidized layer was removed using 50 ㎛ glass bead under pressure about 4~6 bars and then was polished using cotton wheel by the manufacture's recommendation. Figure 3 shows the procedure to prepare the specimen from casting to bead blasting. A total of eight specimens were fabricated for this group.

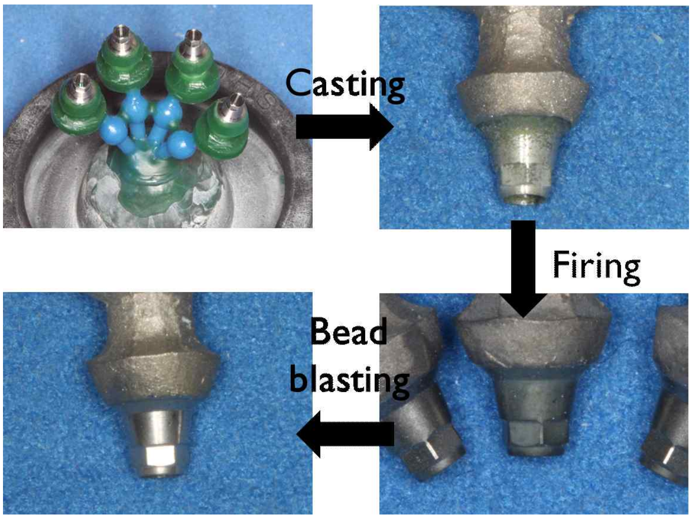

Figure 3. Connecting portion after casting, burn-out and bead blasting procedure of CCM abutment

c. Fixing the fixture inside mold

The standard mold was used, consistent with one used in chewing simulator CS4 (SD Mechatronic, Feldkirchen, Westerham, Germany) (Figure 3). Fixture was embedded in prepared mold with clear acrylic resin (Ortho-jet self curing acrylic resin, Lang dental manufacturing Co Inc., Wheeling, USA) filling the mold (Figure 2). It was also ensured that the most upper margin of the mold was consistent with the margin 1 mm under the interface between fixture and abutment, while the mold was completely filled with resin. The mold was filled with resin incrementally to prevent polymerization shrinkage.

d. Connecting the fixture and prosthesis

Superstructure is connected to fixture which is embedded in using abutment screw. At the time of connection, for simulation of clinical procedure, screw tightening was done with hand torque wrench at 30 Ncm torque. Additional tightening was also done 3 times with 10 minutes intervals.

e. Equipment of mold.

After equipping the mold into chewing simulator (Figure 4), stylus was positioned 3 mm away from the center of crown and water was filled up to 2 mm above platform of the fixture (Figure 5). Chewing simulation started with setting value inserted into the computer program (Table 3) and it was ensured that the pin inside the mold was positioned perpendicularly to the stylus axis. A target of 1.0 x 10^6 cycles was defined. Loading was set to 5 Kg. At 1.0 x 10^6 cycle intervals, screw loosening was evaluated in cyclic loading procedure. The number of specimen that screw loosening had taken place was recorded and statistic processes had been included as well.

Figure 4. Chewing simulator CS4 (SD Mechatronic, Feldkirchen, Westerham, Germany)

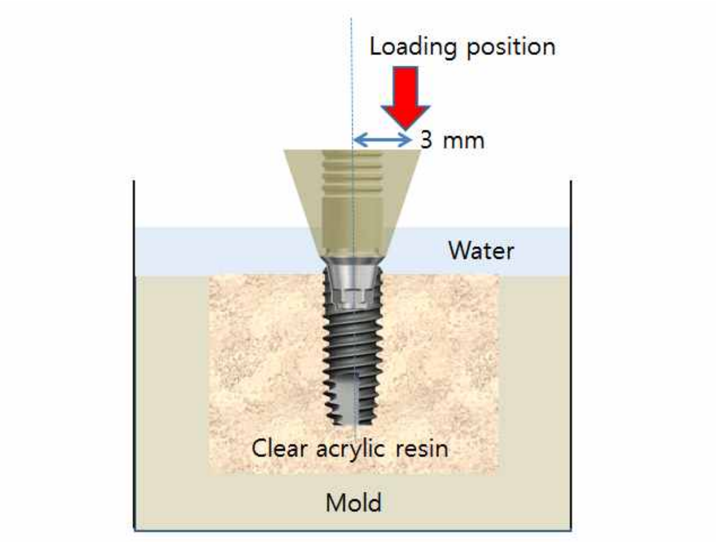

Figure 5. Schematic diagram of connecting implant and prosthesis & loading position which is 3 mm away from the center of crown

Table 3. Test parameters of chewing simulation

Test parameter	Setting	Test parameter	Setting
Chewing cycles	1,000,000	Applied weight per sample	5 kg
Cycle frequency	1 Hz	Hot dwell time	60 sec
Vertical movement	3 mm	Hot bath temperature	55 ℃
Descending speed	30 mm/s	Cold dwell time	60 sec
Rising speed	30 mm/s	Cold bath temperature	5 ℃
Forward speed	20 mm/s	Intermediate pause	0 sec
Backward speed	20 mm/s		

f. Measuring the removal torque value

Removal torque value was measured after cyclic loading. in present study, driving torque tester (Biomaterials Korea Inc., Seoul, Korea) was used for measuring the removal torque value (Figure 6). The advantage of this tester is that it has constant rotational velocity and vertical load, providing reproducibility. Driving torque tester was rotated counterclockwise and had 3 rpm. Removal torque value was recorded every 0.1 seconds. Software program, QuickDataAcq (SDK Developer, London, Uk), was used. The first peak of graph was selected as representative value.

Figure 6. Driving torque tester
(Biomaterials Korea Inc, Seoul, Korea)

g. Statistical analysis

Independent t-test was conducted using means and standard deviation of removal torque value in gold abutment and CCM abutment. SPSS for windows 18.0 (SPSS Inc., Chicago, Illinois, USA) was used for statistical analysis.

h. Wear pattern at interface of abutment and fixture

After measuring removal torque values, abutment screw was removed; then fixture and abutment were separated. SEM photographs were taken above connecting portion of all implant fixture and abutments in gold and CCM groups at magnification (x50) with SEM (Hitachi, S-800, Japan).

Results

I. Examination of surface change and surface roughness after casting & firing procedure

Figure 7 shows specimens in each group. After casting procedure, there were no irregularities on abutment on all the specimens. The edge of abutment in group B retained the angular shape of the original hex while the edge of hex in group D was not as angular as the original shape (arrow on Figure 8, 9). Oxide layer was found in group B while no significant oxide layer was found in group D after bead blasting procedure (Figure 10, 11). Table 4 shows the surface roughness value R_a for each group. The means of surface roughness value R_a for groups A, B, C, D were 0.119 ㎛, 0.320 ㎛, 0.094 ㎛, and 0.212 ㎛ respectively. The mann-whitney test showed that there was statistical difference only between group A and group B (P=0.050).

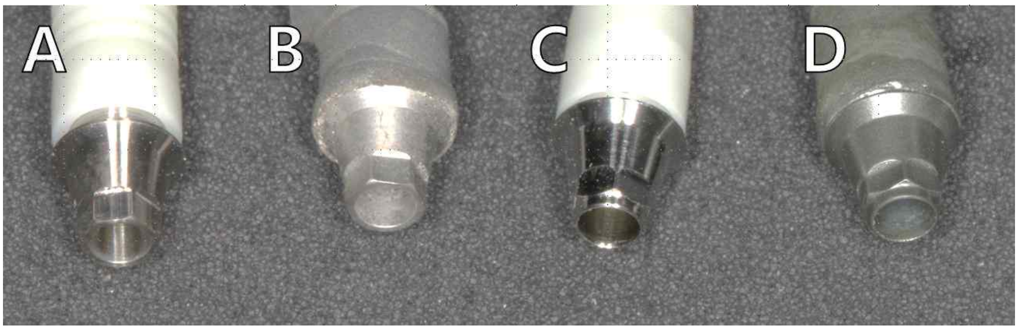

Figure 7. A. untreated gold abutment, B. Gold abutment after firing, C. untreated CCM abutment D. CCM abutment after firing & bead blasting

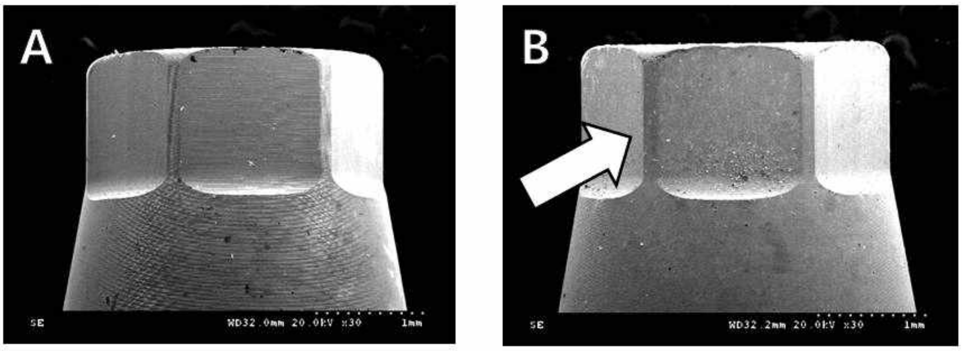

Figure 8. SEM photograph of untreated gold abutment (A), gold abutment after firing cycle (B). (original magnification : x30)

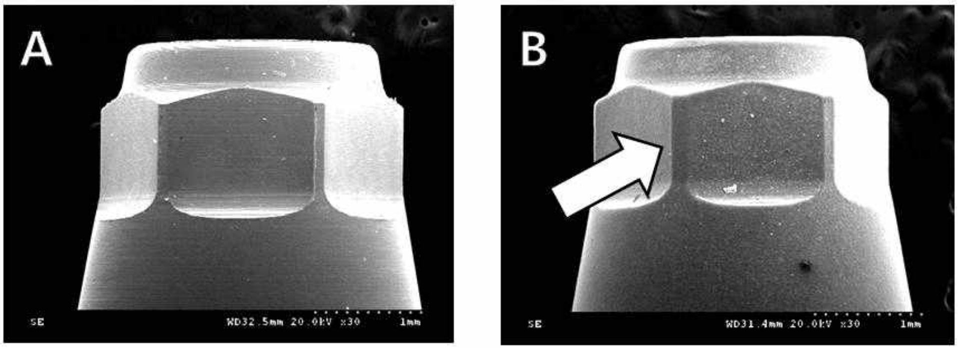

Figure 9. SEM photograph of untreated CCM abutment (A), CCM abutment after firing cycle and bead blasting (B). (original magnification: x30)

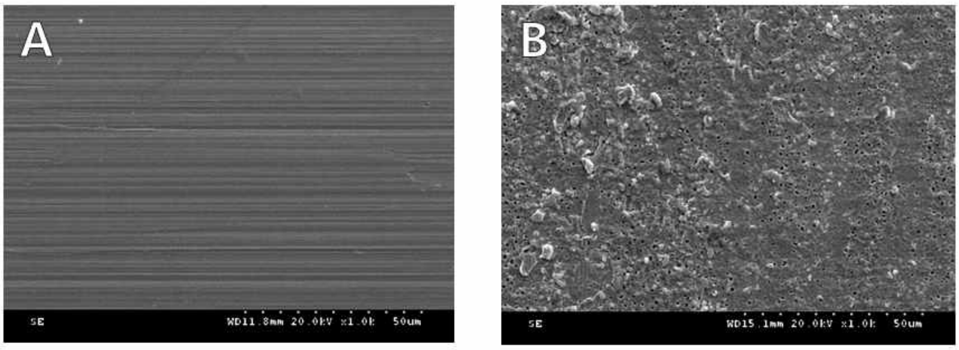

Figure 10. SEM photograph of untreated gold abutment (A), gold abutment after firing cycle (B). (original magnification: x500)

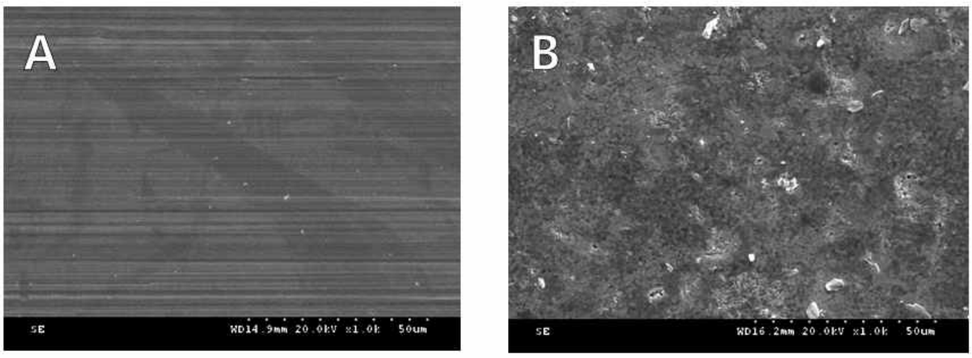

Figure 11. SEM photograph of untreated CCM abutment (A), CCM abutment after firing cycle and bead blasting (B). (original magnification: x500)

Table 4. Surface roughness value (R_a) of group A (untreated gold abutment), group B (gold abutment after firing cycle), group C (untreated CCM abutment), group D (CCM abutment after bead blasting)

	Group A	Group B	Group C	group D
surface roughness (R_a, ㎛)	0.086	0.268	0.102	0.190
	0.034	0.362	0.126	0.306
	0.236	0.330	0.053	0.139
Mean	0.119	0.320	0.094	0.212
S.D.	0.105	0.047	0.037	0.085

2. Analysis of removal torque value and evaluation of wear pattern after chewing simulation

a. Analysis of removal torque value

In chewing simulation, fracture or deformation of prosthesis or implant fixture was not observed. The typical graph showing changes of removal torque value with elapse of time (every 0.1 sec) measured by driving torque tester is shown in (Figure 12). The first peak in each graph was selected as the representative value. The tendency for most graphs is that removal torque value steeply increased up to the first peak then gradually decreased.

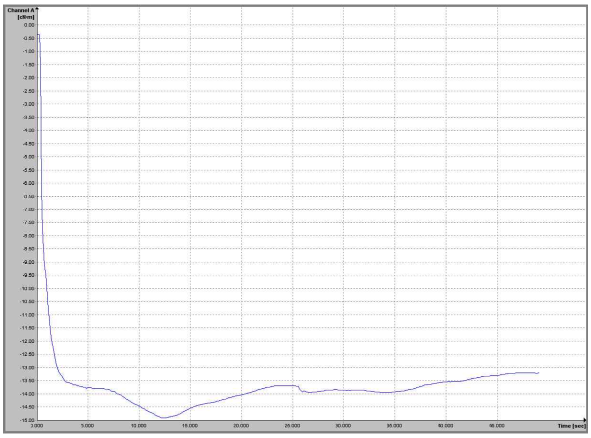

Figure 12. Representative time table of removable torque value changes in CCM group

Table 4 shows removal torque value of all specimens and means and standard deviations in each groups. In the gold group, the minimum value was recorded as 10.11 Ncm and maximum value was recorded as 20.31 Ncm. In CCM group, minimum value was 10.16 Ncm and maximum was 22.13 Ncm. Mean value and standard deviation in gold group and CCM group was 14.88 ± 3.66 Ncm and 14.66 ± 3.58 Ncm respectively.

In independent t-test, P-value was 0.927 (>0.05) and there was no significant difference between the two groups.

Table 5. First peak value in the graph of removal torque value changes in each group

Gold group (Ncm)		CCM Group (Ncm)	
1	20.31	1	10.16
2	17.23	2	11.67
3	12.04	3	15.42
4	17.83	4	22.13
5	12.78	5	14.92
6	10.11	6	15.71
7	11.68	7	14.28
8	17.03	8	12.97
Mean	14.88	Mean	14.66
S.D.	3.66	S.D.	3.58

b. Evaluation of wear patterns interface between abutment and fixture after chewing simulation

At the interface of gold abutment, wear patterns were observed in the corner of hex part of connection portion and most specimens showed irregular scratches at the surface of the interface. In contrast, at the interface of CCM abutment, no obvious wear patterns were observed.

At the interface of fixture in gold and CCM group, no obvious wear patterns were observed (Figure 14). The CCM abutment has greater physical strength and hardness than implant fixture, so it was expected that it would show more significant wear patterns. However, from the result of SEM photographs, it appeared that there were no considerable mechanical damages.

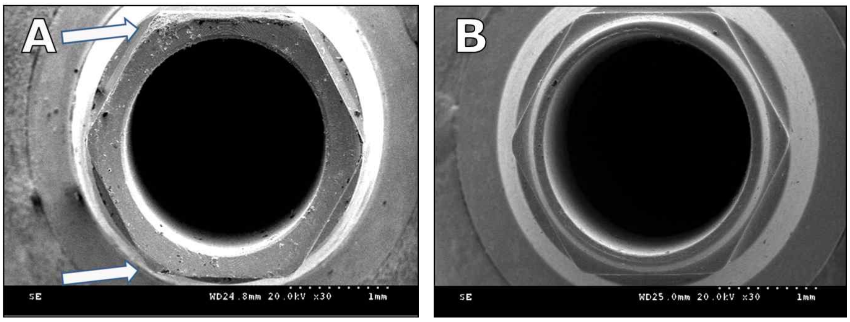

Figure 13. SEM photograph taken above connecting portion of the abutment of gold group (A) and CCM group (B) after chewing simulation (original magnification: x50)

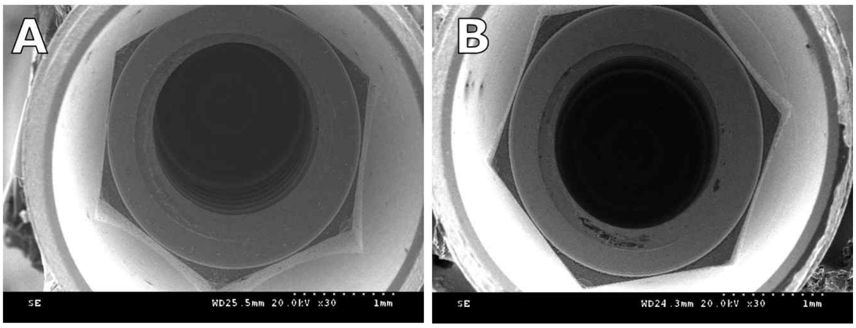

Figure 14. SEM photograph taken above connecting portion of the implant fixture of gold group (A) and CCM group (B) after chewing simulation (original magnification : x50)

Discussion

The manufacture (Osstem Co., Seoul, Korea) recommends Ni-Cr alloy for fabricating the restoration using CCM abutment because using Co-Cr Alloy as casting material may cause excessive oxide layer formation and casting shrinkage. The Ni-Cr alloys is an excellent alternative for noble alloys, primarily for usage in metal-ceramic prostheses due to the high modulus of elasticity, greater resistance, thermal compatibility with the porcelain, ease of use and low cost. Some Ni-Cr alloys contain Be (Beryllium) because Be provides good castability and interaction with ceramics and reduces the fusion temperature and increases the alloy fluidity. Bezzon OL. et al[2] reported that for Be-containing Ni-Cr alloy, there was no statistical difference of the castability between direct flame and induction casting machine, while for Be-free Ni-Cr alloy, higher castability was obtained at controlled high temperature by induction casting machined than direct flame. The success of the gas oxygen torch mainly depends on the operator experience while the induction technique allows objective control of the temperature.[3) Also, Ni-Cr alloy containing Be is not recommended for safety of the technician because of carcinogen from inhalation of Be during casting, polishing or finishing. For this reason, the superstructure cast was fabricated with Be-free Ni-Cr alloy at high temperature (1460 ℃) for CCM group using induction centrifugal casting machine in present study.

High temperature during casting and porcelain firing cycle changes the microstructure of cast alloys including homogenization, phase transformation, and oxidation. The composition change of the surface oxides may alter corrosion behavior and subsequent reactivity with patient's tissue. Qiu, J. et al[4) reported that the Co-Cr alloy has more corrosion resistance than Ni-Cr alloy in as-cast and fired condition and that the corrosion properties of the Co-Cr alloy and the Be-containing Ni-Cr alloy were not significantly affected by the firing process but the corrosion rate of the Be-free Ni-Cr alloy increased significantly after firing. Ryu JH and Jung CM[5) reported that thick oxide layer formed after casting and firing procedure and oxygen and chromium increased while cobalt decreased. On their study, abutment settlement value of CCM abutment were increased with oxide layer removal process by glass bead blasting and cotton wheel polishing while settlement value of CCM abutment was statistically lower than that of gold abutment expecially after cyclic loading.

In present study, the oxidized layer on CCM abutment after firing cycle was removed using 50 μm glass bead under pressure about 4 ~ 6 bars and then was polished using cotton wheel by the manufacture's recommendation.[6) They prohibit blasting with aluminum oxide or using grinding tools as rubber point or rubber wheel. After casting procedure, sandblasting is usual method to remove the refractory material and the oxide film. But, it did not improve the surface. So, the finishing procedure should consist of smoothing the metal with progressive finer abrasive agents. But, the finishing and polishing procedure might cause loss of mass and weakening the abutment.[7) Surface irregularities are related to the presence of a microgap between implant components and the microgap could cause peri-implant inflammation and bacteria infiltration. The Surface finishing process of the connection components are major factors of surface roughness. The premachined abutment was smoother than the cast abutments and the microgap of implant-abutment connection could be reduced with smother mating surfaces.[8)

Surface roughening may contribute increase in plaque quantity without a dramatic change in plaque composition. Bollen CML et al[9] reported that the reduction of the roughness of intraoral hard surfaces below the threshold R_a of 0.2 ㎛ would result in a retardation of the supra and subgingival plaque maturation but, excessively smooth surface might interfere with the stability of the soft tissue attachment. They concluded that a good balance between both aspects (bacterial adhesion and soft tissue sealing) seems to be reached at a surface roughness of Ra=0.2 ㎛. Even though the number of specimens of each group were only three, surface roughness value increased after firing and bead blasting (in case of CCM) in both gold and CCM abutment. Also, Surface roughness of gold abutment after firing was greater than that of CCM abutment after firing and bead blasting procedure. It is assumed that glass bead blasting procedure reduced surface roughness. However, loss of surface mass was not measured in present study and further study is needed to evaluate the effect to microgap caused by bead blasting.

Kano et al [10],[11] compared the removal torque values in machined titanium and in cast UCLA-type abutments cast with various dental alloys and reported that machined titanium abutments retained a significantly greater percentage of the applied torque than cast abutments. They showed that cast abutments from plastic abutments or premachined metal abutments presented roughness and some irregularities, while machined abutments presented a smooth and well-finished contact surface. Especially, the level of imperfections in castable abutment cast with Co-Cr alloy was notably great and demonstrated a significantly greater rotational misfit. Even on their studies, premachined abutment cast with gold alloy had roughness and irregularities, in present study, there were not roughness and deformations on all specimens after casting procedure. It seems that the melting temperature (1175 ℃) of the gold they used is higher than that(988 ℃) of gold we used. Their composition is (Pd 80 %, Ag 30 %) and (Au 46 %, Pd 4 %, Ag 38 %) respectively. Carr AB. et al[12] recommended use of premachined abutment over castable abutment due to advantage in preload magnitude and precision and if castable abutments are used, it should be finished and polished to provide an increased preload.

Ding et al[13] suggested that the restorative clinician loosen the ITI 2-piece synOcta abutment after initial torque and then proceed to re-torque the abutment to 35 Ncm to achieve a greater clamping force between the abutment and the implant. On the other hand, Byrne et al[14] found that repeated opening and closure of implant screws had different results, depending on screw type and the gold-coated screw lost more preload through repeated insertion/removal cycle. They documented that the gold-coated screw fixed to the prefabricated abutment, displayed higher preloads for the first tightening, on the other hand, the same screw fixed to the cast-on abutment showed higher values for the second and third tightening. A significant mechanism that results in screw loosening of implant-supported restorations is the settling effect because that there is no surface being completely smooth. Settling occurs as the rough spots flatten under load and initial preload is lost as a result of settling. The extent of settling depends on the initial surface roughness, surface hardness, and magnitude of the loading forces. To reduce the settling effect, Winkler S. et al[15) recommended that implant screws should be retightened 10 minutes after the initial torque application as a routine clinical procedure. In present study, screw was tightened to 30 Ncm torque 4 times without insertion/removal procedure to prevent negative impact on retention

Ha CY. et al[16)] compared the removal torque values of ready-made straight abutment, ready-made angled abutment and gold abutment cast with type III gold in external- and internal-implants after 10^6 times cyclic loading of 20 to 200 N. Internal tapered implant combined with two-piece abutments showed more torque loss than external implant. In internal tapered implant, there were no significant differences in RTVs among angled, straight, and gold premachined UCLA abutment and RTV after dynamic loading decreased 38.7 %, 35.8 % and 37.2 % respectively compared to the initial torque value.

Ricciardi Coppedê A et al[17)] studied the effects of mechanical loading and repeated insertion/removal cycles on the torque loss of abutments for internal tapered implant. In case of two-piece abutment, removal torque value required to loosen the fixation screw decreased over 30 % and removal torque value to remove the abutment from the implant increased 39 % after mechanical loading. On their findings, they suggested that under occlusal loading, the tapered portion of the two-piece abutments increases contact pressure and frictional resistance with the mating part of the implant without any interference from the fixation screw, and they become frictionally locked. Also, they reported that removal torque values decreased as the number of insertion/removal cycles increased.

Pintinha M. et al[18)] evaluated the effect of simulated mechanical loading on the removal torque of 1-piece and 2-piece abutments connected to internal tapered implants. For 2-piece abutments groups, an additional traction test was carried out after the removal of the abutment screw to determine the force necessary to dislodge the abutment from the implant. The mean removal torque after mechanical loading of 1-piece abutment group was 85.0 % of the placement torque and that of 2-piece abutment group was 59.1 % of the placement torque. Both of groups did not show statistical difference in the removal torque between before and after dynamic loading. But, traction force after dynamic loading was twice than traction force before loading. They mentioned that the main function of the fixation screw is to place the abutment into the correct position inside the implant and the friction was generated by the placement preload torque and by the application of mechanical loading. In present study, the mean removal torque value measured after chewing simulation using thermocyclic functional loading was 14.88 Ncm in gold group and 14.66 Ncm in CCM group. The ratio of mean removal torque to initial torque were 49.6 % and 48.9 % respectively. When we compared the removal torque value of gold abutment and CCM abutment after chewing simulation for external implant in preceding study, the mean RTV was 20.31 Ncm and 20.38 Ncm and the ratio of mean removal torque to initial torque were 67.8 % and 67.8 % respectively[19]. The ratio in external implant was higher than internal implant in our studies. This is similar to result of the studies mentioned above. No difference between gold group and CCM group seems to be that the screw loosening is hardly influenced by the eccentric occlusal loading possibly due to the mechanical stability provided by the internal tapered connection.[15] Further studies are needed to compare the traction force of abutment out of implant fixture of gold and CCM group because that there might be the difference of traction force between gold group and CCM group due to different settlement of them as Ryu JH. et al mentioned.[5]

In present study, when observed in SEM photographs, no remarkable wear patterns were observed at the interface of CCM group with fixture. On the other hand, remarkable wear patterns were observed at the interface of gold group with fixture. Klotz et al[20] reported that the implants with the zirconia abutments showed a greater rate of wear than the implants with the titanium abutments following cyclic loading and the potential for component loosening and subsequent fracture and/or the release of particulate titanium debris may be of concern. When two components with different material rigidity are in function, the deformation energy is distributed to the material with the lower Young’s modulus.[21] When implant and abutment are made from the same material like titanium, the deformation energy will be distributed between both components equally. If titanium implant are connected to a zirconia abutment with a higher Young’s modulus, the deformation energy is distributed to the implant fixture with the lower Young’s modulus. The hardness of zirconia used in dental implant restoration is 77 to 82 HRC. The hardness of CCM abutment decreased from 44 to 39 HRC when it is blasted with glass bead after casting and porcelain burn-out and that of gold abutment decreased from 18.1

to 11.1 HRC.[5)] The grade 4 commercially pure titanium, the implant material used in present study, is 23 HRC. The difference of hardness of zirconia and titanium is higher than that of Co-Cr-Mo ally and titanium. Also, we did cyclic loading procedure in wet condition using the chewing simulator considering the oral environment. The aqueous environment might reduce the amount of wear compared to dry testing as Klotz et al mentioned and the lower loading force in present study might affect wear patten because maximum load of the simulator was 5 Kg that is maximum force allowed in chewing simulator we used, while the maximum force in their study was 100 N.

It is hard to evaluate which groups showed more wear patterns accurately only with the SEM photographs, but there is a probability that wear patterns of CCM group interface is more destructive because of strength and hardness difference between CCM and titanium alloy. CCM abutment may result in mechanical damage to fixture when loaded during long periods. As previously mentioned, present study did not have enough loading conditions to simulate the intraoral environment and show long term clinical outcome. Thus additional study on the microgap due to bead blasting procedure and the effect of higher loads than in present study may be necessary for the stability of CCM abutment.

Taher, N. M. and A. S. Al Jabab[22)] reported that Co-Cr-Mo alloy can be used for implant suprastructures due to good galvanic corrosion behavior when coupled with titanium. But, the loading condition would increase ion release rates directly and increase susceptibility to pitting corrosion due to lowering of breakdown potential.[23)] These conditions could increase risk of localized inflammatory reactions and possibly also regarding systemic effects caused by metal concentration. It is more important in internal tapered implant systems because the implant-abutment junction locates closer to alveolar bone than in other system.

There is insufficient evidence on CCM abutments in vivo and in vitro, but they are currently available for clinical use. Present study refers only to mechanical properties. Thus, further study focused on the biologic consequences and long-term clinical study may be needed.

Conclusions

1. Surface roughness value of CCM group after firing and bead blasting procedure was smaller than that of gold group after firing procedure.

2. There was no statistically significant difference in removal torque value between CCM and gold group.
3. On the SEM photographs, remarkable wear patterns were observed at the interface of abutment in gold group, but there were no remarkable wear patterns at the interface of fixture in gold group and at the interface of fixture and abutment in CCM group.

Based on limited present study, CCM abutment can be alternative to gold abutment for internal tapered implant. However, consideration on biological aspect and long-term clinical study is needed

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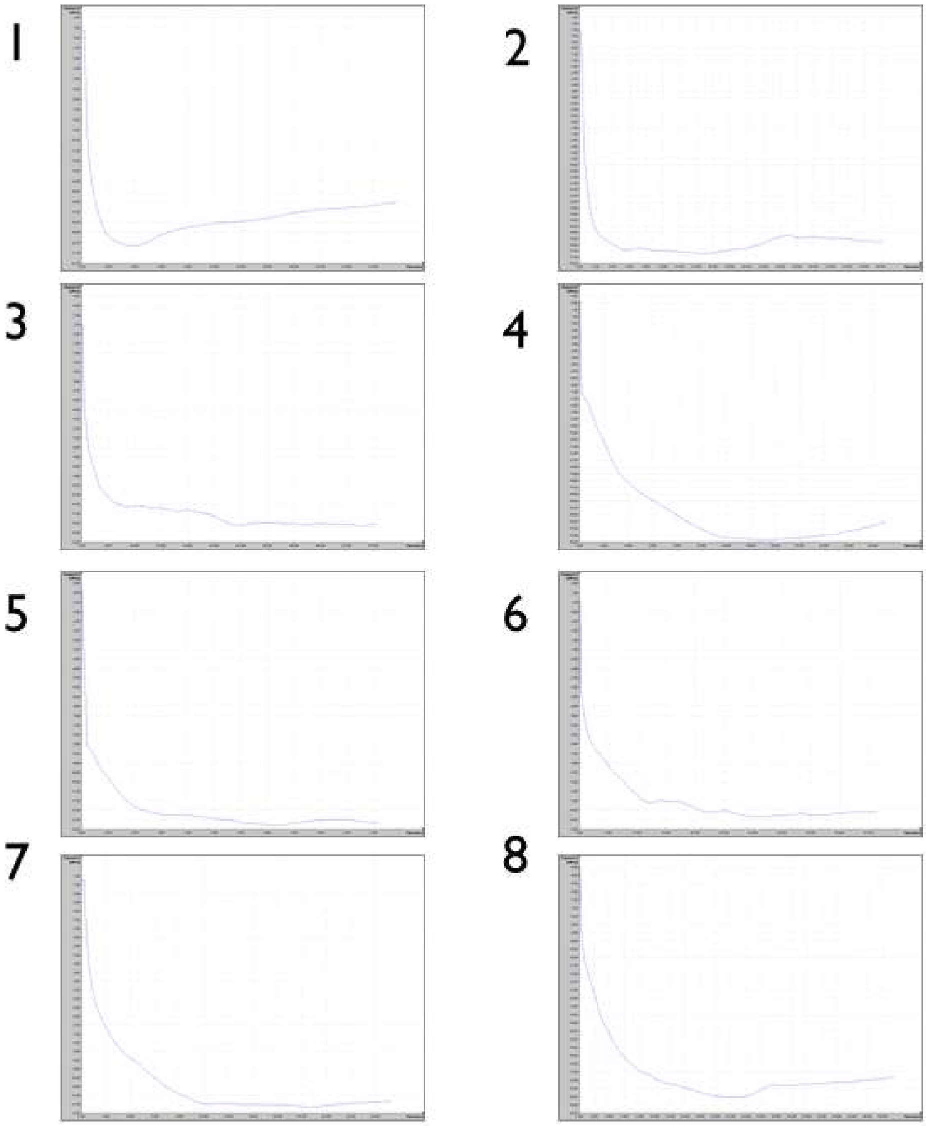
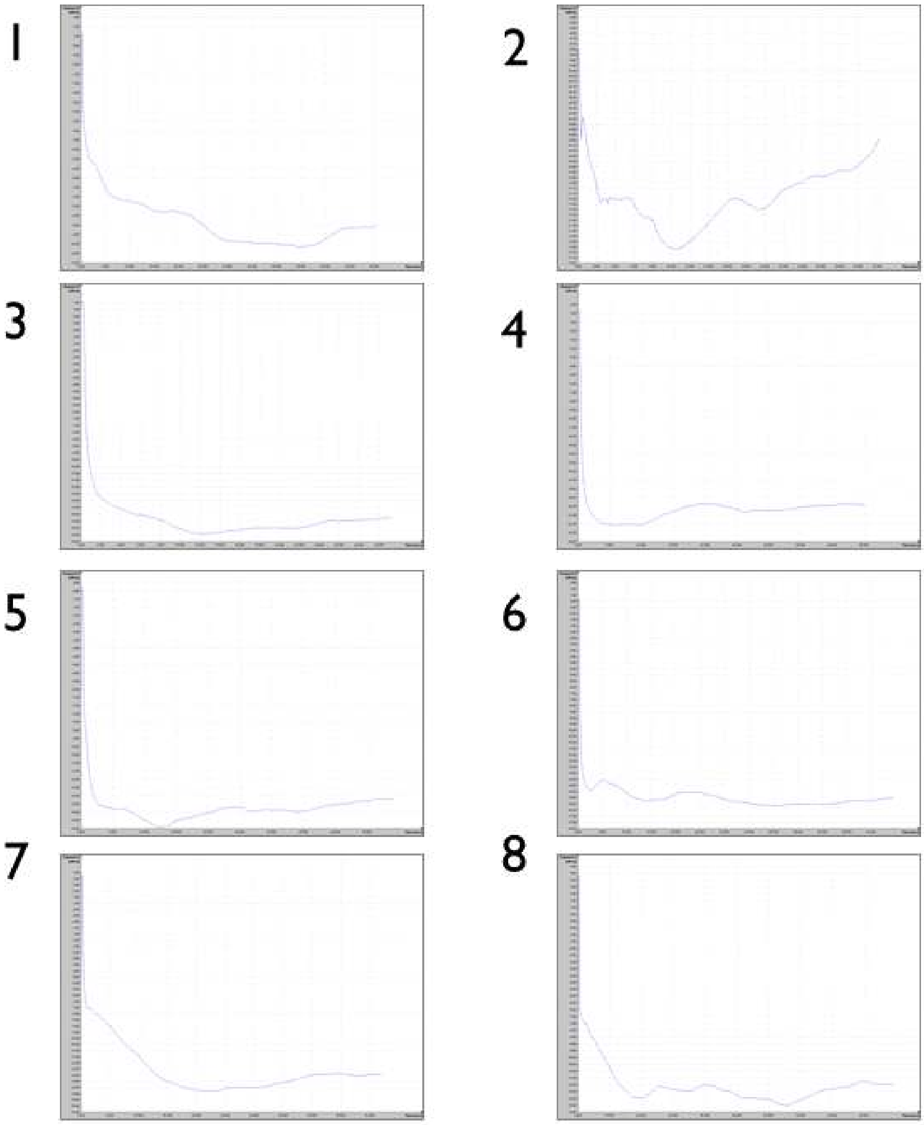
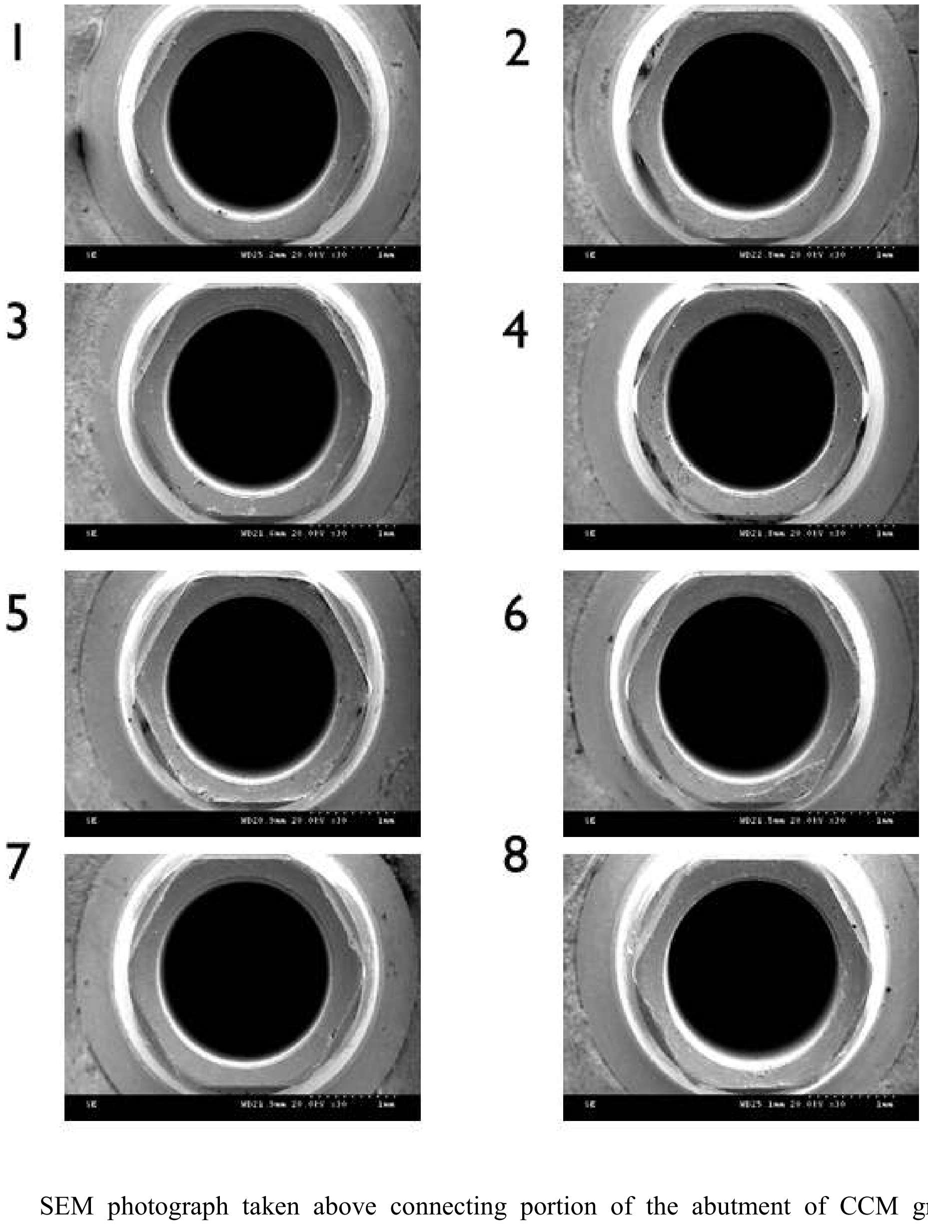
Appendix



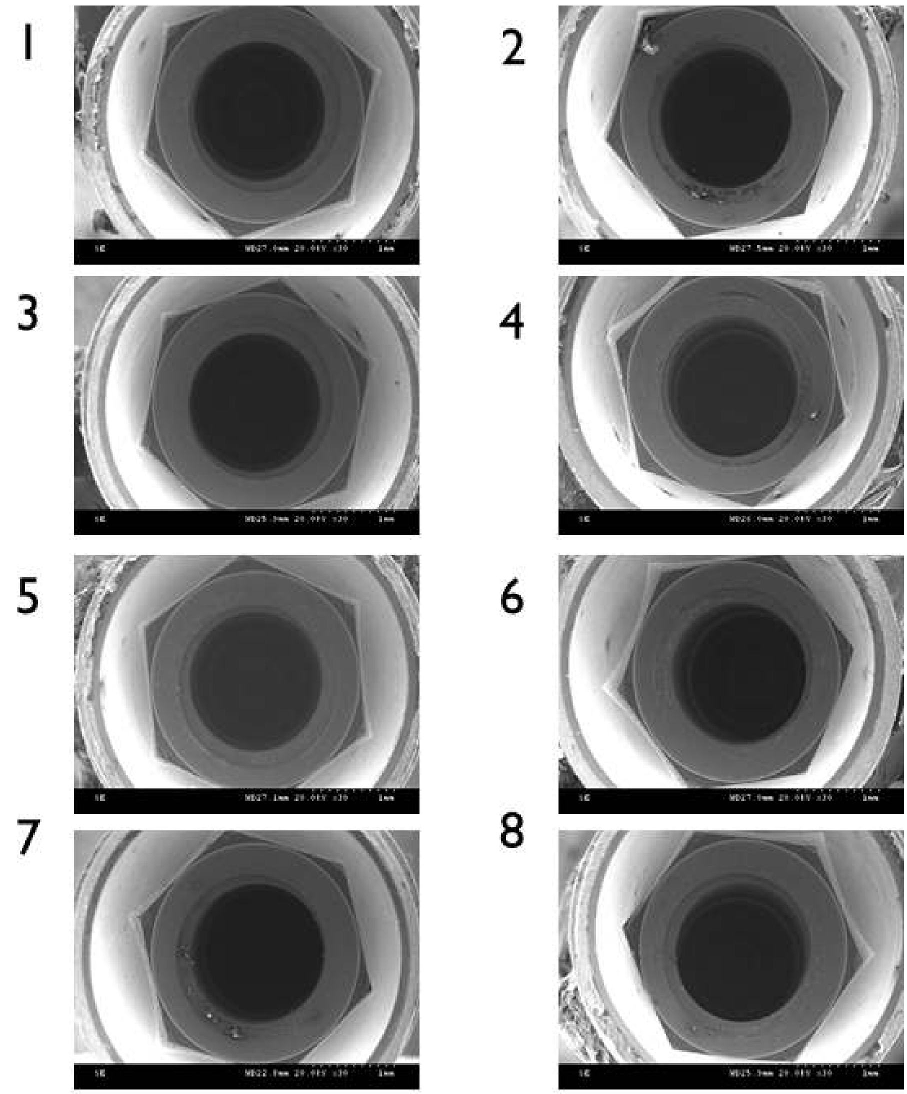
Reverse torque value(every 0.1sec) by driving torque tester(gold Group)



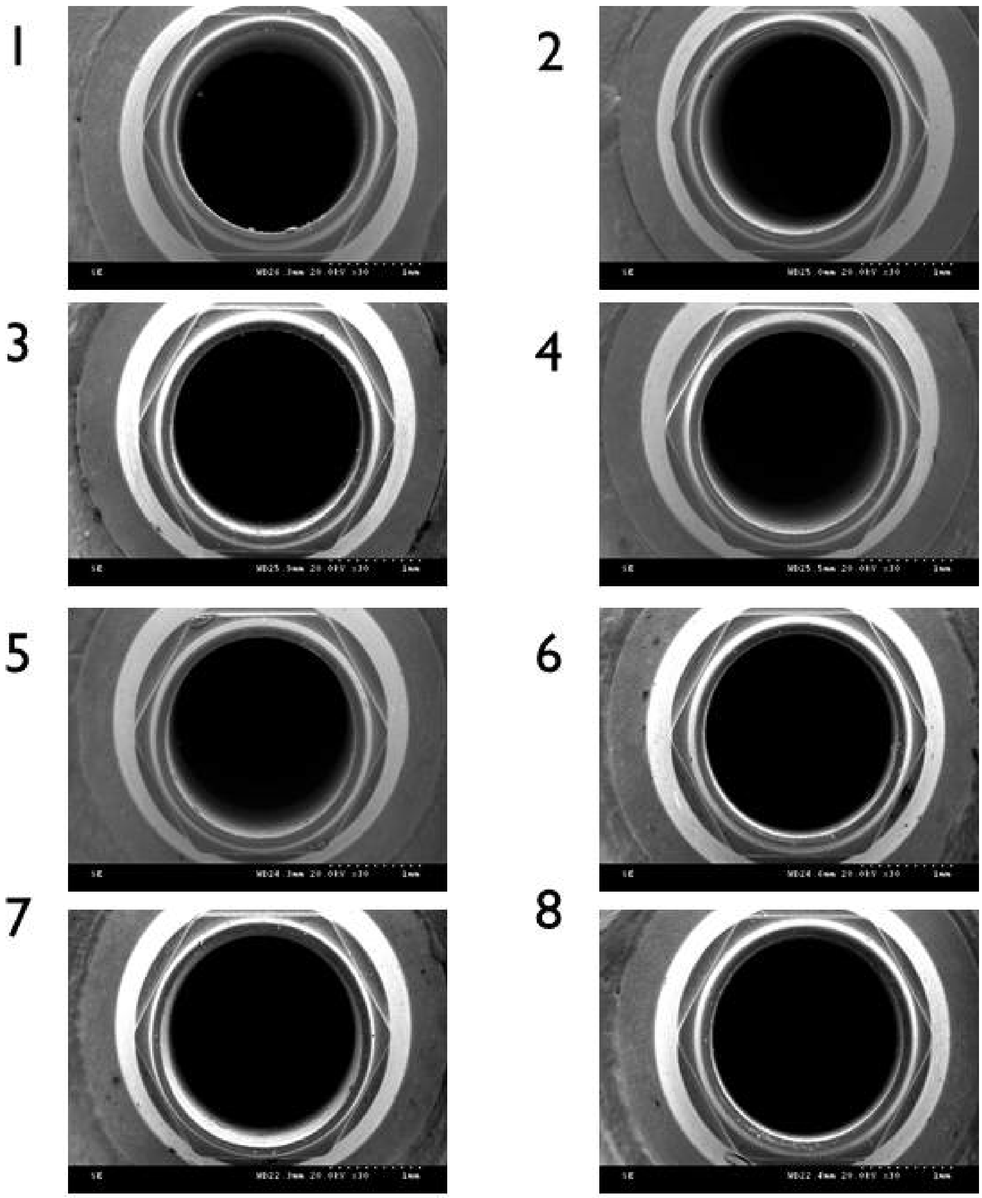
Reverse torque value(every 0.1sec) by driving torque tester(CCM Group)



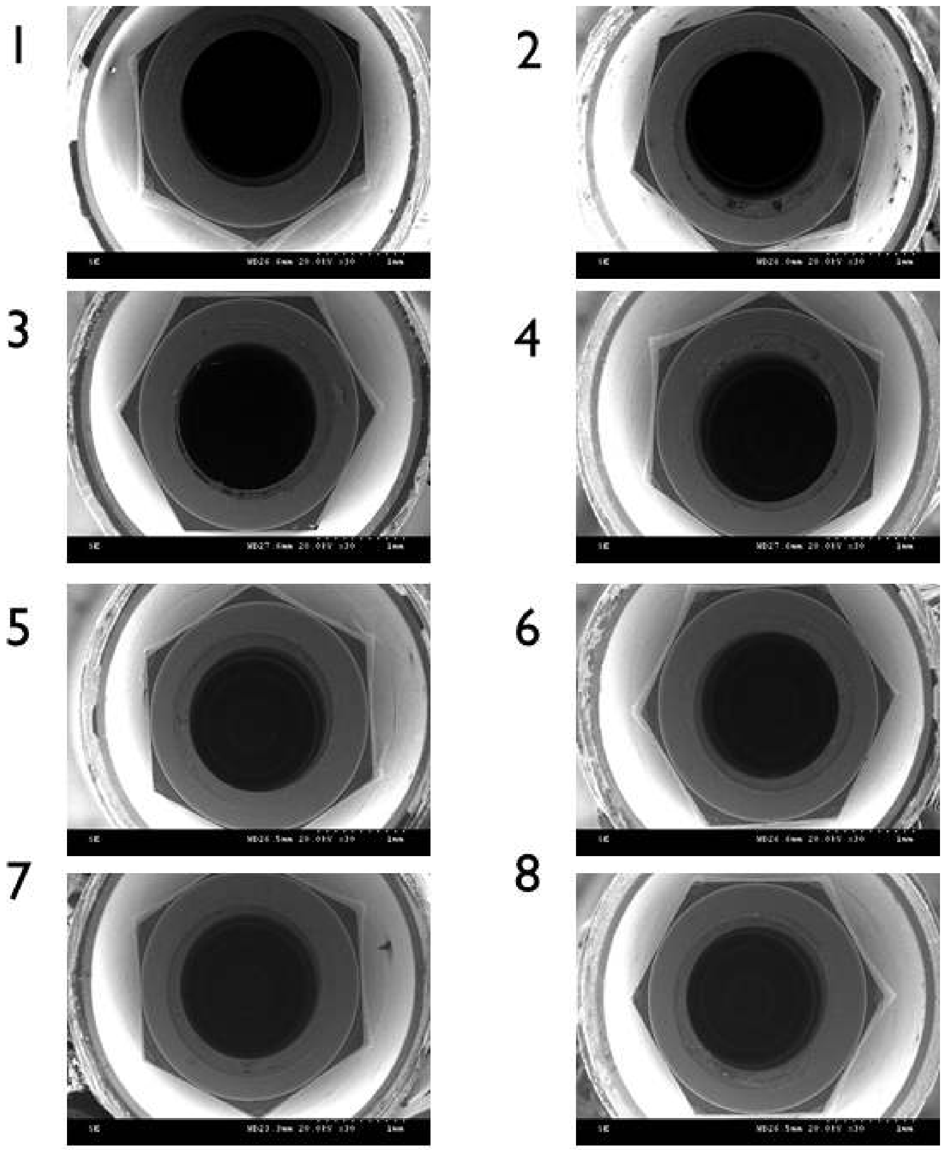
SEM photograph taken above connecting portion of the abutment of CCM group chewing simulation (original magnification : x50)



SEM photograph taken above connecting portion of the implant fixture of gold group chewing simulation (original magnification : x50)



SEM photograph taken above connecting portion of the abutment of CCM group chewing simulation (original magnification : x50)



SEM photograph taken above connecting portion of the implant fixture of CCM group chewing simulation (original magnification : x50)

국문요약

내부원추형 Co-Cr-Mo UCLA 지대주의 효용성에 관한 연구

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서론 및 목적: 치과임플란트 수복을 위한 다양한 지대주 재료들이 존재한다. gold가 최적의 재료이지만 지속적인 금값의 상승으로 인하여 접착형 수복물인 경우에는 티타늄과 지르코니아가 지대주의 재료로서 널리 사용되고 있다. 나사형 수복물의 경우에는 Ni-Cr합금이나 Co-Cr합금으로 주조할 수 있는 플라스틱 지대주가 소개되었으나 주조후 표면거칠기가 증가하고 변형이 발생하여 보철물의 안정성에 해칠 가능성이 높다. 최근에는 많은 임플란트 제조사들이 Co-Cr-Mo합금을 이용하여 선삭가공된 지대주를 제작하고 있다. Co-Cr-Mo 합금은 오랫동안 정형외과영역에서 사용되어져 왔다. 하지만 임플란트 수복물을 제작하기 위한 주조 및 도재용 소환과정이 Co-Cr-Mo합금의 성질을 변화시킬 가능성이 존재한다. 현재 Co-Cr-Mo 합금 지대주에 대한 연구가 부족한 실정이다. 본 연구의 목적은 주조 및 소환 과정시 발생하는 지대주의 표면변화 및 표면거칠기(R_a)를 관찰하고, 저작 모의 실험이후 나사풀림토크를 측정하고 지대주와 임플란트상에 나타나는 마모를 비교 관찰하여 내부원추형 Co-Cr-Mo UCLA지대주의 효용성을 평가하고자 한다.

실험 재료 및 방법: I. 주조 및 소환 과정 후의 지대주 표면 변화 관찰: 여섯 개의 gold 지대주와 여섯 개의 CCM 지대주가 사용되어졌다. 3개의 gold 지대주는 주조 전 상태 그대로이었으며(그룹 A) 나머지 3개는 type III gold을 이용하여 주조되었다(그룹 B). 3개의 CCM 지대주는 주조전 상태 그대로이었으며(그룹 C), 나머지 3개는 Ni-Cr합금을 이용하여 주조되었다(그룹 D). 주조된 시편들은 도재전장관 제작을 위한 소한 과정을 거쳤으며, CCM지대주는 bead를 이용한 연마과정을 거쳤다. 주사전자현미경을 통하여 표면변화를 관찰하였으며 표면거칠기값(R_a)을 측정하였다. II. 저작모의실험후의 나사풀림토크와 마모형태의

비교 관찰. 16개의 내부원추형 임플란트고정체를 Gold군과 CCM군으로 나누었다. 각각 8개의 CCM지대주와 Gold지대주를 이용하여 나사연결형 보철물을 제작하고 임플란트 고정체에 30Ncm의 토크로 연결하였다. 저작모의실험하에서 임플란트 고정체의 중심에서 3mm떨어진 지점에 수직으로 5kg의 하중을 1,000,000번 가하였다. 이후 나사풀림토크를 측정하였고 각각의 임플란트 고정체와 지대주의 연결부위를 주사전자현미경을 이용하여 마모정도를 관찰 비교하였다.

결과: Ⅰ. 주조 및 소환 과정 후의 지대주 표면 변화 관찰. 주조과정이후에는 모든 실험체에서 표면의 변형이 관찰되지 않았다. 그룹 A, B, C, D의 표면거칠기(R_a)는 각각 0.119㎛, 0.320㎛, 0.094㎛, and 0.212㎛이었다. Ⅱ. 저작모의실험후의 나사풀림토크와 마도형태의 비교 관찰. Gold지대주군에서의 나사풀림토크의 평균치 및 표준편차는 4.88±3.66Ncm 이었으며, CCM지대주군은 14.66±3.58Ncm이었다. 주사전자현미경하에서 표면관찰 결과, Gold지대주에서는 마모가 관찰되어졌으나, Gold군의 임플란트고정체, CCM군의 임플란트 고정체와 CCM지대주에서는 마모가 관찰되지 않았다.

결론: Ⅰ. 소환 및 bead 연마후의 CCM그룹의 표면거칠기 값은 소환후의 gold그룹보다 적었다. 2. 저작모의실험후 두 그룹간의 나사풀림토크는 통계학적으로 유의차가 없었다. 3. 마모양상은 gold그룹의 지대주에서만 관찰되었다. 제한적인 본 실험의 연구결과를 토대로 내부원추형 임플란트용 CCM지대주는 gold지대주를 대체할 수 있을 것으로 여겨지나, 생물학적 고려 및 장기적인 임상연구가 필요하다.

핵심되는 말: Co-Cr-Mo지대주, 내부원추형 임플란트, 저작모의실험, 산화막, 나사풀림토크, 마모형태