A STUDY ON SURFACE OF VARIOUS ABUTMENT SCREWS

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Statement of problem : Regardless of any restoration, most of case, we used in screw connection between abutment and implant. For this reason, implant screw loosening has been remained problem in restorative practices.

Purpose : The purpose of this study was to compare surface of coated/plated screw with titanium and gold alloy screw and to evaluate physical property of coated/plated material after scratch test in FESEM investigation

Material and methods : GoldTite, titanium screw provided by 3i (Implant Innovation, USA) and TorqTite, titanium screw by Steri-Oss (Nobel Biocare, USA) and gold screw, titanium screw by AVANA (Osstem Implant, korea) - were selected for this study. Each abutment screw surface was observed at 100 times, and then screw crest, root, and slope were done more detailed numerical value, at 1000 times with FESEM. A micro-diamond needle was also prepared for the scratch test. Each abutment screw was fixed, micro-diamond scratch the surface of head region was made at constant load and then was observed central region and periphery of fine trace through 1000 times with FESEM.

Results : The surface of GoldTite was smoother than that of other kinds of screw and had abundant ductility and malleability compared with titanium and gold screw.The scratch test also showed that teflon particles were exfoliated easily in screw coated with teflon.Titanium screw had a rough surface and low ductility.

Conclusion : It was recommended that the clinical use of gold-plated screw would prevent a screw from loosening.

CLINICAL IMPLICATIONS

Clinical use of gold-plated screw would prevent a screw from loosening because it had abundant ductility and malleability compared with titanium and gold screw.

Key Words
Screw loosening, Screw surface treatment, FESEM, Scratch test

In recent years, the use of osseointegrated implants has been popular single-tooth restoration, partially edentulous, fully edentulous restoration. Regardless of any restoration, most of case, we used in screw connection between abutment and

implant. For this reason, implant screw loosening has been remained problem in restorative practices.[1,2]

Abutment screw loosening was reported in a large number of studies and ranged from 2% to 45% of the abutment.[3-6] One suggested reason for the high incidence of screw loosening from early studies was that the abutment screw were made of titanium, and devices capable of providing counter torque during tightening were not available. These problems seemed to be solved through the use of gold alloy abutment screw that yield a higher screw preload when properly torqued.[2] Current gold screw varied between manufacturers, ranging in gold content from 64.1% to 2%, with yield strength of 1,270 N to 1,380 N[7].

In an effort to reduce frictional resistance even more, dry lubricant coating have been applied to abutment screw. The most notable were GoldTite (Implant Innovation, 3i) and TorqTite (Nobel Biocare, Steri-oss).[8]

The GoldTite was to plate the standard gold-alloy screw with 0.76㎛ thickness of pure gold. With a tightening torque of 32 Ncm, the manufacturer reported a 24% increased preload for the gold-plated screw.[9] TorqTite was a teflon coating applied to titanium alloy screw, with a reported reduction of the frictional coefficient by 60%.[6,10]

Will C. et al. noted that GoldTite and TorqTite abutment screw with enhanced surfaces that help reduce the coefficient of friction produced greater rotational angles and preload values than the conventional gold alloy and titanium alloy screws.[2] Jeong. et al. reported that in the case of GoldTite, implant and screw had relatively close and tight contact without the presence of large gap and in the case of TorqTite, abutment screw and implant interface demonstrate incomplete seating and only partially contact of threads between implant and screw5. Rachel et al. noted that the mean values for combined anodizing abutment versus nonanodized group in ITI system were 27.9 Ncm and 33.9 Ncm and anodization of the abutment surface reduced the resistance to loosening by approximately 20%.[11]

These articles presented that surface treatments(coating, plating, anodization) play a role of preventing screw from loosening in implant screw mechanism.

The purpose of this study was to compare surface of coated/plated screw with titanium and gold alloy screw and to evaluate physical property of coated/plated material after scratch test in FES-EM investigation.

MATERIALS AND METHODS

Materials(Table Ⅰ)

Each of the following type of abutment screws - GoldTite, titanium screw provided by 3i (Implant Innovation, USA) and TorqTite, titanium screw by Steri-Oss (Nobel Biocare, USA) and gold

Table I. manufacturers and type of screws used in this study.

Implant manufacture	Type of Screw	Type of Alloy
3i,	GoldTite	Gold-plated gold-palladium
Implant Innovation	Titanium	Titanium
Steri-Oss,	TorqTite	Teflon-coated Titanium
Nobel Biocare	Titanium	Titanium
AVANA,	Gold	Gold
Osstem Implant	Titanium	Titanium

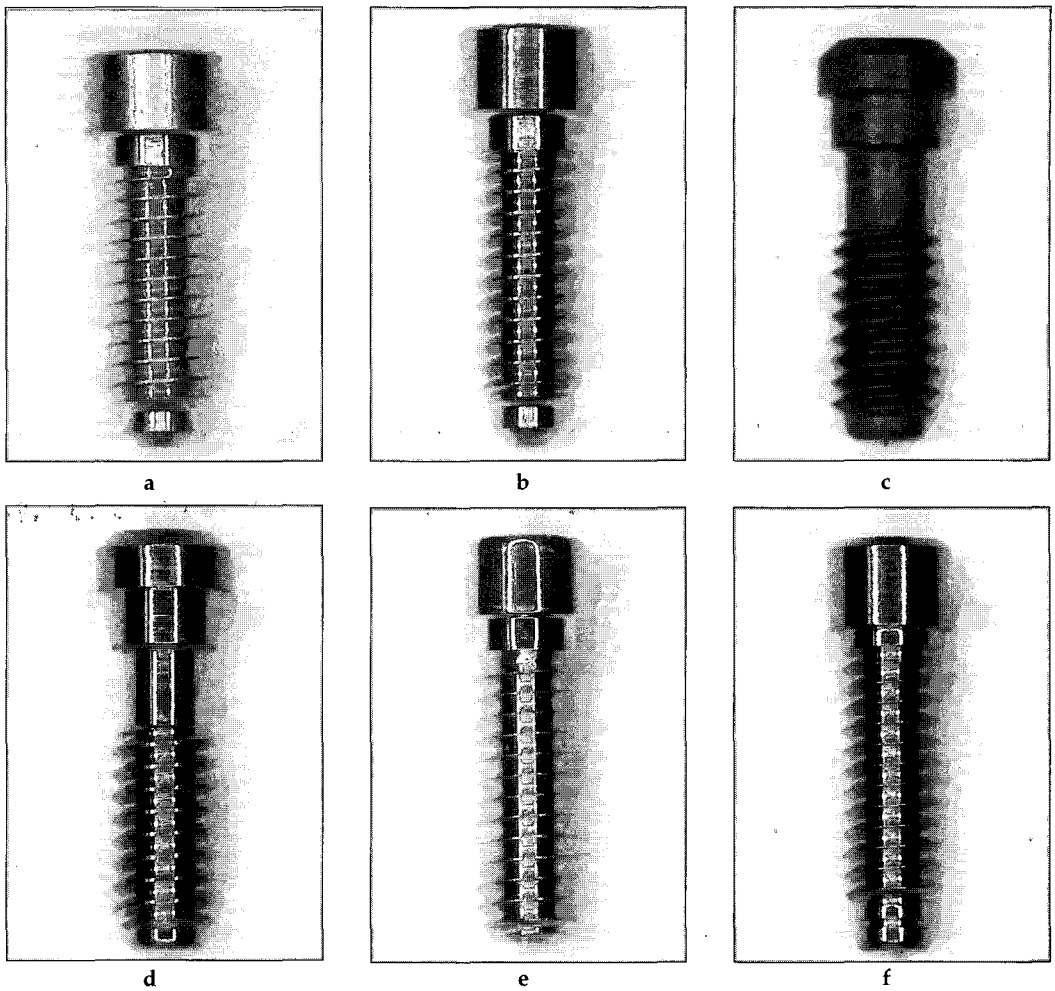


Fig. 1. Type of screws (a: GoldTite of 3i, b: titanium screw of 3i, c: TorqTite of Steri-Oss, d: titanium screw of Steri-Oss, e: gold screw of AVANA, f: titanium screw of AVANA).

screw, titanium screw by AVANA (Osstem Implant, Korea) - were selected for this study. Fig 1. shows the type of screws used in this study. Table Ⅰ. lists the manufacturer and type of screws used in this study.

Methods

1. FESEM investigation of surface of new abutment screw

The new screws which was provided by a manufacturer were taken. A tungsten tip was used where micromanipulation of the specimens was carried out under FESEM (field emission scanning electron microscope, Netherland, Phillips co, model:XL 30 SFEG) investigation. Care was taken not to touch the thread surface of abutment screw to avoid contamination of the surface. Each abutment screw surface was observed at 100 times, and then screw crest, root, and slope were done more detailed numerical value, at 1000 times.

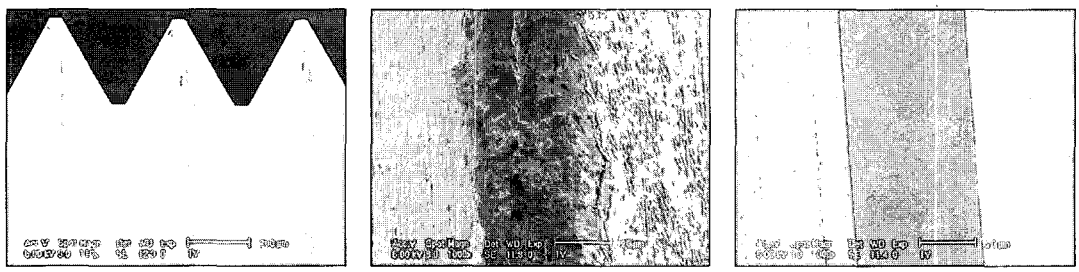
2. FESEM investigation of scratched abutment screw surface

A micro-diamond needle was also prepared for the scratch test. When it was a condition that each abutment screw was fixed, it was made the micro-diamond scratch the surface of head region at constant load and then was observed central region and periphery of fine trace through the numerical value, 1000 times with FESEM.

Results

1. FESEM investigation of surface of new abutment screw

After watching the surface of new abutment screws that were provided with companies with FESEM that had 100 times, we came to know that all of them have different external forms, and the amount of surface roughness and foreign-material was various. It was resulted that GoldTite had very smooth surface (Fig. 2) and TorqTite had rough surface due largely to coated material on the surface (Fig. 4). There was a large amount of foreign-materials in titanium screw of Steri-Oss (Fig. 5). In this case, through 1000 times, the crests of all screws showed the rough surface and the surfaces of root were very smooth. In the case of slope, the milling statement of GoldTite was the best quality while there was shown that screw of AVANA was rough statement (Fig. 2,3,4,5,6,7).



a b c

Fig. 2. Pictures of GoldTite screw surface of 3i, Implant Innovation in FESEM (a: magnification ×100, b: screw crest, ×1000, c: screw root, ×1000).

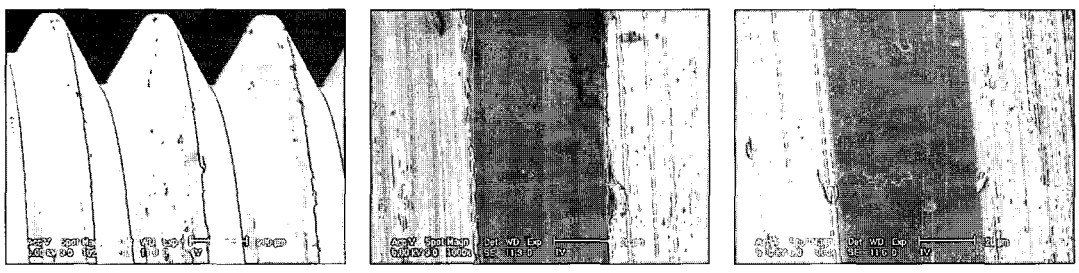


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Fig. 3. Pictures of titanium alloy screw surface of 3i, Implant Innovation in FESEM (a: magnification ×100, b: screw crest, ×1000, c: screw root, ×1000).

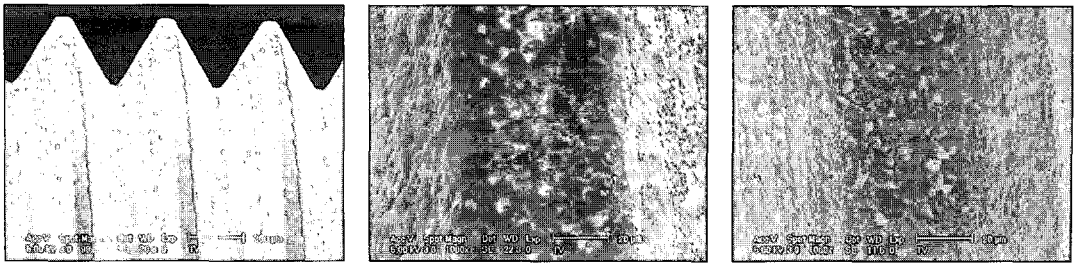

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Fig. 4. Pictures of TorqTite screw surface of Steri-Oss, Nobel Biocare in FESEM (a: magnification ×100, b: screw crest, ×1000, c: screw root, ×1000).

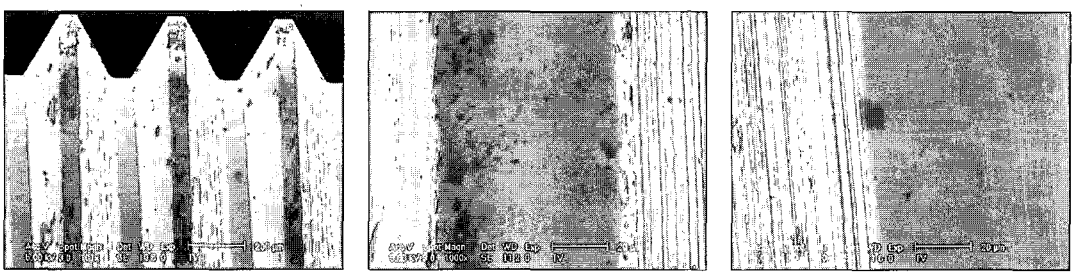

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Fig. 5. Pictures of titanium alloy screw surface of Steri-Oss, Nobel Biocare in FESEM (a: magnification ×100, b: screw crest, ×1000, c: screw root, ×1000).

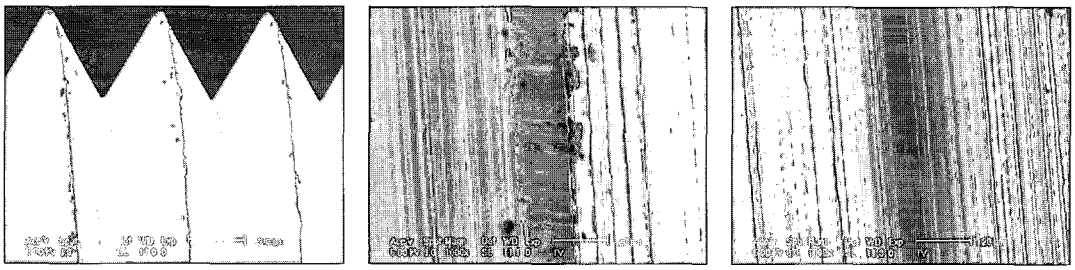

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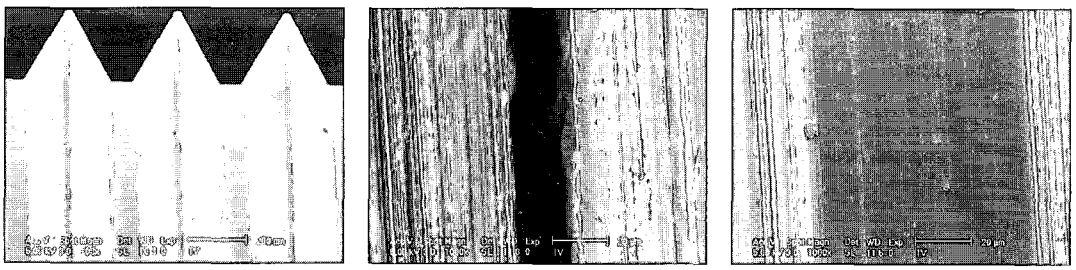
Fig. 6. Pictures of gold alloy screw surface of AVANA, Osstem Implant in FESEM (a: magnification ×100, b: screw crest, ×1000, c: screw root, ×1000).



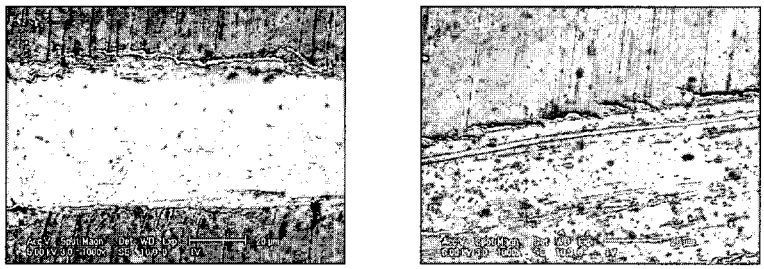
a b c

Fig. 7. Pictures of titanium alloy screw surface of AVANA, Osstem Implant in FESEM (a: magnification ×100, b: screw crest, ×1000, c: screw root, ×1000).

2. FESEM investigation of abutment screw surface after scratch test

After scratch test, abutment screws surface in each manufacture was magnified at 1000 times with FESEM.

1) In case of 3i, GoldTite screw surface showed that irregular material metamorphosis were observed in periphery of the trace, which means it was because of abundance of ductility and malleability that was one of the gold properties. Titanium screw surface had a little bit ductility trace, so it was shown not only ductility less than GoldTite screw surface but also depth of trace was not deeper than it(Fig. 8).
2) In case of Steri-Oss, TorqTite screw surface coated with teflon showed almost the similar appearance with titanium screw surface but teflon particles were exfoliated easily(Fig. 9).
3) In case of AVANA, gold screw had more ductility trace than titanium screw and it had less than GoldTite(Fig. 10).



a b

Fig. 8. Pictures of 3i abutment screw surface after scratch test in FESEM (magnification × 1000, a: GoldTite, b: titanium alloy screw).

a b

Fig. 9. Pictures of Steri-Oss abutment screw surface after scratch test in FESEM(magnification × 1000, a: TorqTite, b: titanium alloy screw).

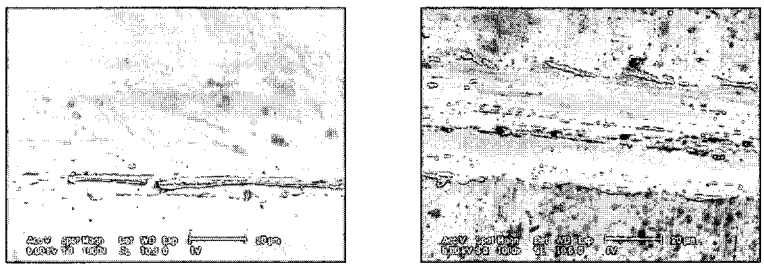


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Fig. 10. Pictures of AVANA abutment screw surface after scratch test in FESEM (magnification × 1000, a: gold screw, b: titanium alloy screw).

DISCUSSION

This study showed surface roughness of screws were difficult with the manufacturer and materials of screw. This was related with settling that happens with screw tightening.

As the screw-joint components pressed together, the microsurface irregularities under the screw head, in the threads, and on the contact surface of the gold cylinder and the abutment start to flatten out. This surface deformation of the contacting surfaces is called "settling".[12] The magnitude of settling depends on the initial surface roughness and surface hardness as well as the magnitude of the loading forces. Rough surfaces and large external loads increase the settling.[11] After engaging the threads, the surface asperities are flattened so more input torque is applied toward elongation of the screw and production of preload. Ten percent of initial preload can be lost because of setting.[13-16]

In this study, it was observed that GoldTite had very smooth surface and TorqTite had rough surface due largely to coated material on the surface. It might be thought that gold plating made surface smooth, settling was generated less. But, rough surface of TorqTite can generated more settling effect. In addition, the different magnitude of foreign materials of screw surface and inaccuracy of milling statement can made settling effect accelerate. Thus, it is thought that manufactures have to make milling accurately and keep it carefully for smooth surface.

In the screw mechanism, when less input torque is lost to friction and heat, a higher preload is achived.[13] Motosh noted that initially, about 90% of input torque is used to overcome friction and only 10% to induce preload.[17] When titanium slides in contact with other metals of similar hardness, the coefficient of friction is initially fairly low, with repetitions of tightening and loosening, the values gradually increase to that for titanium against titanium.[18] Abkowitz et al. found this increase in the coefficient to be attributable to the galling and seizing tendency of titanium. Because of this property, there was found friction power increasing in the interval between titanium and titanium or between gold screws after loosening continually.[18]

In our study, scratch test indicated that the surface of titanium screw and gold screw showed less ductility and malleability, which corresponded with the result that friction power between titanium and titanium increased when tightening.

Richard L. et al. noted that the importance of tightening is the application of the optimum preload, but the operation of tightening involves the application of torque. Applied torque and preload are only indirectly proportioned to one another because of the influence of the friction forces under the head of the screw. The coefficient of friction is depending on the hardness of the threads, the surface finishes, the quantity and properties of the lubricant, and the speed of tightening. The coefficient of friction will increase as the quantity of lubricant decreases.[19]

Now that it was used gold at 3i and teflon at Steri-oss in dry lubricant coating surface screw, it helped reduce the coefficient of friction, so made loosening decrease with being provided with increased preload when tightening screw.[9] Gold has physical property such as the most malleable and ductile of any metal, resistance to corrosion,[20] so space can be closed between screw and thread if pure gold compress slightly between titanium and gold alloy[5] And also, high ductility leaded to decrease of friction and settling when screw is tightened. Teflon consists of bond of carbon and fluorine such as polytetrafluoroethylene, or PTFE, which has physical properties, low adhesive property, low coefficient of friction, thermal resistance, chemical resistance, abrasion resistance and thermal conductivity. With using

this physical properties, it can have preload more that coating on titanium screw in order to decrease friction when tightening. In addition, it also has the advantage that is not contained foreign-material because of low adhesive property. However, it is easy to fracture in the region of stress concentration because these polymer has the property of brittle. This study showed that as a result of scratch test, exfoliation of teflon was seen more than other material. It gave suggestions that particle of teflon can be exfoliate after tightening and loosening and loading inside the oral cavity. Resultantly, contact between TorqTite and titanium implant will show the same appearance of contact between titanium and titanium. Jung et al. mentioned about TorqTite that abutment screw and implant interface demonstrate incomplete seating only partially contact of threads between implant and screw, which was related to the phenomenon of teflon exfoliation in our study.

According to this study, it was recommended that the clinical use of gold-plated screw would prevent a screw from loosening, because settling effect and friction force generates less and preload does more in the gold-plated screw with titanium screw when tightening and loosening. It is also considered that Teflon coating helps friction power to lessen although it had a possibility of exfoliation. we recommended that it avoid tightening repeatedly.

CONCLUSIONS

The purpose of this study was to compare surface of coated/plated screw with titanium and gold alloy screw and to evaluate physical property of coated/plated material after scratch test in FES-EM investigation.

The results were as follows;

1. The surface of GoldTite was smoother than that of other kinds of screw.
2. The surface of TorqTite was rougher than that of other kinds of screw.
3. The result of scratch test was that the screw surface plated with pure gold had abundant ductility and malleability compared with titanium and gold screw.
4. The result of scratch test also showed that gold screw had a more ductility and malleability compared with titanium screw.
5. The scratch test also showed that teflon particles were exfoliated easily in screw coated with teflon.
6. Titanium screw had a rough surface and low ductility.

In conclusions, it was recommended that the clinical use of gold-plated screw would prevent a screw from loosening. It is also considered that Teflon coating helps friction power to lessen although it had a possibility of exfoliation. we recommended that it avoid tightening repeatedly.

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