[UCI]I804:24011-200000237707

2009년 2월
석사학위 논문

Sinking and Fit of Abutment of Conical Internal Connection Implant System

조선대학교 대학원

치의학과

문 승 진

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원추형 내측연결 임플랜트 시스템에서 지대주 침하 및 적합에 관한 연구

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이 논문을 치의학 석사학위신청 논문으로 제출함

2008년 10월

조선대학교대학원

치의학과

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Screw의 대체방법으로 locking taper 연결방식이 소개되었으며, 본 연구에서는 원추형 내측연결 임플랜트의 한 종류인 Bicon 임플랜트에 여러 하중을 가했을 때 지대주의 적합도 및 침하정도를 평가하고자 하였다.

실험에는 10개의 Bicon 임플랜트가 사용되었다. 지대주를 고정체에 연결할때는 임상에서 locking taper connection 형태의 지대주를 고정체에 연결하는 순서대로 하중을 가하였다. 먼저 지대주를 손으로 지긋이 눌러 고정시킨 후, mallet을 이용하여 약 3회 정도 타격을 가하여 고정시켰다. 다음으로 하중적용장치를 제작하여 저작력에 해당하는 20Kg의 하중을 추가로 적용하였다. 지대주-고정체에 압력을 가하지 않고 가볍게 결합시킨 상태를 참고길이로 하고, 각각 하중 후마다 길이를 측정하여 길이의 변화(침하량)를 측정하였다.

주사전자 현미경 관찰을 위한 시편을 제작하기 위해 시편을 액상 불포화 polyester(Epovia)에 매몰하여 중합시킨 후 High Speed Precision Cut-off로 절단하였다. 그 다음 Automatic Specimen Polisher로 연마하고 Ultrasonic cleaner로 세척한 후 주사전자 현미경으로 관찰하였다.

그 실험결과는 다음과 같았다.

1. 하중이 추가됨에 따라 지대주는 더 침하하는 양상을 보였다.
2. 하지만 20kg 하중을 수회 적용한 결과, 5-7회 적용 후 총 0.45±0.09mm까지 침하한 후 더 이상 침하하지 않았다.
3. Locking taper 연결방식의 임플랜트는 대체로 저작압에 좋은 적합도를 보이지만,

하중을 받음에 따라 지대주가 침하하는 경향을 가지고 있음을 알 수 있었다.
4. Locking taper 연결방식의 임플랜트를 사용할 때는 지대주를 정확히 위치시키기 위해 저작력에 준하는 하중을 5회 이상 적용하는 것이 추천된다.

I. Introduction

Various connection types between implant and abutment are being used, and these determine joint strength, joint stability and stability of location and rotation. It is critical to and synonymous with prosthetic ability.[1)]

Connection between implant and abutment can be classified into external connection and internal connection. External connection is made by connecting abutment to the hex top at the upper part of the implant fixture and fixing it with screw. On the contrary, some portion of the abutment is inserted into the fixture in internal connection. Advantages of external connection are that it's operator friendly and various prosthetic restorations are available by selecting various abutments. However it is vulnerable to rotational and lateral force because of the butt joint on abutment and fixture interface permitting slight movement.[2,3)] To overcome these kind of inherent design limitations of the external connection, internal connection has been developed.[1)] Internal connection gives delicate abutment/fixture engagement, following no micromovement or microleakage, and prevention of loosening by frictional resistance between metal surfaces. It has stable interface geometry with sloped internal wall of fixture distributing lateral loading and occlusal pressure.[2,4)] Moreover, it offers reduced vertical height platform for restorative components; distribution of lateral loading deep within the implants; a shielded abutment screw; the potential for a microbial seal; and extensive flexibility. Long internal wall engagement creats a stiff, unified body that resists joint loosening and buffers vibration. For last, it is more esthetic because restorative interface is lowered to the implant level.[1)]

The original and most commonly used method for connecting abutment to implant is using screw. But screw loosening and screw fracture are major disadvantage of this method. Charles J. et al mentioned screw loosening is the most frequent complication reported.[5)] Screw loosening occurs when occlusal force excesses preload or when it comes to creep deformation on screw-implant interface.[6)] Jemt et al reported that screw loosening can cause more serious problem with single tooth restoration.[7] Also screw loosening appears to be a factor of other components' failure[8] and some authors proposed to re-tighten the screw every 5 years.[9]

Locking taper connection has been introduced alternative to screw-retained abutment systems.[10] Unlike screw-retention type, fixture-abutment retention in Locking taper connection depends on the frictional force so it has possibility of abutment sinking. Thus, we used Bicon Implant System® (Bicon Inc, Boston, USA) which is one of the conical internal connection implant system, and applied loading to the abutments connected to the fixture and measured the amount of sinking. Also we observed adaptiveness at abutment-fixture connection part through field emission scanning electron microscopy.

Ⅱ. Materials and Methods

1. Materials

1) Implant fixture and abutment

In this study, we used 4.5 x 11mm (Uncoated implant 3.0mm well) sized fixture of Bicon Implant System® (Bicon Inc, Boston, USA) which is conical internal connection implant system. For the abutment, we used locking taper connection type of conical abutment (5.0 x 6.5mm 0° Non-Shouldered Abutment 3.0mm Post) (Fig.1).

2) Loading application instrument

An apparatus was designed to tap with load of 20Kg vertically as many times as possible (Fig.2).

2. Methods

1) Connecting abutment to the implant fixture

The abutment was slightly attached to the fixture with no pressure and this state of length was treated as a reference length of abutment-fixture (Fig.3).

2) Loading conditions

We applied loads in the clinical order of connecting locking taper connection type abutment to the fixture. First, we connected the abutment to the fixture using finger force (Fig.4). Then we tapped with a mallet for 3 times (Fig.5) and loads of 20kg corresponding to masticatory force were applied successively.

A Jig that fits into the fixture was made not to make any movement of the fixture (Fig.6).

In order, a finger force, 3 times of malleting force, and vertical load of 20kg were added to 10 each abutments which were connected with fixtures. Load of

20kg were added until there was no more sinking of the abutment.

3) Measuring the amount of sinking.

0.01mm unit Caliper (Absolute Digimatic Caliper, Mitutoyo, Kawasaki, Japan) was used to measure total length of abutment-fixture (Fig.7). The state of abutment being slightly connected to the fixture with no pressure was considered as a reference length, and every length was measured after each loads were added. The amount of abutment sinking(mm) was gained by subtracting the length of abutment-fixture under each loading condition from reference length.

4) Making samples and measuring adaptiveness

(1) Mounting implant with resin block

Unsaturated polyester (Epovia, Cray Valley Inc, Jeonju, Korea) that consists of resin and hardener was used to mount implants and it was polymerized completely (Fig.8,9).

(2) Cutting, polishing and ultrasonic washing of samples.

We used High Speed Precision Cut-Off (Accutom-5, Struers, Ballerup, Denmark) for cutting off resin block, Automatic Specimen Polisher (Rotopol 2, Struers, Ballerup, Denmark) for polishing and ultrasonic cleaner for washing (Fig.10,11).

(3) Examination of samples through field emission scanning electron microscopy

FE-SEM(field emission scanning electron microscopy) was used to analyze and compare the adaptiveness of connection of abutment-fixture (Fig.12).

5) Statistical Analysis

SPSS 16.0 program for Windows was used to analyze statistical significance of differences between two proximal loading groups.

If normality and homoscedasticity were not shown in two groups, Mann-Whitney Rank Sum Test was performed, and Student T Test was conducted if normality and homoscedasticity were shown.

Also we used Oneway ANOVA on Ranks to see the differences between two groups fell apart (not proximal).

Fig.1. Fixture and abutment used for this study.

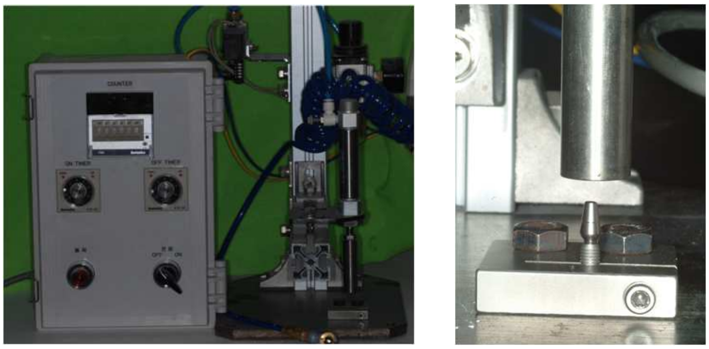


Fig.2. Loading application instrument.

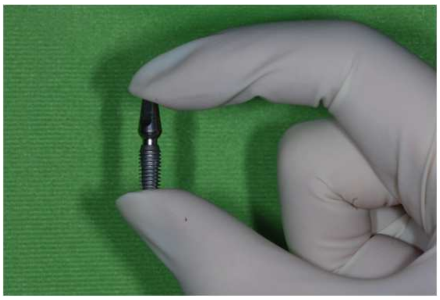


Fig.3. Reference length of abutment-fixture under no pressure.

Fig.4. Application of finger force.

Fig.5. Tapping with a mallet.

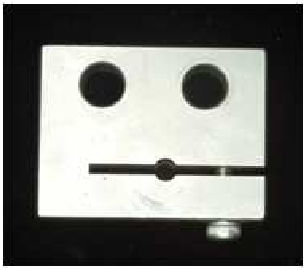


Fig.6. Jig for implant fixation.

Fig.7. Caliper (Absolute Digimatic Caliper, Kawasaki, Japan) for measurement of implant length.

Fig.8. Mounting media.

Fig.9. Abutment-fixture mounting.

Fig.10. High Speed Precision Cut-off.

Fig.11. Automatic Specimen Polisher.

Fig.12. Specimen which was sectioned.

Ⅲ. Results

1. Amount of abutment sinking under loading condition.

A finger force, 3 times of malleting force, and load of 20kg were added in order and we obtained the amount of sinking by measuring length of abutment-fixture with Caliper (Absolute Digimatic Caliper, Kawasaki, Japan) (Fig.13., Table 1.).

(unit : mm)

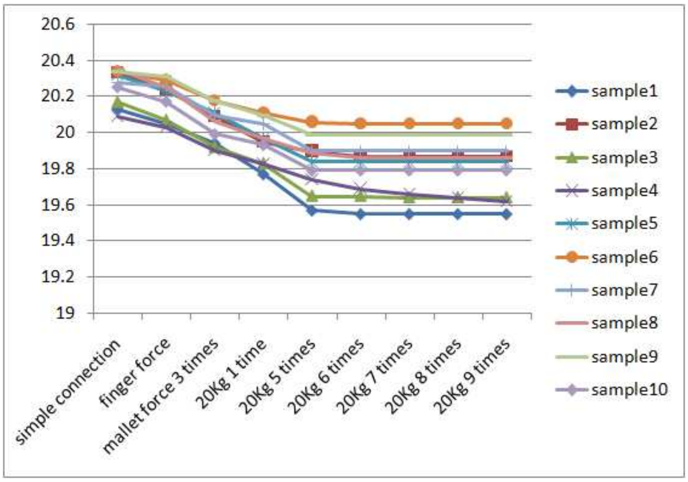


Fig.13. Change in length of abutment-fixture.

Table 1. Amount of abutment sinking under loading application. *(unit : mm)*

Loading condition \ Sample No.	1	2	3	4	5	6	7	8	9	10	Mean	SD
Load 1	0.08	0.09	0.10	0.06	0.09	0.05	0.02	0.10	0.03	0.08	0.07	0.03
Load 2	0.19	0.24	0.25	0.19	0.21	0.16	0.18	0.29	0.16	0.26	0.21	0.04
Load 3	0.36	0.38	0.34	0.26	0.35	0.23	0.23	0.38	0.24	0.32	0.31	0.06
Load 4	0.56	0.43	0.52	0.35	0.48	0.28	0.38	0.46	0.35	0.46	0.43	0.09
Load 5	0.58	0.46	0.52	0.40	0.48	0.29	0.38	0.49	0.35	0.46	0.44	0.09
Load 6	0.58	0.46	0.53	0.43	0.48	0.29	0.38	0.49	0.35	0.46	0.45	0.09
Load 7	0.58	0.46	0.53	0.45	0.48	0.29	0.38	0.49	0.35	0.46	0.45	0.09
Load 8	0.58	0.46	0.53	0.47	0.48	0.29	0.38	0.49	0.35	0.46	0.45	0.09

Load 1: Finger force 1 time application.

Load 2: Finger force 1 time and malleting force 3 times application.

Load 3: Finger force 1 time and malleting force 3 times and 20kg 1 time application.

Load 4: Finger force 1 time and malleting force 3 times and 20kg 5 times application.

Load 5: Finger force 1 time and malleting force 3 times and 20kg 6 times application.

Load 6: Finger force 1 time and malleting force 3 times and 20kg 7 times application.

Load 7: Finger force 1 time and malleting force 3 times and 20kg 8 times application.

Load 8: Finger force 1 time and malleting force 3 times and 20kg 9 times application.

As seen above, abutment kept sinking as loads were added. After 5-7 times of load of 20kg, sinking stopped at 0.45±0.09mm, except for sample 4. It took 9 times of load of 20Kg to stop sinking.

2. Statistical analysis (Fig.14.)

In Mann-Whitney Rank Sum Test and Student T Test, we could see statistical significance only between the amount of abutment sinking under Load 1 and 2 (Mann-Whitney Test, $P<0.05$).

In Oneway ANOVA on Ranks, the amount of abutment sinking under Load 1 showed statistically significant difference with that of Load 4 and above (Tukey Test, $P<0.05$).

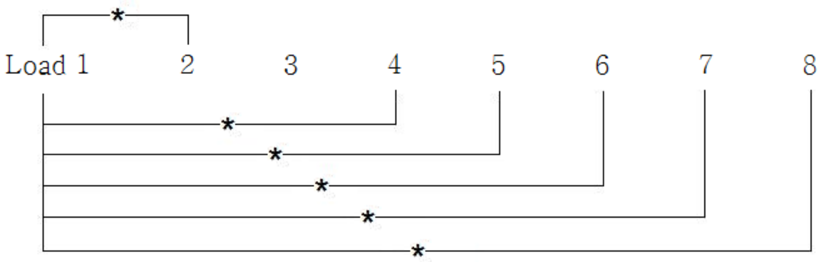
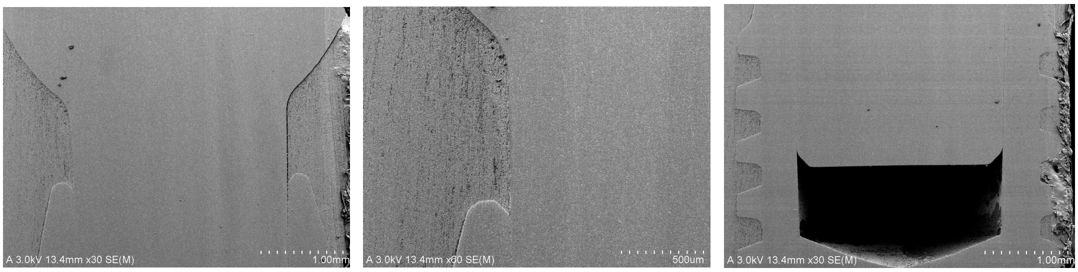


Fig.14. Statistical significant difference between the amount of abutment sinking under each loading condition.

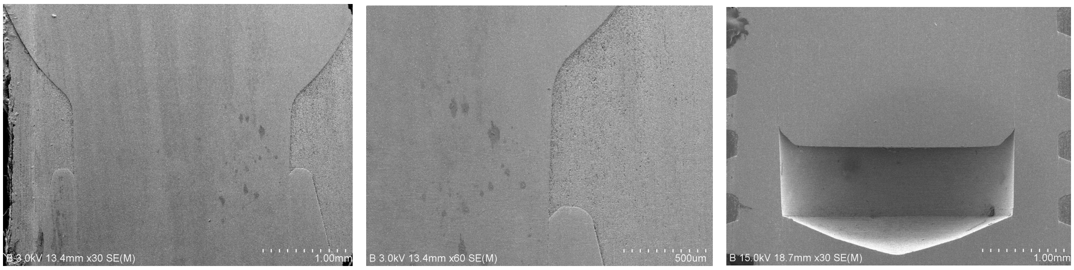
3. Adaptiveness of abutment-fixture

Fig. 15-19 shows cross sections of samples in resin block viewed by FE-SEM. Abutment of Bicon implant system® is locking taper connection type with 1.5° morse tapered post. It had relatively smooth and intimate contact except for the gap below the abutment. The contact was precise and compact(Fig. 15-19).



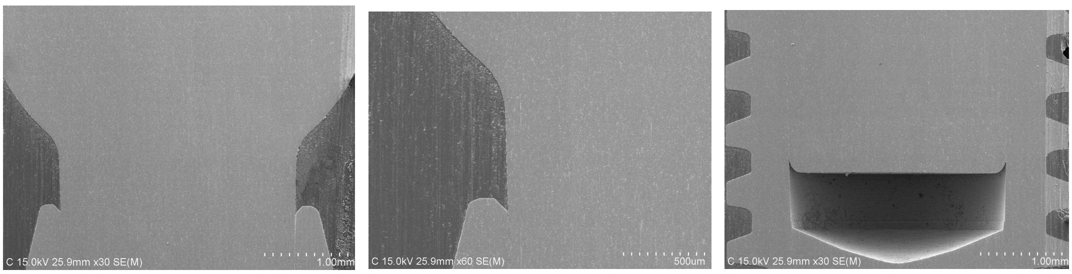
(a) (b) (c)

Fig.15. FE-SEM view of Load 2: mallet force 3 times (a: x30, b: x60, c: x30).



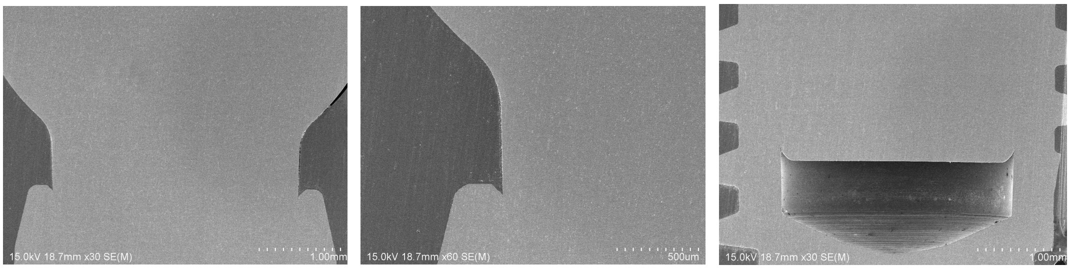
(a) (b) (c)

Fig.16. FE-SEM view of Load 3: 20Kg 1 time (a: x30, b: x60, c: x30).



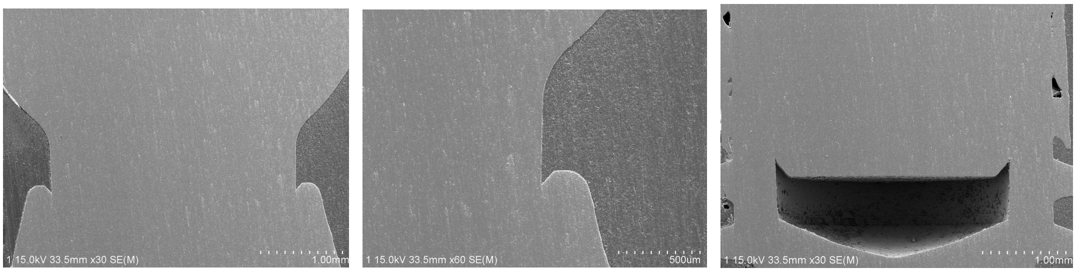
(a) (b) (c)

Fig.17. FE-SEM view of Load 4: 20Kg 5 times (a: x30, b: x60, c: x30).



(a) (b) (c)

Fig.18. FE-SEM view of Load 5: 20Kg 6 times (a: x30, b: x60, c: x30).



(a) (b) (c)

Fig.19. FE-SEM view of Load 6: 20Kg 7 times (a: x30, b: x60, c: x30).

Ⅳ. Discussion

The geometry of implant-abutment interface is one of the primary determinants of joint strength, joint stability, locational and rotational stability, and thus prosthetic stability.

Locking taper connection type abutment has been introduced alternative to screw-retained abutment systems. It has 1~2 degree tapered post that fits into a smooth mirror-image shaft, without any screw.[1] Surface of the abutment for Locking taper connection type appears to be smooth but actually it's not. Retention depends on the frictional resistance through morse taper. The high frictional force comes out of high contact pressure by relative slip between two surfaces. As a result, surface oxide layers break down, and the asperities fuse (known as cold welding). Therefore gaps between two surfaces disappear.[10]

Locking taper connection type implant with conical abutment has potential for microbial seal, prevention of joint opening, distribution of lateral loading deep within the implants and buffering vibration. Also it has high resistance to lateral force owing to fin shape increasing surface of the fixture.

However it is impossible to place abutment precisely and repeatedly without an index form. Also even the connections are stable, it lacks flexibility.[1] Through clinical study about reliability of Locking taper, Chapman et al.[11] reported occlusion and imprecise prosthesis can result in abutment fracture in screw-retained abutment. After analyzing 1,757 cases of Bicon implant there were no problem with retention or fracture of abutment but some losses of abutments were reported which were no big deal because it could be reconnected.

Unlike screw-retention type, abutment-fixture retention in Locking taper connection depends on the frictional force so it has possibility of abutment being sinking. Thus, we used Bicon implant system® which is one of the conical internal connection implant system, and applied loading to the abutments connected to the fixture and measured the amount of sinking. Also we observed adaptiveness at abutment-fixture connection part through field emission scanning electron microscopy.

In this study, masticatory force was assumed as 20kg. This value was referred to Gibbs and Mahan,[12] Craig,[13] Andersson,[14,15]'s study about occlusal force in natural dentition and Richter et al[16]'s study about occlusal force while implant functioning. However many studies have been demonstrated that direction and amount of occlusal force is not regular. It is reported the maximum vertical occlusal force that human can make is close to 800N and lateral force to 20 N.[17] Also it is reported implants on posterior regions connected to premolars obtained 60-120N of vertical loading while chewing. In single premolar or molar, they got maximum 120-150N of vertical loading. Also they reported clenching in centric occlusion caused 50N of loading both in natural and artificial teeth.[16] We made loading application instrument and applied load of 20kg corresponding to masticatory force. Unlike in oral conditions, fixed loads were applied in a fixed direction which gave limitations for representing forces applied in oral conditions.

The magnitude of the forces made by finger pressure and malleting can be converted into numerical value using Basic Force Gauge(Basic Force Gauge, Mecmesin, England).[18] Lee et al. figured out the mean value by measuring 20 times for each forces and the measurement was carried out by one person. As a result, they got the average value of finger force 5.91±0.58Kg, malleting force 3.35±0.29Kg.

The amount of abutment sinking in Bicon implant system® was shown to be increasing as loads were added. However little or no more sinking was shown when loads were applied more than 5-7 times. Consequently, locking taper type implant can cause occlusal discrepancy resulting from abutment sinking due to mastication. Thus when using locking taper connection type implant like Bicon implant system, following methods can be thought to prevent occlusal change caused by abutment sinking due to mastication; In laboratory, abutment should be tapped sufficiently in advance of making prosthesis. In clinic, dentist performs occlusal adjustment to some degree and finish complete occlusal adjustment after they make sure patients have masticated for enough period of time. In clinic, after connecting abutment, dentist make patients to use temporary crown for enough period of time and then take impression for abutment. Also check amount of sinking through periodic follow-up. There was a study about the amount of abutment sinking in Alloden implant system® (Nei corp, Seoul, Korea) (one of locking taper connection type implant) by Lee et al.[18)] They reported 0.51±0.06mm of sinking when loads were applied 7-8 times in conventional abutment, and 0.75±0.06mm of sinking when loads were applied 10-13 times in For Deep Implant(FDI) abutment. Comparing with our result, Bicon implant system® had less amount of sinking and fewer number of times needed to stop sinking than Alloden implant system®.

From statistical analysis, the amount of abutment sinking under Load 1 had statistically difference with that of Load 2 and load 4 above. Thus, the length under finger force shows statistically difference with that of 3 times of malleting force and shows statistically difference not until 1 time but from 5 times of load of 20Kg corresponding to masticatory force. Therefore, it has clinical implication that connecting abutment with malleting force and applying 5 or more times of setting force.

In FE-SEM examination, it had relatively smooth and intimate contact except for the gap below the abutment. The contact was precise and compact. Therefore, 1.5° locking taper connection is expected to play an important role in microbeal seal.

Therefore, when we use locking taper connection type implant, setting force of 5 or more times for precise abutment location and follow-up check for correcting occlusal discrepancy are recommended. The manufacturer should complement this aspect.

Ⅴ. Conclusion

In this study, to recognize the effect of abutment sinking on occlusion with Locking taper connection type implant, we used Bicon Implant System® (Bicon Inc, Boston, USA) and applied some loads on abutments connected to the fixture and measured the amount of sinking. And then we observed adaptiveness of connection of abutment-fixture through field emission scanning electron microscopy.

The results were as follows;

1. The amount of abutment sinking in Bicon Implant System® was shown to be increasing as loads were added.
2. When loads were applied more than 5-7times, sinking stopped at 0.45±0.09mm.
3. Even though locking taper connection type implant shows good adaptiveness against occlusal force, it has potential for abutment sinking as loads are given.
4. When we use locking taper connection type implant such as Bicon implant system®, setting force of 5 or more times is recommended for precise abutment location.

In conclusion, locking taper connection type implant showed generally favorable fitness to masticatory force. However the amount of abutment sinking was shown to be increasing as loads were added. When loads were applied more than 5-7times no more sinking was shown.

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저작물 이용 허락서

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논문제목	한글 : 원추형 내측연결 임플랜트 시스템에서 지대주 침하 및 적합에 관한 연구				
	영문 : Sinking and Fit of Abutment of Conical Internal Connection Implant System				

본인이 저작한 위의 저작물에 대하여 다음과 같은 조건아래 조선대학교가 저작물을 이용할 수 있도록 허락하고 동의합니다.

- 다 음 -

1. 저작물의 DB구축 및 인터넷을 포함한 정보통신망에의 공개를 위한 저작물의 복제, 기억장치에의 저장, 전송 등을 허락함
2. 위의 목적을 위하여 필요한 범위 내에서의 편집・형식상의 변경을 허락함. 다만, 저작물의 내용변경은 금지함.
3. 배포・전송된 저작물의 영리적 목적을 위한 복제, 저장, 전송 등은 금지함.
4. 저작물에 대한 이용기간은 5년으로 하고, 기간종료 3개월 이내에 별도의 의사표시가 없을 경우에는 저작물의 이용기간을 계속 연장함.
5. 해당 저작물의 저작권을 타인에게 양도하거나 또는 출판을 허락을 하였을 경우에는 1개월 이내에 대학에 이를 통보함.
6. 조선대학교는 저작물의 이용허락 이후 해당 저작물로 인하여 발생하는 타인에 의한 권리 침해에 대하여 일체의 법적 책임을 지지 않음
7. 소속대학의 협정기관에 저작물의 제공 및 인터넷 등 정보통신망을 이용한 저작물의 전송・출력을 허락함.

동의여부 : 동의(0) 반대( )

2009년 2월 일

저작자: 문 승 진 (서명 또는 인)

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