

Osseointegration of dental implants installed without mechanical engagement : a histometric analysis in dogs.

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감사의 글

먼저 박사 논문이 나오기까지 아낌없는 격려와 지도를 해 주신 최성호 교수님께 진심으로 감사 드립니다. 그리고 본 학위 논문의 시작에서 끝까지 소중한 충고와 조언을 해 주신 정의원 교수님, 김성태 교수님, 또한 논문 심사를 맡아주셨던 조규성, 이용근 교수님께도 깊은 감사의 말씀 전합니다.

또한 치주학이라는 학문에 입문하여 현재에 이르기까지 수많은 가르침과 지도 편달을 아끼지 않으셨던 김종관, 채중규, 김창성 교수님께도 깊은 감사를 드립니다.

그리고 실험과 수업 및 대학원 생활에서 많은 도움을 주신 치주과 의국 및 수련의 선생님들께 특히 차재국 선생님께 고마운 마음 전합니다.

대학원 석사과정부터 박사과정까지 함께하면서 서로 의지가 되고 힘이 되었던 동기 두 이 선생에게도 고마운 마음 전합니다.

늘 따뜻한 마음으로 응원해 주시고 힘이 되어주시는 시부모님, 친정부모님, 그리고 동생 주원이와 유정이, 늘 바쁘다는 핑계로 잘 보살펴주지 못해도 씩씩하게 잘 커주는 우리 아들 원영이, 원제, 병원 생활과 대학원 생활을 잘 할 수 있도록 실질적인 큰 도움을 주시는 이모님, 석사 논문에 이어 박사 논문에서도 통계처리에 도움을 준 나의 남편 용호씨, 우울할 때나 힘들 때나 언제나 내편 되어주는 친구들, 모두에게 진심으로 사랑하고, 감사의 마음 전합니다.

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김영희

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ABSTRACT

Osseointegration of dental implants installed without mechanical engagement: a histometric analysis in dogs

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Objectives: The purpose of this study was to elucidate the healing pattern of sand-blasted, large grid, acid-etched (SLA)-surfaced implants at two healing periods in a model that represents loosened implants (LIs) installed without mechanical engagement.

Materials and methods: Five mongrel dogs were used, in which 20 dental implants were prepared. The implants were divided into two groups according to the absence or presence of initial mechanical engagement: loosened implants (LIs) and control, respectively. An oversized drill was used to prepare the implant area for the LI group. The implants were allowed to heal for 4 or 8 weeks. After the healing period, the experimental animals were sacrificed and block sections were obtained for histological analysis and histometric measurements.

Results: All implants were in intimate contact with the host bone and were without any inflammation after both 4 and 8 weeks of healing. While the mean amount of bone-to-implant contact (BIC) was constant in the control group, it tended to increase in the LI group with increasing healing period. However, neither BIC nor bone density differed significantly between the groups or with the healing period.

Conclusion: From the results of the study, it can be conjectured that the submerged and unloaded SLA-surfaced implants could result in successful osseointegration, even if the mechanical engagement was not obtained at placement of the implants.

Key Words: dental implant, osseointegration, implant stability, implant surface, histomorphometry

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I. Introduction

Implant stability can be classed as either primary or secondary stability. Primary stability is defined as the stability achieved by mechanical engagement at placement of dental implants, where there is no biological union. In general, the diameter of the final drill used to prepare the implant site is slightly smaller than that of the corresponding fixture. Partial engagement of the thread into the bone produces a “press fit,” which secures the wound against external loading in the initial recovery stage, until biological osseointegration is established.

The level of primary stability is associated with the condition of the host bone bed, the thread design of the implant, and the surgical techniques used (Meredith 1998). The presence of more cortical bone in the bone bed will improve the primary stability. Primary stability might also be achieved by using a self-tapping, double-thread, tapered implant fixture with appropriate thread dimensions, even in cases of poor bone quality. Several techniques can be used to enhance bone quality, such as bone

compaction by an osteotome, undersized drilling, and implant installation without pretapping, instead of standard drilling protocols (Martinez et al. 2001). Nevertheless, clinical situations are often encountered in which it is not possible to obtain mechanical engagement. In particular, poor bone quantity and quality can compromise the stability of the implant. A widened drilling socket produced by inconsistent drilling may also be responsible for rotationally loosened implants (LIs).

The importance of primary stability has been emphasized since the introduction of the concept of immediate loading (Adell et al. 1981; Sennerby et al. 1992; Meredith 1998; Szmukler-Moncler et al. 2000). However, how much mechanical engagement is required for optimal bone healing around implants has yet to be determined, and the effect of rigid mechanical engagement on osseointegration is controversial. Overcompression of bone may result in hyalinization of the surrounding bone during the early healing stages, which may in turn result in a delayed overall healing time for osseointegration (Ueda et al. 1991).

The vital importance of rigid primary stability of the implant to successful and predictable osseointegration has been questioned. This might be true for machined-surfaced implants, but whether this is also true for sand-blasted, large grid, acid-etched (SLA)-surfaced implants is yet unclear. In unloaded and submerged situations, the fate of the implant installed without mechanical engagement by oversized drilling has not been determined.

Several rabbit experiments evaluating rotationally mobile implants revealed favorable outcomes (Ivanoff et al. 1996; Fernandes Ede et al. 2007; Blanco et al.

2011). However, these studies have been performed at the rabbit long bone. The results cannot be applied to human clinical situations due to significant differences in the metabolism of bone healing and micro/macrostructure of bone between the two species (Roberts 1994; Wang et al. 1998; Pearce et al. 2007). Thus, outcomes from experiments on alveolar bone in dogs would be more clinically relevant to humans.

The appropriate healing time is also important for successful osseointegration. Some studies have investigated the relationship between the initial and final stability of implants relative to healing time (Bischof et al. 2004; Nedir et al. 2004). It was found that implants with or without mechanical engagement reached a similar level of stability after the appropriate healing time. If final osseointegration of the loosened implant is achieved after a certain period of healing, the minimal healing time required for the implant to be able to bear the occlusal load should be determined.

The purpose of this study was to elucidate the healing pattern of SLA-surfaced implants at two healing periods in a model that represents loosened implants installed without mechanical engagement.

II. Material and methods

1. Experimental animals

Five male mongrel dogs, 18–24 months old and weighing about 30 kg, were used. All of the dogs had intact dentition and a healthy periodontium. Animal selection, management, and preparation, and the surgical protocols followed routine procedures approved by the Animal Care and Use Committee, Yonsei Medical Center, Seoul, Korea.

2. Experimental design

The bone sites were prepared and a total of 20 SLA surfaced implants (Implantium, Dentium, Seoul, Korea) were placed. Implants were divided into two groups according to the absence or presence of initial mechanical engagement: loosened implant (LI) and control, respectively (Fig. 1). The implants were allowed to heal for either 4 or 8 weeks.

3. Surgical procedures

All surgical operations were performed under general anesthesia. The dogs

received a preanesthetic intravascular injection of atropine (0.05 mg/kg; Kwangmyung Pharmaceutical, Seoul, Korea) and an intramuscular injection of xylazine (2 mg/kg; Rompun, Bayer Korea, Seoul, Korea) and ketamine hydrochloride (10 mg/kg; Ketalar, Yuhan, Seoul, Korea). Inhalation anesthesia was administered using 2% enflurane (Gerolan, Choongwae Pharmaceutical, Seoul, Korea). Infiltration anesthesia was administered using lidocaine (2% lidocaine hydrochloride-epinephrine 1:100,000; Kwangmyung Pharmaceutical). Following the extraction of all mandibular premolars and the first molar, the edentulous alveolar ridges were allowed to heal for 8 weeks. For the 8-week implant healing group, a midcrestal incision and full-thickness mucoperiosteal flap was made in the left side of the mandible. Implant osteotomy was prepared with a final drill bit that was the same size as the fixture (3.4 mm in diameter and 10 mm in length) for the LI group. The fixtures were placed manually using the fixture adapter without mechanical engagement, and rotational and vertical mobility was confirmed by digitally applied force to the fixture adaptor which was connected to the implant. The fixture adaptor was carefully removed after the insertion of fixture. Conventional standard drilling procedures and implant placements were performed in the control group, for which the final drill bit had a diameter of 2.85 mm; the fixture sizes of the control group were the same as for the LI group. Initial mechanical

engagement with the insertion torque exceeded 30 NCm was obtained. SLA-surfaced implants were placed in all cases. The flaps were sutured with a 4-0 resorbable suture material (Monosyn 4.0 Glyconate Monofilament, B. Braun, Tuttlingen, Germany), and the implants were submerged during the entire experimental period. The sutures were removed after 10 days.

After 4 weeks of healing, the same procedure was repeated on the right side of the mandible. The sacrifice of all the animals was executed by anesthesia drug overdose 4 weeks after the previous procedure (i.e., 8 and 4 weeks after implanting on the left and right sides, respectively). Block sections that included segments of the implants were dissected for histological analysis.

4. Specimen preparation

The block sections were fixed in 10% neutral buffered formalin for 10 days. They were then dehydrated in ethanol, embedded in methacrylate, and sectioned in the buccolingual plane using a diamond saw (Exakt, Apparatebau, Norderstedt, Germany). From each implant site, the central section was reduced to a final thickness of about 20 μ m. The sections were stained with hematoxylin-eosin. Histological analysis was performed using a stereomicroscope (MZFLIII, Leica, Wetzlar, Germany) and microscope (DM-LB, Leica). After conventional microscopic examination, histometric measurements were made using an automated image-

analysis system (Image-Pro Plus, Media Cybernetics, Silver Spring, MD, USA). The following parameters were measured:

- Bone-to-implant contact (BIC) within the six most coronal threads at the lingual side of the implant, defined as the percentage of the implant zone that is in direct contact with the bone over the total length of the implant.
- Bone density (BD) within the six most coronal threads at the lingual side of the implant, defined as the percentage of bone area over the total area between the imaginary line connecting the top of the thread and the fixture lines.

5. Statistical analysis

In this study, descriptive data analysis was performed. The measured data was presented as mean \pm standard deviation value.

III. Results

1. Clinical findings

Surgical wound healing was uneventful during the experimental period, with no complications including wound dehiscence, severe swelling, or bleeding being observed. All implants were well maintained during the postoperative periods.

2. Histologic findings

Light microscopic examination of all the implants demonstrated no sign of inflammation. No intervening fibrous tissue layer between any implant and the surrounding bone was observed. Most of the implant surface was in intimate contact with the host bone.

After 4 weeks of healing

In the LI group, a reversal line demarcating the drilled margin was present away from the tip of the implant thread, and the space was filled with newly formed, woven bone (Fig. 2). The coronal part of the implant was surrounded by dense cortical bone with a high BIC, while no difference in the BIC between the tip surface and the inner surface of the thread was found in the LI group. In the control group, several voids were

found at the thread tip engaged to the cortical bone (Fig. 3). The apical part of the implant was present in a marrow compartment containing adipocytes, vessels, collagen fibers, and some mononuclear leukocytes, and a narrow rim of bone was apparently apposed along the implant surface (Fig. 2b). There was no notable difference between the groups at this point in the healing process.

After 8 weeks of healing

The general histologic features of the LI group were similar to those of the control group (Figs. 4a and 5a). The borderline of the original drilling socket, which was apparent after 4 weeks of healing, was less clear after 8 weeks in both the LI and control groups (Fig. 5a). The woven bone within the thread was partly replaced by mature lamellar bone in the 8-week groups. Many primary osteons were observed around the implants (Figs. 4b and 5b).

3. Histometric analysis

The results of histometrical analysis of all 20 implants ($N=5$) are presented in Table 1. While the mean BIC was constant in the control group, in the LI group it tended to increase with the healing time. The BD was lower after 4 weeks than after 8 weeks of healing in both the LI and control groups.

IV. Discussion

Oversized drilling sockets were prepared to exclude the effect of mechanical engagement during the healing process of implants in the present study. The rotationally and vertically loosened implants were submerged, allowing undisturbed healing. The results revealed that SLA-surfaced implant installed with no mechanical engagement could achieve successful osseointegration that was comparable with the control condition after both 4 and 8 weeks of healing. The implant with mechanical engagement already exhibited a higher mean BIC value in the early phase, and maintained this BIC throughout the experimental period. On the other hand, the mean BIC value in the LI group appeared to increase gradually from 4 to 8 weeks of healing. It can be assumed that osseointegration would be obtained differently when there is no initial mechanical engagement. The result could be extrapolated that osseointegration in LI group is made totally with the newly formed bone from the bone adjacent to implant surface. It was observed that osseointegration was still going on even at 8 weeks. Furthermore, the similar levels of BIC were acquired in both groups in 8 weeks and this period of time could be expected to be shortened by the development of the surface modification of implant. It could be explained that compromised initial mechanical engagement was compensated by rapid biologic response which is obtained by direct osseointegration at bone-implant interface during healing (Meredith et al. 1997).

Poor primary stability has been considered as one of the major causes of implant failure in machined-surfaced implants (Romanos 2004). Micromotion at the bone–implant interface may affect the bone healing process and result in fibrous encapsulation (Soballe et al. 1992; Lioubavina-Hack et al. 2006). However, SLA surfaces accelerate osseointegration and facilitate appositional bone growth at the void between the drilled socket and the body of the implant. Recent advances in surface treatment have been found to promote BIC, even where the quality of the bone is poor, making earlier loading possible (Gotfredsen et al. 1995; Wennerberg et al. 1997; Lazzara et al. 1999). In other words, optimal surface treatment produces higher and faster osseointegration.

The apical portion of the implant is placed in the medullar space, where little mineralized substance exists. Since bony contact at the apical part is less than the coronal part, healing might be less influenced by the use of the oversized drilling protocol. In the present study, the histologic features of the apical part were similar in the groups. Thus, only coronal and lingual side of implant was investigated to exclude the buccal side where various level of bone loss can occur, and to exclude the apical area where various amount of trabecular bone exists. Davies reported that de novo bone formation can occur directly on an implant with a SLA surface by contact osteogenesis (Davies 1998). In the present study, the apical part of the implant was covered by a thin bony rim projecting into the medullar space, which can be elicited by contact osteogenesis.

The main difference was seen at the coronal cortical portion, which is composed mainly of dense mineralized bone. The control group was installed using a “press fit” method, which means that the triangular thread tip is partly engaged with the dense bone via mechanical compression. However, excessive compression forces might be detrimental to bone healing (Duyck et al. 2010; Padmanabhan & Gupta 2010). It has been reported that BIC is higher in rotationally mobile implants than in those with good mechanical engagement (Fugazzotto et al. 1993; Ivanoff et al. 1996). Duyck et al. (2010) also showed that implants with a high insertion torque were associated with greater marginal bone loss, thereby compromising implant success.

In the present study, resorption voids were observed at the thread tip area in the cortical part of the implant in the control group, while there were no such voids in the LI group. It has been reported that bone resorption can initially take place at compressed areas before new bone is formed (Berglundh et al. 2003; Slaets et al. 2006). In noncontact areas, bone can be formed immediately without a resorption process, thereby allowing faster osseointegration.

The submerged and unloaded implant model was used in this study. This would prevent the LI group from micro and macro movement during initial healing period, as they were not loaded postoperatively. The importance of an initial postsurgical healing without loading stress in the unstable implants has been demonstrated by the previous reports (Uthoff 1973; Ivanoff et al. 1996). In the present study, a torque rigid enough to tighten the abutment for loading could not be applied to the screw due to the rotational and vertical movement of implants in the LI group.

There are a few limitations in the present study. The sample size is quite small to show the statistical power. Further comparative studies with larger sample size should be conducted so as to increase the scientific and statistical power.

V. CONCLUSION

From the results of the study, it can be conjectured that the submerged and unloaded SLA surfaced implants could result in successful osseointegration, even if the mechanical engagement was not obtained at placement of the implants.

References

- Adell, R., Lekholm, U., Rockler, B. & Branemark, P.I. (1981) A 15-year study of osseointegrated implants in the treatment of the edentulous jaw. *International Journal of Oral Surgery* **10**: 387-416.
- Berglundh, T., Abrahamsson, I., Lang, N.P. & Lindhe, J. (2003) De novo alveolar bone formation adjacent to endosseous implants. *Clinical Oral Implants Research* **14**: 251-262.
- Bischof, M., Nedir, R., Szmukler-Moncler, S., Bernard, J.P. & Samson, J. (2004) Implant stability measurement of delayed and immediately loaded implants during healing. *Clinical Oral Implants Research* **15**: 529-539.
- Blanco, J., Alvarez, E., Munoz, F., Linares, A. & Cantalapiedra, A. (2011) Influence on early osseointegration of dental implants installed with two different drilling protocols: a histomorphometric study in rabbit. *Clinical Oral Implants Research* **22**: 92-99.
- Davies, J.E. (1998) Mechanisms of endosseous integration. *International Journal of Prosthodontics* **11**: 391-401.
- Duyck, J., Corpas, L., Vermeiren, S., Ogawa, T., Quirynen, M., Vandamme, K., et al. (2010) Histological, histomorphometrical, and radiological evaluation of an experimental implant design with a high insertion torque. *Clinical Oral Implants Research* **21**: 877-884.

- Fernandes Ede, L., Unikowski, I.L., Teixeira, E.R., da Costa, N.P. & Shinkai, R.S. (2007) Primary stability of turned and acid-etched screw-type implants: a removal torque and histomorphometric study in rabbits. *International Journal of Oral and Maxillofacial Implants* **22**: 886-892.
- Fugazzotto, P.A., Wheeler, S.L. & Lindsay, J.A. (1993) Success and failure rates of cylinder implants in type IV bone. *Journal of Periodontology* **64**: 1085-1087.
- Gotfredsen, K., Wennerberg, A., Johansson, C., Skovgaard, L.T. & Hjorting-Hansen, E. (1995) Anchorage of TiO₂-blasted, HA-coated, and machined implants: an experimental study with rabbits. *Journal of Biomedical Materials Research* **29**: 1223-1231.
- Ivanoff, C.J., Sennerby, L. & Lekholm, U. (1996) Influence of initial implant mobility on the integration of titanium implants. An experimental study in rabbits. *Clinical Oral Implants Research* **7**: 120-127.
- Lazzara, R.J., Testori, T., Trisi, P., Porter, S.S. & Weinstein, R.L. (1999) A human histologic analysis of osseotite and machined surfaces using implants with 2 opposing surfaces. *International Journal of Periodontics and Restorative Dentistry* **19**: 117-129.
- Lioubavina-Hack, N., Lang, N.P. & Karring, T. (2006) Significance of primary stability for osseointegration of dental implants. *Clinical Oral Implants Research* **17**: 244-250.

- Martinez, H., Davarpanah, M., Missika, P., Celletti, R. & Lazzara, R. (2001) Optimal implant stabilization in low density bone. *Clinical Oral Implants Research* **12**: 423-432.
- Meredith, N. (1998) Assessment of implant stability as a prognostic determinant. *International Journal of Prosthodontics* **11**: 491-501.
- Meredith, N., Book, K., Friberg, B., Jemt, T. & Sennerby, L. (1997) Resonance frequency measurements of implant stability in vivo. A cross-sectional and longitudinal study of resonance frequency measurements on implants in the edentulous and partially dentate maxilla. *Clinical Oral Implants Research* **8**: 226-233.
- Nedir, R., Bischof, M., Szmukler-Moncler, S., Bernard, J.P. & Samson, J. (2004) Predicting osseointegration by means of implant primary stability. *Clinical Oral Implants Research* **15**: 520-528.
- Padmanabhan, T.V. & Gupta, R.K. (2010) Comparison of crestal bone loss and implant stability among the implants placed with conventional procedure and using osteotome technique: a clinical study. *Journal of Oral Implantology* **36**: 475-483.
- Pearce, A.I., Richards, R.G., Milz, S., Schneider, E. & Pearce, S.G. (2007) Animal models for implant biomaterial research in bone: a review. *Eur Cell Mater* **13**: 1-10.
- Roberts, E.G.J., Breznak, N. (1994) Bone physiology and metabolism. *Contemporary Implant Dentistry*: 557-598.

- Romanos, G.E. (2004) Surgical and prosthetic concepts for predictable immediate loading of oral implants. *Journal - California Dental Association* **32**: 991-1001.
- Sennerby, L., Thomsen, P. & Ericson, L.E. (1992) A morphometric and biomechanic comparison of titanium implants inserted in rabbit cortical and cancellous bone. *International Journal of Oral and Maxillofacial Implants* **7**: 62-71.
- Slaets, E., Carmeliet, G., Naert, I. & Duyck, J. (2006) Early cellular responses in cortical bone healing around unloaded titanium implants: an animal study. *Journal of Periodontology* **77**: 1015-1024.
- Soballe, K., Brockstedt-Rasmussen, H., Hansen, E.S. & Bunger, C. (1992) Hydroxyapatite coating modifies implant membrane formation. Controlled micromotion studied in dogs. *Acta Orthopaedica Scandinavica* **63**: 128-140.
- Szmukler-Moncler, S., Piattelli, A., Favero, G.A. & Dubruille, J.H. (2000) Considerations preliminary to the application of early and immediate loading protocols in dental implantology. *Clinical Oral Implants Research* **11**: 12-25.
- Ueda, M., Matsuki, M., Jacobsson, M. & Tjellstrom, A. (1991) Relationship between insertion torque and removal torque analyzed in fresh temporal bone. *International Journal of Oral and Maxillofacial Implants* **6**: 442-447.
- Uhthoff, H.K. (1973) Mechanical factors influencing the holding power of screws in compact bone. *Journal of Bone and Joint Surgery. British Volume* **55**: 633-639.

- Wang, X., Mabrey, J.D. & Agrawal, C.M. (1998) An interspecies comparison of bone fracture properties. *Bio-Medical Materials and Engineering* **8**: 1-9.
- Wennerberg, A., Ektessabi, A., Albrektsson, T., Johansson, C. & Andersson, B. (1997) A 1-year follow-up of implants of differing surface roughness placed in rabbit bone. *International Journal of Oral and Maxillofacial Implants* **12**: 486-494.

Table

Table 1. Histometric results for bone-to-implant contact (BIC) and bone density (BD) in the loosened implant (LI) and control groups after 4 and 8 weeks of healing. Data are percentages (mean \pm standard deviation values; $N=5$).

	BIC		BD	
	LI	Control	LI	Control
4 weeks	67.94 \pm 18.49	76.13 \pm 7.98	64.87 \pm 14.90	62.29 \pm 14.76
8 weeks	75.51 \pm 18.07	74.34 \pm 29.81	46.94 \pm 10.09	54.90 \pm 23.09

Figures



Figure 1. Schematic illustrations of the experimental design.

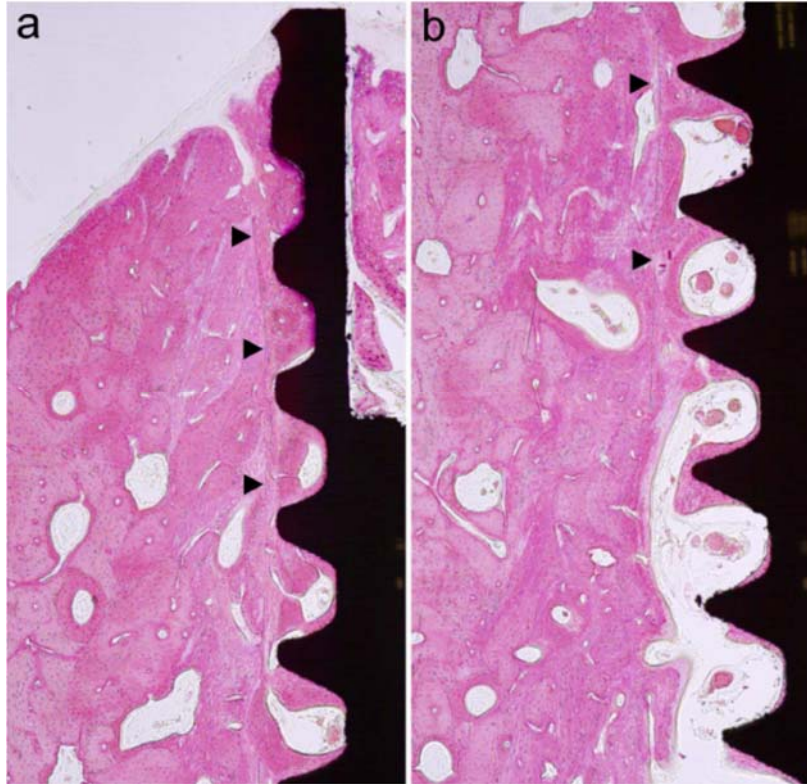


Figure 2. Histologic photomicrographs from the loosened implant (LI) group after 4 weeks of healing. (a) Coronal part of the implant (original magnification $\times 40$). (b) Apical part of the implant (original magnification $\times 40$). Arrowhead = reversal line demarcating the drilled margin.

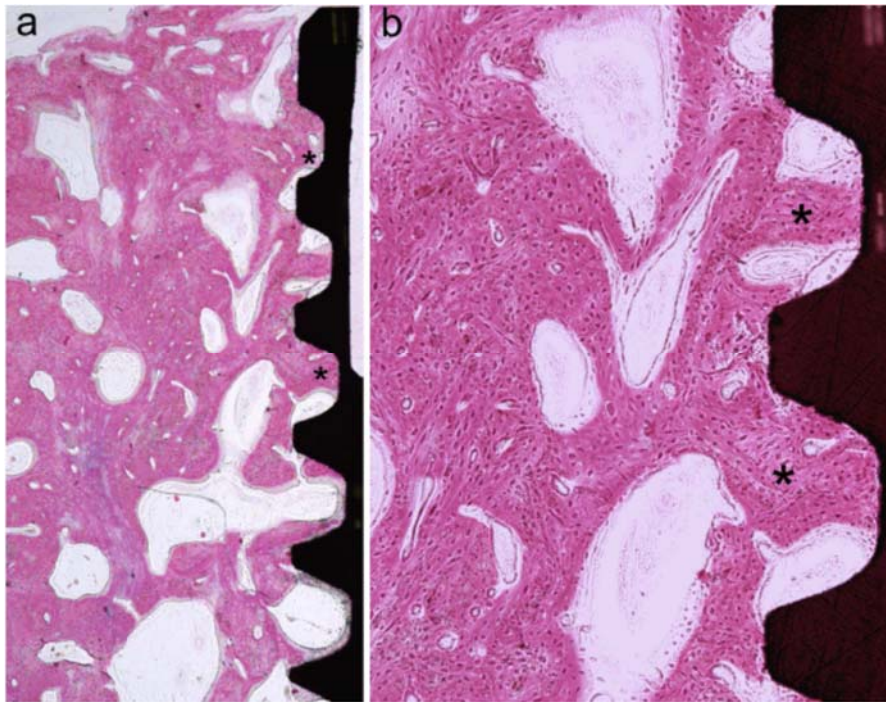


Figure 3. Histologic photomicrographs from the control group after 4 weeks of healing. (a) Coronal part of the implant (original magnification $\times 40$). (b) Highly magnified view of the coronal part (original magnification $\times 100$). Star = newly formed woven bone.

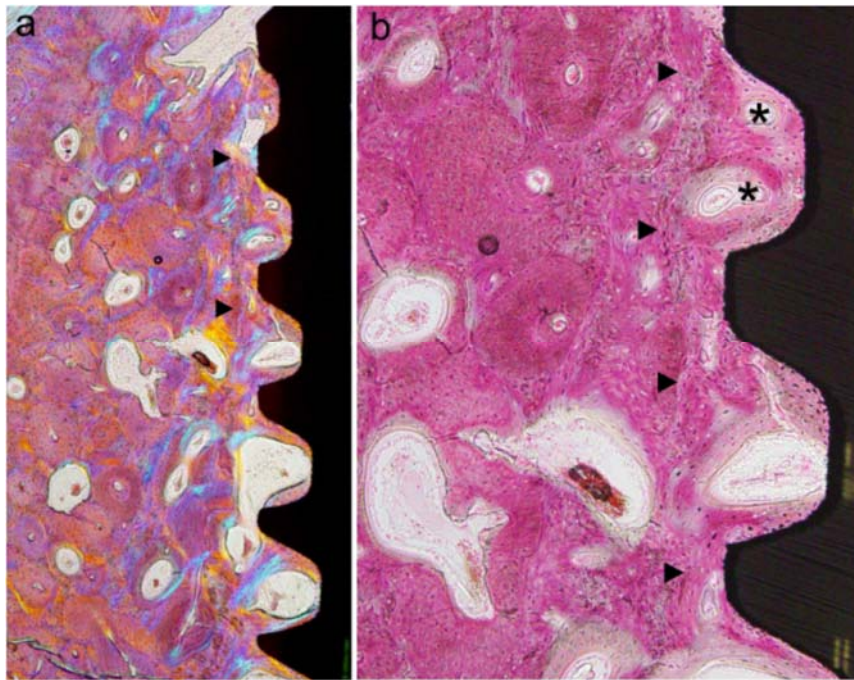


Figure 4. Histologic photomicrographs from the LI group after 8 weeks of healing. (a) Polarized photomicrograph at the coronal part of the implant (original magnification $\times 40$). (b) Highly magnified view of the coronal part (original magnification $\times 100$). Arrowhead = reversal line demarcating the drilled margin; star = primary osteon.

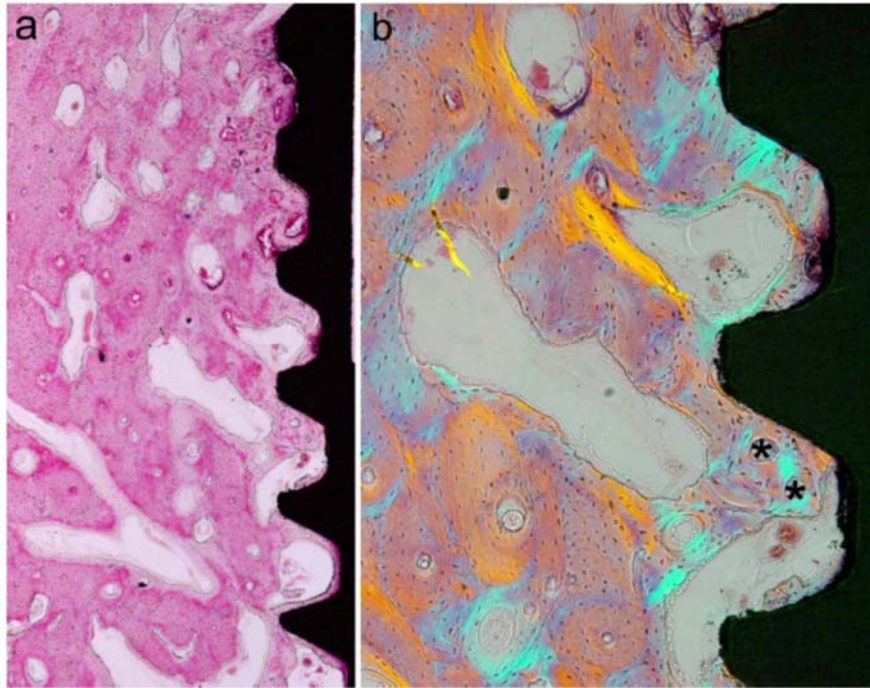


Fig. 5. Histologic photomicrographs from the control group after 8 weeks of healing. (a) Coronal part of the implant (original magnification $\times 40$). (b) Polarized photomicrograph of the coronal part (original magnification $\times 100$). Arrowhead = reversal line demarcating the drilled margin; star = primary osteon.

국문요약

성견에서 초기고정없이 식립된 치과임플란트의 골유착 치유기전에 관한 조직계측학적 연구

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목적: 본 연구의 목적은 초기고정없이 식립된 동요도가 있는 sand-blasted, large grid, acid-etched (SLA) 표면의 임플란트의 식립 4 주, 8 주후의 치유 형태를 밝혀보고자 한다.

방법: 5 마리의 성견에서 20 개의 임플란트를 식립하였다. 임플란트는 초기고정의 유무에 따라서 동요도가 있는 실험군과 대조군으로 나누었다. 실험군은 임플란트와 같은 직경의 드릴을 임플란트 식립을 위한 골삭제시 사용하였다. 4 주, 8 주의 치유기간을 가진 후에 실험 동물을 희생하여 조직계측학적 분석을 시행하였다.

결과: 모든 임플란트는 4 주와 8 주 후에 염증반응 없이 긴밀한 골유착을 이루었다. 평균 골-임플란트 접촉은 치유기간이 증가함에 따라 대조군에서는 일정한데 반하여 실험군에서는 증가하는 경향을 보였다. 그러나 골-임플란트 접촉과 골밀도 모두 군간에 또는 치유기간 사이에 통계적으로 유의한 차이는 없었다.

결론: 이번 연구를 통해서 식립시 초기고정이 없는 경우에도 외력을 받지 않고 매몰된 SLA 표면의 임플란트는 성공적으로 골유착을 이룰 수 있다고 사료된다.

핵심되는 말: 치과 임플란트, 골유착, 임플란트 안정성, 임플란트 표면, 조직계측학