[UCI]I804:24011-200000234361

2007년 8월
석사학위논문

다양한 두께로 *TiN* 코팅된 지대주 나사의 반복 착탈 후 풀림력에 관한 연구

조 선 대 학 교 대 학 원

치 의 학 과

김 한 수

다양한 두께로 *TiN* 코팅된 지대주 나사의 반복 착탈 후 풀림력에 관한 연구

Detorque force of TiN-coated
abutment screw with various coating thickness after
repeated closing and opening

*2007*년 *8*월 *24*일

조선대학교 대학원

치 의 학 과

김 한 수

다양한 두께로 *TiN* 코팅된 지대주 나사의 반복 착탈 후 풀림력에 관한 연구

지도 교수 정 재 헌

이 논문을 치의학 석사학위 논문으로 제출함.

*2007*년 *4*월 *18*일

조선대학교 대학원

치 의 학 과

김 한 수

김한수의 석사학위 논문을 인준함.

위원장　조선대학교 교 수 계기성 인

위 원　조선대학교 교 수 김학균 인

위 원　조선대학교 교 수 정재헌 인

2007년 5월 일

조 선 대 학 교 대 학 원

Contents

List of Table

List of Figures

국문초록

다양한 두께로 *TiN* 코팅된 지대주 나사의 반복 착탈 후 풀림력에 관한 연구

김한수

지도교수 : 정재헌, 치의학 박사

조선대학교 대학원, 치의학과

TiN 코팅은 가장 일반적이고 대중화된 코팅 방법으로 황금과 같은 색깔을 띠므로 심미적으로 우수하며 금속표면에 코팅 시, 마찰계수의 감소와 부식에 대한 저항, 기계적 취약함의 해소 등이 보고되었으며, 산업적으로도 널리 사용되고 있다. 치과계에서도 기구의 수명연장을 위해 TiN 코팅이 사용되어 지고 있으며, 최근 TiN 코팅을 지대주 나사에 적용시키려는 시도들이 이루어지고 있고 TiN 코팅된 지대주 나사에서 마모와 적합도, 풀림력이 향상되었다는 결과들이 보고되고 있다. 그러나 임플란트 지대주 나사에 TiN을 코팅 시 정량화된 코팅 두께에 대한 연구는 보고되지 않고 있는 실정이다. 이에 본 연구에서는 타이타늄 지대주 나사에 TiN 코팅 시간을 달리해 다양한 두께로 TiN을 코팅 처리 한 후, 반복 착탈 시 이들의 표면 변화와 풀림력을 조사하여 TiN 코팅을 지대주 나사에 적용함에 있어 최상의 풀림력과 물리적 성질을 제공하는 코팅의 두께를 결정하여 임상적으로 문제가 되고 있는 지대주 나사의 풀림현상을 해소하는데 그 목적이 있다.

35개의 코팅되지 않은 타이타늄 지대주 나사가 본 실험에서 사용되었으며 TiN 코팅시간을 달리한 6개의 실험군(30분, 60분, 90분, 120분, 150분, 180분)과 TiN 코팅 처리를 하지 않은 1개의 대조군으로 10회의 반복 착탈 시 표면변화와 풀림력을 평가하여 다음과 같은 결과를 얻었다.

1. 코팅되지 않은 지대주 나사에 비해 코팅된 지대주 나사는 비교적 균질하고 매끈한 표면을 보였다.

2. 코팅하지 않은 지대주 나사와 30분간 코팅된 지대주 나사에 비해 60분 이상 코팅된 지대주 나사에서 반복 착탈 후의 표면 변화가 없었다.

3. 코팅하지 않은 지대주 나사와 30분간 코팅된 지대주 나사에 비해 60분 이상 코팅된 지대주 나사에서 반복 착탈 전과 후의 무게의 변화가 적었다.

4. 코팅하지 않은 지대주 나사에 비해 코팅된 지대주 나사의 평균 풀림력이 높은 값을 나타내었다. 코팅된 지대주 나사들 중에서 60분간 코팅된 지대주 나사가 평균 풀림력이 가장 높게 나타났으며 평균 풀림력의 감소 경향도 가장 적었다.

결론적으로, 균질하고 매끈한 표면 및 반복 착탈 시에 마모 저항성과 풀림력을 증가시키기 위해서는 적절한 TiN의 코팅 두께가 요구되며. 이 실험의 결과를 토대로 지대주 나사의 우수한 기계적 성질을 얻기 위해서는 약 60분 이상의 TiN 코팅이 요구된다고 할 수 있다.

I. Introduction

In recent years, the use of osseointegrated implants has been popular in single tooth restoration, and partially edentulous and fully edentulous restoration. Regardless of the type of performed restoration, in most cases, a screw connection is used between the abutment and implant. However, implant abutment screw loosening has remained a problem in restorative practices[1,2]. Abutment screw loosening was reported in large number of studies and ranged from 2% to 45% of the abutment[3-6]. Screw loosening is a recognized complication in implant restorations[7-11].

The maintenance of a screw joint is achieved when the clamping force exerted by the screw exceeds the joint separating forces acting on the assembly[12]. To reduce the possibility of screw loosening, potential joint separating forces should be minimized by optimal positioning and angulation of the implants. Joint separating forces may exceed clamping forces when implant assemblies are subject to non-axial loading because of implant position or angulation, or excessive occlusal forces[13]. Cantilever designs may amplify forces on screw joints due to the lever effect and should, when possible, be avoided[14].

Preload is the term given to the tension generated in the screw upon tightening and is a direct determinant of clamping force. As the abutment screw is torqued down, preload is generated within the screw, placing the abutment/implant assembly under compression[15,16]. This is a function of the frictional forces in the mating threads and screw head, the metallurgical properties of the screw, and the applied closing torque[16]. Micromovement, component surface wear, and embedment relaxation during functional loading may gradually erode the preload and cause progressive slippage and screw joint failure[16,17].

When torque is applied to new screws, energy is expended in smoothing surface. After thread engagement, surface asperities are flattened and additional input torque is applied toward elongation of the screw and generation of preload. It is claimed that thread friction is higher on initial closure, decreasing after repeated tightening and loosening cycles[16]. The process of screw loosening under clinical conditions, whether gradual or sudden, has to overcome the tension in the tightened screw and friction between the mating components.

When torque is applied to a new screw, about 90% of input torque is used to overcome friction and only 10% to induce preload[18]. For that reason, a few manufactures had altered the surface of abutment screw to reduce the friction coefficient and obtain the higher preload[19,20]. The well-known abutment screws are Gold-Tite of 3i(3i® Implant Inovations, INC., U.S.A.) and TorqTite of Steri-Oss(Nobel Biocare AB, Sweden) and WCC of Osstem(Osstem.Co.,Ltd., Korea).

Martin et al reported that Gold-Tite and TorqTite abutment screws with enhanced surfaces helped reduce the friction coefficient, and generated greater rotational angles and preload values than conventional screw[2]. Drago reported that the use of Gold-Tite square abutment screws, torqued to 32Ncm, maintained a stable abutment/implant connection that was successful in clinical practice for one year[21].

Titanium nitride(TiN) coating is the most general and popular coating method and used to improve the properties of metallic surface for industrial purposes. This coating layer of 2-3μm thickness renders the surface scratch-proof and is considered to be clinically stable[22]. TiN is used as a hard coating for metal cutting tools like drills and burs, and forming tools such as dies and punches because it has high hardness, low friction coefficient and good resistance to adhesive wear[22]. Additionally, it has a golden appearance and is useful for ornamental purposes.

TiN coating has been applied to clinical dentistry since early times. The clinical trials which coated crown, partial fixed denture and removable prostheses made from casting dental alloy with TiN had been performed by several dentists[22]. Kim et al reported that TiN coating of abutment screw helped to reduce the risk of screw loosening and improved the stability of screw joint[23]. When TiN coating applied to the abutment screw, frictional resistance would be decreased, as a results, the greater preload and prevention of the screw loosening could be expected. However, the proper thickness of TiN coating on abutment screw has not been reported yet.

The purpose of this study was to evaluate the removal torque value and surface change of titanium abutment screw with various TiN coating thickness.

II. Materials and Methods

1. Materials

Thirty five non-coated GSII abutment screws(GSASR, Osstem.Co.,Ltd., Korea) were prepared for TiN coating. They were randomly selected and divied into 7 groups. According to coating deposition time(CDT), experimental groups were divided into 6 groups: group A(CDT 30min), group B(CDT 60min), group C(CDT 90min), group D(CDT 120min), group E(CDT 150min), group F(CDT 180min). TiN was coated for the specimens of 6 groups respectively, and those of 1 group(group G) was not coated as a control group. Each group was made up of 5 abutment screws(Fig. 1, Table 1).

Table 1. Classification of groups

Group	Specimen No.	Coating deposition time	Applied torque
A	5	30 min	30Ncm
B	5	60 min	30Ncm
C	5	90 min	30Ncm
D	5	120 min	30Ncm
E	5	150 min	30Ncm
F	5	180 min	30Ncm
G*	5	None	30Ncm

* : Control group

2. Methods

1) TiN coating using Arc ion plating

TiN coatings were produced by Arc ion plating on titanium abutment screw. For controlling of coating thickness, each group had the variation of coating deposition time, such as 30, 60, 90, 120, 150, and 180 minutes. Temperature was supported to 350-380℃ on purpose to increase adhesion degree.

2) Mounting of implant fixtures

The implant fixtures used in this study were internal conical joint design(GSII, with diameter 4mm and length 13mm, Osstem.Co.,Ltd., Korea). Abutments for this experiment were GS Transfer Abutment(Hex Standard, with diameter 5mm and gingival height 3mm and abutment height 5.5mm, Osstem.Co.,Ltd., Korea). Thirty five pairs of implant fixtures and abutments were selected respectively. One fixture, abutment and abutment screw comprised a specimen. Each fixture was mounted in liquid unsaturated polyester. The mounting media(Epovia, CrayValley Inc. Korea) was a 2-part system made up resin and hardener. Two components were mixed together and cured overnight after fixtures were embedded. After mounting media was completely hardened, abutment was connected to each fixture(Fig. 2).

Fig. 1. Abutment screws used in this study(Osstem.Co.,Ltd., Korea)

Fig. 2. Fixture and abutment connection

3) Ultrasonic cleansing of specimens

Abutment screws were cleansed with alcohol and aceton in ultrasonic cleaner (Branson 3510, Bransonic, USA) for 10 minutes.

4) FE-SEM and EDX investigation of thread surface on the abutment screw

FE-SEM(Field Emission Scanning Electron Microscoper) was used to observe change of thread surface of the abutment screw after repeated closing and opening 10 trials. The thread surface of each abutment screw was observed at 100 magnifications, and then screw crest, valley, and slope were observed more detailed numerical value, at 1,000, 10,000, 100,000 and 500,000 magnifications.

For examining the changes of coating surface, we operated qualitative analysis by EDX(Energy Dispersive X-ray Spectroscopy), when we carried out repeated opening and closing at before and after.

Care was taken not to touch the thread surface of abutment screw for avoidance of its contamination. The abutment screws were also cleansed with an ultrasonic cleaner before taking photomicrographs.

5) Measurement of abutment screw weight

For comparison of bonding strength and wear resistance of various TiN coating thickness on abutment screw, before and after closing and opening, abutment screw weight was measured by electric scales(GENIUS ME, Sartorius, Germany) up to 0.000001g level. Identical measurements were repeatedly performed 10 times for each sample.

6) Measurement of detorque force

The implant mounted fixture blocks were fixed in the specially devised specimen-holding apparatus before closing and opening(Fig. 3).

Each abutment was secured to the implant fixture by abutment screw with recommended torque value(30Ncm) using finger screw driver(Hand Driver, Osstem.Co.,Ltd., Korea) and torque wrench(TWMW, Osstem.Co.,Ltd., Korea). Finger screw driver was used to fix the abutment screw till thread mating components were slightly contact. After that, torque wrench was used to tighten the screw to 30Ncm. It was used to insure that an accurate and reproducible force was applied to each abutment screw. The abutment screws were repeatedly tightened and removed 10 trials. The number of trials included several try-in of abutment screw up to final setting. One operator who had experienced implant prosthetic restorations accomplished this operation. Sample with abutment screw tightened was fixed in the customized jig for the measurement of detorque force. Detorque forces were measured with digital torque gauge(MGT 12®, Mark-10 Corp., U.S.A, Fig. 4).

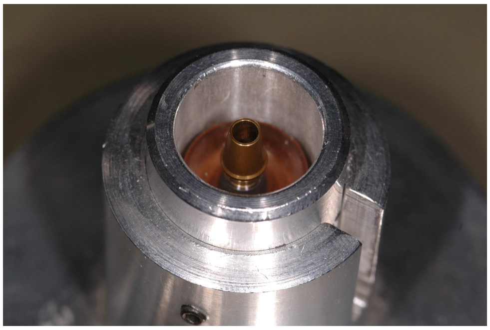


Fig. 3. Specimen-holding apparatus for measurement of detorque force

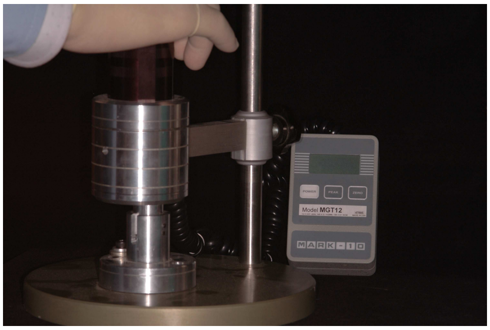


Fig. 4. Digital torque gauge and measurement of detorque force

3. Statistical analysis

SPSS statistical software for Windows(Release 12.0, SPSS Inc., Chicago, IL, U.S.A.) was used for statistical analysis. One-way ANOVA(Tukey test; level of significance, $P<0.05$), independent t-test(level of significance, $P<0.05$), and validity test of Microsoft Excel were used for the comparison of the mean detorque forces and the tendency of detorque force change measured from coating groups and uncoating group, between coating groups.

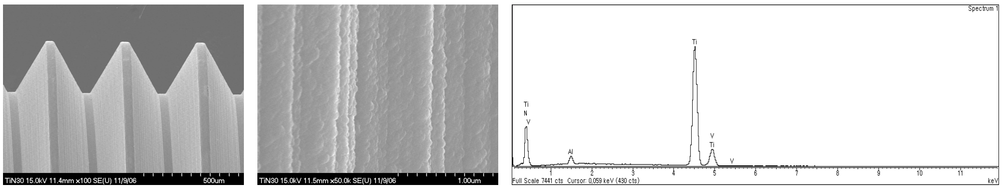
III. Results

1. Coating surface investigation

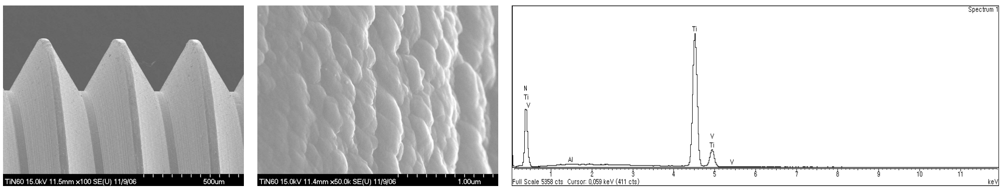
1) Before repeated closing and opening

As the result of observing coating surface with 100 magnifications and 500,000 magnifications, uncoated surfaces of control group(group G) showed somewhat rough surface, TiN particles adhered to coated experimental group surfaces. And, the more coating thickness was thick, the better size of adhered TiN particles were increased at same magnification(Fig. 5).

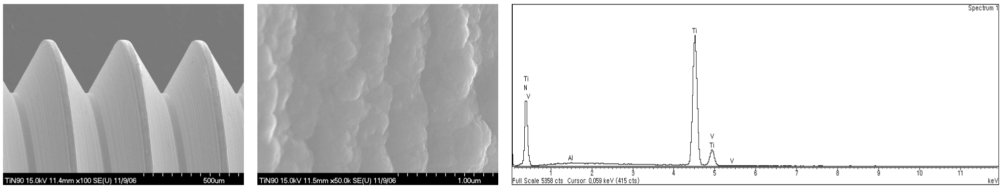
In a result of qualitative analysis of coating surface by using EDX, Ti, Al, and V were detected in uncoated control group(group G), and those were identified by Ti-6Al-4V alloy. In experimental group, Ti, Al, and V were detected, TiN was additionally detected. Also, the more coating thickness was thick, the better TiN particle amounts were increased, and the less Ti, Al, and V detected amounts were decreased(Fig. 5).



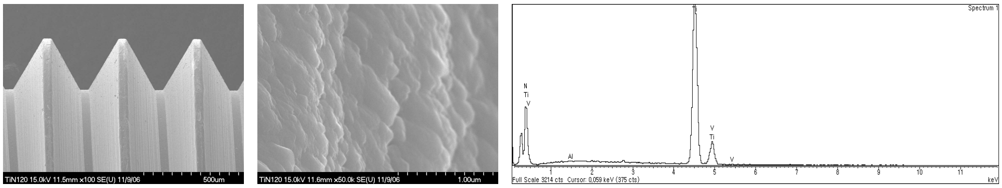
Group A



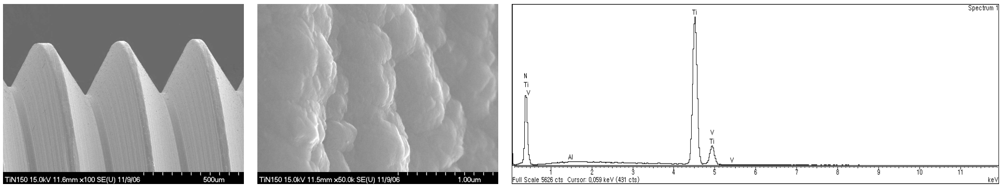
Group B



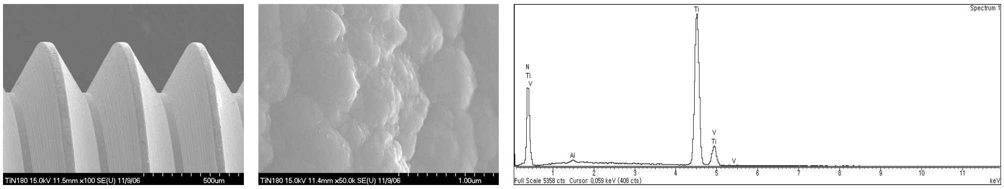
Group C



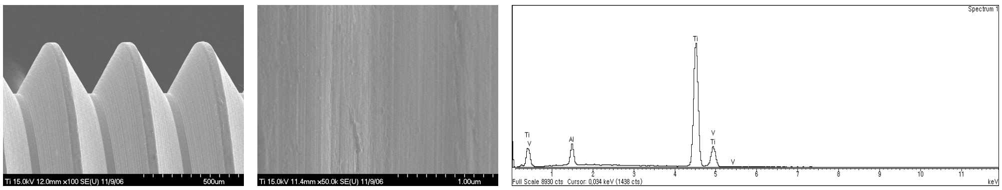
Group D



Group E



Group F



Group G

Fig. 5. FE-SEM micrographs & EDX showing coating surface of each group before repeated closing and opening
(Left : ×100, Right : ×500,000, Below: EDX)

2) After repeated closing and opening

Comparing to before opening and closing, surface change on all groups was not observed in low magnification FE-SEM. But in the high-powered FE-SEM analysis of Group A and Group G had noticeable changes in screw threads after test. The separation of coated TiN was detected in abutment screws of Group A, and Group G was revealed the wear surface and scratches. When observed by high-powered FE-SEM, surface change in other groups was not represented before and after opening and closing(Fig. 6). In result of qualitative analysis of coating surface by using EDX, surface ingredients did not have difference as comparing to before opening and closing.

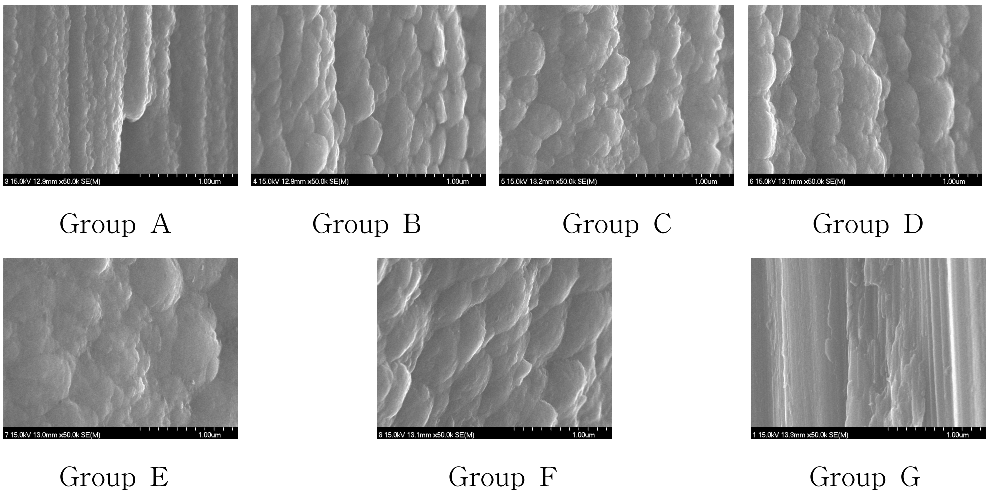


Fig. 6. FE-SEM micrographs showing coating surface of each group after repeated closing and opening(× 500,000)

2. Measurement of abutment screw weight

In result of measuring weight of abutment screw before and after opening and closing, Group G represented the most remarkable weight change, and Group A represented the most remarkable weight change among TiN coated groups(Table. 2).

Table. 2. The mean abutment screw weight (Unit : g)

	Before	After	Difference
Group A	0.125432±0.000019	0.125420±0.000012	0.000012±0.000016
Group B	0.125940±0.000089	0.125920±0.000045	0.000020±0.000084
Group C	0.125912±0.000013	0.125908±0.000016	0.000004±0.000006
Group D	0.122552±0.000015	0.122540±0.000010	0.000012±0.000022
Group E	0.125808±0.000011	0.125808±0.000009	0.000000±0.000010
Group F	0.126018±0.000008	0.128010±0.000007	0.000008±0.000015
Group G	0.125582±0.000008	0.125456±0.000011	0.000076±0.000011

3. Measurement of detorque force

Table 3. show the mean detorque forces of each trial. Group B had a higher mean detorque force than other groups. TiN coating groups showed higher detorque force than group G. All groups had a increasing tendency of detorque force as the closing and opening were repeated by 3rd or 4th trial. And, When we repeated the number of trials after 3rd or 4th trial, detorque forces showed decreased tendency. In 3rd or 4th trial, all groups had maximal mean detorque force(Fig. 7).

There was a statistically significant difference between Group B and Group G($P<0.05$, independent t-test). In the comparison of mean detorque force from 1st trial to 10th trial, there was statistically significant difference Group B and Group G($P<0.05$, One-way ANOVA). About maximal value, minimal value, and all trial detorque forces, Group B was higher than Group G. After 4th trial, two groups revealed declining tendency of mean detorque forces, and Group G was steeper than Group B on slope of declining tendency. In coating groups, such as Group A, B, C, D, E, and F, though every absolute mean detorque force was different, the tendency of detorque force transition was almost similar. There was a statistically significant difference between Group F and Group G($P<0.05$, independent t-test). Although maximal detorque force of Group F was almost same to Group G, general tendency of detorque force change was very different. Additionally, the mean detorque forces between Group F and Group G except for 4th trial represented considerable large difference.

Table. 3. The mean detorque force of each group (Unit : Ncm)

Trial	Group A	Group B	Group C	Group D	Group E	Group F	Group G
1	26.26	27.06	26.6	25.92	25.32	24.84	24.1
2	26.46	27.46	26.8	26	25.58	25.04	24.3
3	26.66	28.08	27.16	26.22	25.78	25.26	25.02
4	26.52	28.4	27.22	26.16	25.7	25.3	25.24
5	26.42	28	26.9	25.82	25.38	25.02	24.54
6	26.16	27.74	26.66	25.66	25.24	24.66	24.36
7	25.88	27.34	26.48	25.5	25.04	24.46	23.88
8	25.58	27.18	26.3	25.24	24.82	24.16	23.36
9	25.44	26.98	26.06	25.14	24.62	23.92	22.84
10	25.2	26.9	25.88	24.94	24.44	23.66	22.48
Mean	26.06	27.51	26.61	25.66	25.19	24.63	24.01
SD	±0.51	±0.52	±0.44	±0.44	±0.45	±0.57	±0.89

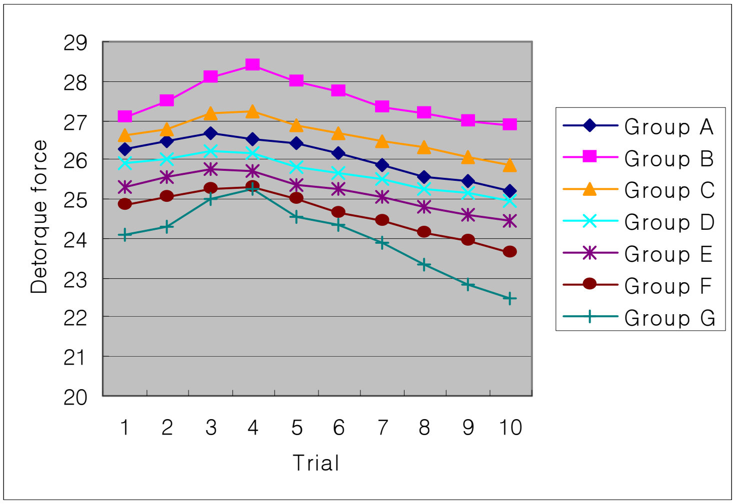


Fig. 7. Comparison with mean detorque force of each group

IV. Discussion

The prevalent method to reduce the screw loosening is the application of dry lubricant coating on abutment screw[24]. The purpose of lubricant is to reduce a frictional coefficient and obtain a higher preload. The need for coating with lubricant has long since introduced.

When titanium slides in contact with other metals of similar hardness, the friction coefficient is initially fairly low. However, the values of friction coefficient gradually increase to that for titanium against titanium, as tightening and loosening are repeatedly performed. Abkowitz et al found this increase in the frictional coefficient to be attributable to the galling and seizing tendency of titanium[25]. TiN film has low friction coefficient, high hardness and good wear resistance. Considering these properties of TiN coating, it seems to be an alternative coating method according to result. Koo et al operated TiN coating to abutment screws and examined those surface characteristics. As a result, abutment screws revealed salient improvement of mechanical properties[26]. Also, Kim reported that titanium abutment screw coated with TiN scored a higher mean detorque value than titanium abutment screw[27].

Researching about proper TiN coating thickness, Lee operated various thickness TiN coating to titanium alloy disk and examined on that mechanical property. In result of that study, he reported that when CDT(coating deposition time) was 30min, coating thickness was 0.5㎛, CDT 60min was 1.05, CDT 90min was 1.32, CDT 120min was 1.40, CDT 150min was 1.72, CDT 180min was 2.10 and coating thickness was thicker than 2㎛ for abutment screw had homogeneous and smooth coating surface and the high-quality mechanical property[28]. However, we considered that Lee's study had limitation of experiment as not mechanical property of abutment screw but that of disk. Therefore, the purpose of this study was to investigate the removal torque value and surface change of titanium abutment screw of various TiN coating thickness.

1. Coating surface investigation

According to researchers including Mezger, TiN coating was good properties on wear-resistance, corrosion-resistance, and surface hardness[22). But, researchers mentioned that coating film had need of homogeneity and consistency because defect of coating surface such as pores or micro-cracks were observed.

When clamping torque force was applied to micro-roughness screw, the points of loading application over yield strength generated and plastic deformation happened at these points.

Settling effect, is the phenomenon that early contact area of surface was deformed and flattened at the points of loading application over yield strength[29)]. Plastic deformation happened until contact area that can be stabilize screw, and if the whole settling effect was larger than elastic extension of screw, then loading applied points of threads could not seize screw. Consequently, the loosening of screw occurred[30)]. Sakaguchi et al, they reported that 2-10% preload disappeared by the influence of settling effect[31)]. Binon et al, reported that the intensity of settling effect was controled by early surface roughness, surface hardness, and applied force[19)]. The less roughness of coating surface was, the less settling effect happened. Consistent and smooth coating surface was needed for decreasing of screw loosening possibility.

In this study, when we observed abutment screw surface, especially upper 3-4 screw threads, according to Sopwith study the length of screw only performed secondary role for screw fixation on technological aspect, and he suggested that about 3-4 screw threads was enough to fix upper structure tight[32)]. In the result of observing abutment screw surface before opening and closing, we observed Arc ion plating TiN film surface by use of FE-SEM, Group G surfaces represented traces that happened on grinding process, other coated groups were observed relative consistent and smooth surfaces. And, the more coating thickness was thick, the better size of adhered TiN particles were increased at same magnification. As the result of EDX ingredients analysis, TiN ingredients were increased by getting along coating time. This fact represented that surface-attached TiN ingredients were increased as coating time was increased. When analyzed ingredients by EDX, TiN proportion beyond certain thickness level was observed equally by depth limitation that incident beam from FE-SEM could collide.

When surface of TiN coated abutment screw was observed after opening and closing, as the result, abutment screws coated with TiN over 60 minutes did not have surface change, and the exfoliation of TiN coating was observed at Group A. In process of the repeated opening and closing of abutment screw, for preventing coating layer from exfoliating easily, adhesion strength should be high, and abutment screw needed to be coated for 60 minutes. After opening and closing, The difference of EDX value was not revealed as comparing to before opening and closing. According to this result, it is considered that repeated opening and closing did not affect the ingredient composition change of coating surface.

On the basis of this result, when abutment screw was coated with TiN, if you want abutment screw to be homogeneity and consistency and to minimize the plastic deformation of TiN coating surface at repeated opening and closing, abutment screw needed to be coated with TiN for 60 minutes. And clinically, it is considered that further studies about quantitative numerical value of proper adhesion strength was needed.

2. Measurement of abutment screw weight

If coated materials of abutment screw had the low abrasion resistance, plastic deformation happened easily, and the abrasion or exfoliation of coating film was occurred. Also this result can cause screw tightening problem. Finally, coating material of abutment screw had to be great in abrasion resistance, therefore the minimization of screw loosening can be accomplished.

Abrasion resistance was not directly measured on abutment screw because size of screw is too small and shape is winding. Thus, this study evaluated the abrasion resistance as comparing with changes of abutment screw weight at before and after opening and closing.

As shown in Table. 2, the reduction of weight at before and after opening and closing was remarkable in Group A and Group G, there was a statistically significant difference between all groups($P>0.05$, One-way ANOVA). However, weight difference was very small. Therefore, abutment screw needed minimal coating time over 60 minutes for decreasing of abutment screw abrasion at repeated opening and closing.

3. Measurement of detorque force

In all groups, detorque force value up to 3rd or 4th trial represented increasing tendency, and detorque force value represented declining tendency from 3rd or 4th trial to 10 trial. The reason that detorque force represented these tendency was settling effect, mechanical or adhesive wear. The reason of increasing tendency of detorque force was that irregularity between fixture surface and coating surface was gradually decreased by settling effect. From 3rd or 4th trial to 10 trial, the reason of declining tendency was that friction between screw surface and fixture surface was increased, and that detorque force was consequently decreased because preload was decreased by adhesive or mechanical wear[33). In analysis of the tendency of detorque force transition, the point we having in mind was that settling effect and adhesive wear were not independent phenomenons. Two effects simultaneously acted like two sides of the same coin, but these detorque force tendency was revealed because each effect differently affected to surface from range to range. The influence of settling effect was more remarkable up to 3rd or 4th trial, influence of adhesive or mechanical wear was more remarkable from 3rd or 4th trial to 10 trial. Also, especially settling effect affected to show the maximal detorque force at 3rd or 4th trial.

There was a statistically significant difference between Group F and Group G($P<0.05$, independent t-test). In every trial, detorque forces of Group F were higher than Group G detorque forces, and also in tendency of detorque force change Group F was more gentle. This result represented that TiN coated abutment screw was better than raw titanium abutment screw on every aspect[34].

As coating to abutment screw with TiN of low friction coefficient and good hardness, it is considered that detorque force was increased and loosening of abutment screw was decreased. According to studies of researchers including Lee, those studies suggested that TiN coating thickness of proper mechanical properties was over 2㎛[28]. But in actual fact, Group B(1.05㎛) represented the highest average detorque force when researched detorque force on abutment screw at repeated opening and closing.

There were several potential limitations to this study. The specimens were randomly selected and tested by one researcher. The number of sample was a few and the friction coefficient could not be found because size of screw was too small and shape was winding.

TiN coating had influence on detorque force, tightening-turning angle, and clamping force. However, This study didn't measure compression force and tightening-turning angle. In this study, we assumed that setting value of torque-generating device was always 30Ncm. But the force generated by torque-generating device might be not regular[35]. The possibility generating this error was passed over on process of this study. Therefore, these factors could make the errors of experimental data. Finally, test was performed under only repeated closing and opening without occlusal loading.

V. Conclusion

In this study, for determining on proper TiN coating thickness when TiN coating applied to abutment screw, we used implant system having internal conical type between implant and abutment connection joint. After various TiN thickness was coated to titanium abutment screw, surface change and detorque force of abutment screw was measured for evaluating proper coating thickness at repeated opening and closing. According to this study result, we obtained the following conclusions.

1. The more coating deposition time increased, the more surface became consistent and smooth.

2. In abutment screw TiN coated over 60 minutes, surface change was not founded after repeated opening and closing.

3. In abutment screw coated over 60 minutes, little weight change was founded between before and after repeated opening and closing.

4. The TiN coated abutment screw was better than non-coated abutment screw on the mean detorque value. In TiN coated groups, abutment screw must be coated during 60 minutes for accomplishing maximal detorque force and gentle declining tendency of mean detorque force.

For obtaining consistent and smooth coating surface, resisting abrasion at repeated opening and closing of screw, and increasing detorque force, coating layer of proper thickness was demanded. Conclusively, when titanium abutment screw was coated with TiN, thickness of Group B condition represented the distinguished improvement of mechanical property. This fact is considered that we can improve screw loosening problem as TiN coating of implant abutment screw.

Reference

1. Goodacre CJ, Kan JKY, Rungcharassaeng K. Clinical complications of osseointegrated implants. J Prosthet Dent 1999;81:537-552.
2. Martin WC, Woody RD, Miller BH, Miller AW. Implant abutment screw rotations and preloads for four different screw materials and surfaces. J Prosthet Dent 2001;86:24-32.
3. Andersson B, Odman P, Lindvall AM. Single-tooth restorations supported by osseointegrated implants : Results and experiences from a prospective study after 2 to 3 years. Int J Oral Maxillofac Implants 1995;10:702-711.
4. Avivi-Arber L, Zarb GA. Clinical effectiveness of implant-supported single tooth replacement : the Toronto study. Int J Oral Maxillofac Implants 1996;11:311-321.
5. Kim NH, Chung CH. A study on the fit of the implant -abutment -screw interface. J Korean Acad Prosthodont 2003;41(4):503-518.
6. L. Jorneous, Nobelpharma News 1, 7 (1987)
7. Jemt T, Laney WR, Harris D. Osseointegrated implants for single tooth replacement: A 1-year report from a multicenter prospective study. Int J Oral Maxillofac Implants 1991;6:29-36.
8. Naert I, Quirynen M, van Steenberghe D. A six-year prosthodontic study of 509 consecutively inserted implants for the treatment of partial edentulism. J Prosthet Dent 1992;67:236-245.
9. Goodacre CJ, Bernal G, Rungcharassaeng K. Clinical complications with implants and implant prostheses. J Prosthet Dent 2003;90:121-132.
10. Wolfinger GJ. Implant prosthodontic and restorative complications. Int J Oral Maxillofac Implants 2003;18:766-767.
11. Hebel KS, Gajjar RC. Cement-retained versus screw-retained implant restorations: Achieving optimal occlusion and esthetics in implant dentistry. J Prosthet Dent 1997;77:28-35.

12. Mcglumphy EA, Mendel DA, Holloway JA. Implant screw mechanics. Dent Clin North Am 1998;42:71-89.
13. Rangert B, Jemt T, Jorneus L. Forces and moments of Branemark implants. Int J Oral Maxillofac Implants 1989;4:241-247.
14. Brosky ME, Korioth TW, Hodges J. The anterior cantilever in the implant-supported screw-retained mandibular prosthesis. J Prosthet Dent 2003;89:244-249.
15. Burguete RL, Johns RB, King T, Patterson EA. Tightening characteristics for screwed joints in osseointegrated implants. J Prosthet Dent 1994;71:592-599.
16. Haack JE, Sakaguchi RL, Sun T, Coffey JP. Elongation and preload stress in dental implant abutment screws. J Oral Maxillofac Implants 1995;10:529-535.
17. Binon PP. The effect of implant/abutment hexagonal misfit on screw joint stability. Int J Prosthodont 1996;9:149-160.
18. Motosh N. Development of design charts for bolts preloaded up to the plastic range. J Eng Ind 1976:98:849-851.
19. Binon PP. Implants and components : Entering the new millenium. Int J Oral Maxillofac Implants 2000;15:76-94.
20. Choi JU, Jeong CM, Jeon YC, Lim JS, Jeong HC, Eom TG. Influence of Tungsten Carbide/Carbon coating on the preload of implant abutment screws. J Korean Acad Prosthodont 2006;44(2):229-242.
21. Drago CJ. A clinical study of the efficacy of Gold-Tite square abutment screws in cement-retained implant restorations. Int J Oral Maxillofac Implants 2003;18(2):273-278.
22. Mezger PR, Creugers NH. Titanium nitride coatings in clinical dentistry. J Dent 1992;20(6):342-344.
23. Kim JN, Chung CH, Kim HJ. Surface change and fit of TiN-coated abutment screw after repeated closing and opening.

J Korean Acad Prosthodont 2007;45(1):119-130.

24. Burguete RL, Johns RB, King T. Tightening characteristics for screwed joints in osseointegrated dental implants. J Prosthet Dent 1994;71:592-599.

25. Abkowitz S, Burke JJ, Hiltz RH. Titanium in industry. New York: Van Nostrand Co Inc; 1955

26. Koo CI, Chung CH, Choe HC. Effects of surface coating on the screw release of dental implant screw. J Korean Acad Prosthodont 2004;42(2):210-225.

27. Kim HJ. Choe HC, Kim SG, Chung CH. Effect of TiN coating of abutment screw on detorque force. Int J Oral Maxillofac Implants 2007 under review

28. Lee JY, Chung CH. Mechanical properties of TiN coated film with various coating thickness on titanium alloy. J Korean Acad Prosthodont 2007 under review

29. Winkler S, Ring K, Ring JD, Boberick KG. Implant screw mechanics and the settling effect : An overview. J Oral Implantol 2003;29:242-245.

30. Jorneus L, Jemt T, Carlsson L. Loads and designs of screw joints for single crowns supported by osseointegrated implants. Int J Oral Maxillofac Implants 1992;7:353-359.

31. Sakaguchi RL, Borgersen SE. Nonlinear contact analysis of preload in dental implant screws. Int J Oral Maxillofac Implants 1995;10:295-302.

32. Sopwith DG. The distribution of load in screw threads. Proc Inst Mech Eng 1948;159:373-383.

33. Bickford JH. An introduction to design and behavior of bolted joints. New York : Marcel Decker, 1981

34. Weiss EI, Kozak D, Gross MD. Effect of repeated closure on opening

torque values in seven abutment-implant systems.
J Prosthet Dent 2000;84(2):194-199.
35. Standlee JP, Caputo AA. Accuracy of mechanical torque-limiting devices for implant. Int J Oral Maxillofac Implants 2002;17(2):220-224.