Histological Evaluation of Orthodontic Miniplates with Two Different Shank Types

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Histological Evaluation of Orthodontic Miniplates with Two Different Shank Types

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감사의 글

본 박사논문이 완성되기까지 그리고 오늘의 제가 있기까지 부족한 저를 많은 사랑과 세심한 지도로 이끌어주신 김경호 교수님 진심으로 감사를 드립니다. 또한 부족한 논문에 많은 관심과 조언으로 완성도를 높여 주신 황충주 교수님, 세심한 지도와 따뜻한 격려로 힘을 주셨던 유형석 교수님 감사를 드립니다. 논문을 계획할 때부터 시작하여 실험 전 단계에 걸쳐 많은 도움을 주신 최병호 교수님, 김진 교수님께 깊은 감사를 드립니다.

많은 가르침과 사랑으로 교정학의 길로 이끌어주신 유영규 교수님, 온화한 미소로 용기와 사랑을 베푸신 손병화 교수님, 존경스럽기에 항상 저의 모범이 되어주시는 박영철 교수님, 관심과 사랑으로 힘을 주시는 백형선 교수님, 값진 아이디어를 아낌없이 나누어 주신 이기준 교수님 진심으로 감사를 드립니다. 또한, 항상 힘이 되어 주는 든든한 동기 차정열 교수님, 정주령 교수님께 감사를 드립니다. 수련 생활 때부터 현재까지도 자상하게 이끌어주시고, 특히 연구강사 시절에는 친형처럼 사랑을 듬뿍 베풀어 주신 최광철 교수님께 깊은 감사를 드리고 싶습니다.

논문을 계획하고 실험하는 과정에서 조언과 따뜻한 배려를 아끼지 않아 주신 원주기독병원 유재하 교수님, 정승미 교수님, 정원균 교수님, 김지훈 교수님, 이윤 교수님께 감사를 드리며, 논문이 있기까지 물심양면으로 많은 도움과 격려를 보내주신 강남 세브란스 치과병원 김형곤 교수님, 박광호 교수님, 한종현 교수님, 문익상 교수님, 허종기 교수님, 김선재 교수님, 박정원 교수님, 신수정 교수님께 감사를 드립니다. 특히 실험 과정에서 많은 도움을 준 원주기독병원 전공의 신애진 선생, 이하용 선생, 조주란 선생, 그리고 의국 선후배님들께 이 자리를 빌어 감사의 마음을 전합니다.

마지막으로, 헤아릴 수 없는 깊은 사랑으로 지켜봐 주시는 아버지, 어머니, 누나들, 매형들, 그리고 누구보다도 큰 힘이 되어 주었던 아내 서효진과 아들 준우에게 사랑과 고마움의 마음을 전합니다.

2009년 12월

저자 씀

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Abstract

Histological evaluation of orthodontic miniplates with two different shank types

The purpose of this study was to examine the soft tissue reaction according to shank design of orthodontic anchorage miniplate.

Thirty six miniplates (Biomaterials Korea, Seoul, Korea), 18 cylindrical shank types and 18 square shank types, were implanted with cross split-mouth design in 9 beagle dogs. Gingival index was examined every week, and orthodontic force was applied 4 weeks after miniplate insertion. Three dogs at 2 weeks and 6 dogs at 12 weeks were sacrificed, and inflammatory changes and epithelial sulcus depths were measured. The Willcoxon signed ranks test was performed to compare the epithelial migrations.

Gingival index of square shank miniplate was higher than that of cylindrical shank miniplate during whole 12 weeks. Inflammatory cell infiltrations of square shank miniplates were distinct compared to those of cylindrical shank miniplates. The epithelial sulcus depth of cylindrical shank miniplate was shallower than that of square shank miniplate ($P < 0.05$).

In conclusion, square shank miniplate showed more epithelial migrations and peri-miniplate inflammations compared to cylindrical shank miniplates.

Cylindrical shank miniplate was beneficial to soft tissue healing of peri-miniplate mucosa, and it would be reliable device for orthodontic anchorage.

Key words : skeletal anchorage, peri-miniplate soft tissue, inflammation, cylindrical shank miniplate, square shank miniplate

Histological evaluation of orthodontic miniplates with two different shank types

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I. Introduction

Recently, clinical orthodontics has been amazingly progressive due to skeletal anchorage system. It began with conventional osseointegrated implants for prosthodontic purpose and miniplates for rigid fixation of fractured jaws and maxillofacial surgeries.[1-2] Conventional implants had limitations when used as orthodontic anchorage: two stage flap surgeries, high price and usability only at the edentulous area. It was not effective as a temporary anchorage device(TAD) because deep surgical procedure was needed to remove the bone block containing implant.

Various minimized and simplified miniscrew implants for the purpose of orthodontic anchorage have been developed to overcome the inconveniences. As a result, it became simple to insert and remove miniscrew implant without flap surgery when implanted on the attached gingiva or palate. Miniscrew implants as TAD is being a routine application in the modern orthodontic office.[3] However, there have been reports that the failure rate is not negligible.[4−5] Dental root and periodontal membrane could be injured during insertion, and root contact during insertion of miniscrews increases the failure rate.[6] Inter−radicular miniscrew implant in itself could be an obstacle during orthodontic treatment especially in the progress of molar distalization and protraction.

Miniplates showed greater success rate than miniscrews,[7] less risk of damaging the neighboring anatomical structures,[8−9] no interference in the progress of tooth movement,[8−10] and stable mechanical properties.[11] Various clinical applications and successful results were reported using miniplates as orthodontic or orthopedic anchorage.[8,12−18] Several studies documented that stability of miniplate anchorage is reliable and it makes treatment predictable.[12−15]

However, flap surgeries are needed for insertion and removal of miniplate, and accompanied by discomforts of post−surgical swelling and inflammations of soft tissue around miniplates.[7,10,19−20]

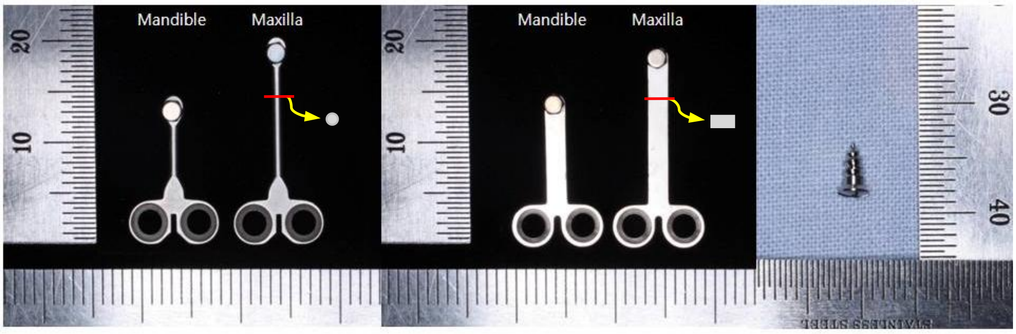
Inflammation of soft tissues around TAD plays an important role in TAD stability.[4] Although oral hygiene care has been emphasized to prevent inflammation, most of studies using conventional miniplates with rectangular shank of cross section reported inflammations around miniplates.[19−21] On the other hand, clinical studies using miniplates of cylindrical shank documented that soft tissues surrounding miniplates were not inflammatory.[13,16,22] Miniplate shank design might be a contributing factor to affecting the miniplate complications. However, there is no or little scientific study of soft tissue response according to miniplate shank design.

This study was to examine the reaction of soft tissue to miniplate according to shank design. Peri−miniplate soft tissue of cylindrical shank miniplate and that of square shank miniplate were compared histologically and clinically in beagle dogs.

II. Materials and Methods

1. Miniplate type

The shank of experimental miniplates was cylindrical that the cross section is round shape, and that of control miniplate was square that the cross section is rectangular shape (Fig 1). Both shank types of miniplates were made of pure titanium with smooth surface (Biomaterials Korea, Seoul, Korea). The other designs containing size (length of maxillary miniplate: 19.5 millimeters; length of mandibular miniplate: 14.5 millimeters) and head shape were same between the experimental and control miniplates.



A B C

Fig 1. Experimental and Control miniplates.

A: Experimental (Cylindrical shank miniplate): The cross-section is round shape (Diameter = 1.1 millimeters).

B: Control (Square shank miniplate): The cross-section is rectangular shape (Width x Depth = 2.1 x 1.0 millimeters).

C: Fixation screw (Length x Diameter = 5.0 x 1.8 millimeters).

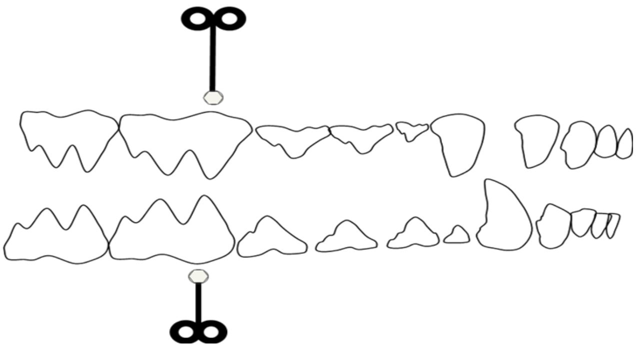


Fig 2. Insertion site.

Miniplates were implanted on the mesial cusp areas of first molars on noth maxilla and mandible.

2. Animal experiment

Nine male beagle dogs (Age: 12 to 18 months, Weight: 11.5 to 16.0 kilograms) were used for this study. Eighteen cylindrical shank miniplates and 18 square shank miniplates were implanted on maxilla and mandible. One miniplate per each quadrant was implanted with cross split-mouth design between two different shank type miniplates.

Insertion site was first molar area on both maxilla and mandible (Fig 2). After vertical incision under general and local anesthesia, the surrounding periosteum was detached. Monocortical self-tapping miniscrews (insertion depth in bone, 4 mm; diameter, 1.8 mm) were inserted after pilot drilling, and the cut was sutured (maxilla, 4 stitches; mandible, 3 stitches) (Fig 3). Four weeks after miniplate insertion heavy continuous force (600 gm, Nickel-titanium closed coil spring, Biomaterials Korea, Seoul, Korea) was applied (Fig 4, 5).

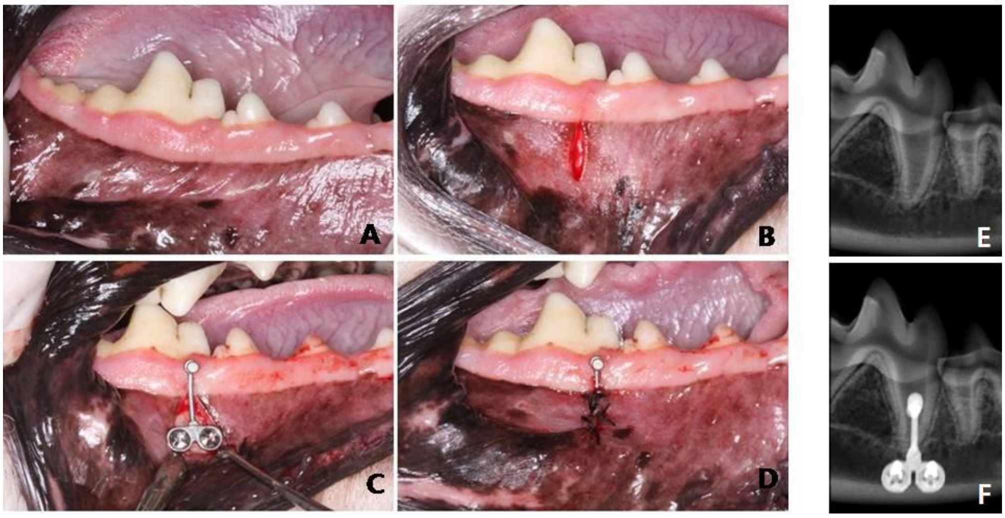


Fig 3. Surgical procedure.

A: Implantation site was the mesial cusp area of first molar, B: Vertical incision, C: Implantation of miniplate, D: Suture, E and F: Periapical radiographs (E: before, F: after miniplate implantation).

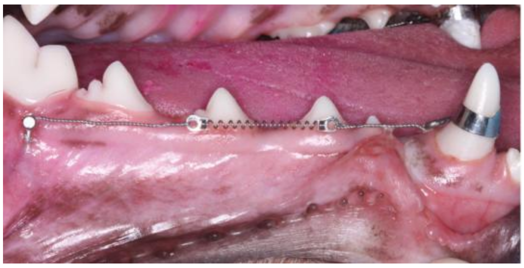


Fig 4. Force application of miniplate.

Application of orthodontic force (600 gm) to miniplate was started from 4 weeks after miniplate implantation using Nickel−titanium closed coil spring.

Saline and chlorhexidine irrigation were performed every day. Four days after implantation, tooth brushing was started using soft brush (Special Care, TePe®, Malmö, Sweden) without tooth paste, and tooth brushing with tooth paste was started 15 days after implantation.

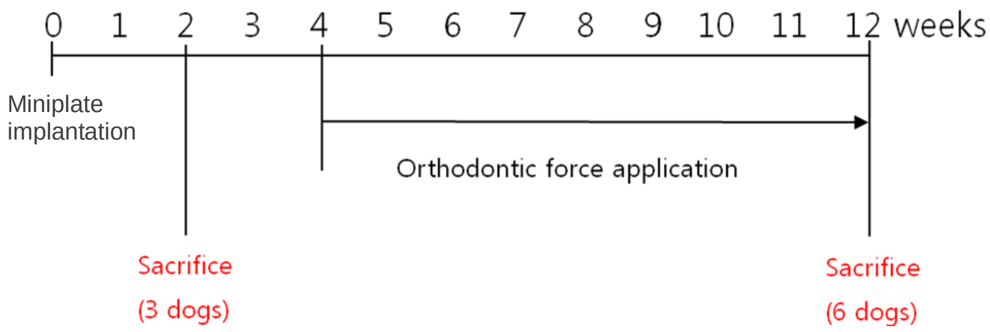


Fig 5. Experimental time table.

Three dogs were sacrificed 2 weeks after miniplate implantation and the rest 6 dogs were sacrificed 12 weeks after miniplate implantation. Orthodontic force was applied continuously from 4 weeks to 12 weeks.

3. Evaluation of soft tissue response

(1) Gingival index

Gingival index was examined every week by one investigator.

It was as follows:

Gingival index

0 = healthy

1 = gingival redness but no bleeding at brushing

2 = gingival redness + bleeding at brushing (not spontaneous)

3 = spontaneous bleeding

(2) Histological evaluation and statistical analysis

Two weeks after insertion, randomly selected 3 dogs among 9 dogs were sacrificed by potassium chloride injection to the ventricle of the heart (Fig 5). Eight weeks after force application (12 weeks after miniplate insertion) the rest 6 dogs were sacrificed. The dissected specimens of miniplate areas were fixed for 5 days by 4% paraformaldehyde solution. Peri−miniplate soft tissue was sectioned bucco−lingually as 3 ㎛ thickness after removing miniplates and hard tissues and paraffin embedding. The sections were attached to slide glass and dried on dry oven at 68℃ for an hour. Hematoxylin−eosin staining was performed conventionally after deparaffination by xylene and soaking by distilled water.

Inflammatory cell infiltration, hyperemia, and epithelial migration were examined and compared between two different shank types after digital scanning (x400) (ScanScope CS, Aperio Technologies, CA, USA).

The criteria of inflammatory cell infiltration are as follows:

No: Not detectable

Moderate: Inflammatory cell infiltration was focalized to the areas nearby artery or just under the epithelium

Severe: Diffused or band like inflammatory cell infiltration to connective tissue beneath epithelium

Epithelial sulcus depth of peri−miniplate was measured from gingival crest to the end of epithelium according to the axis of miniplate using histologic image software (ImageScope version 10.0, Aperio Technologies, CA, USA) after digital scanning, and the Willcoxon signed ranks was tested. The measuring unit was 0.01 millimeter. Epithelial sulcus depths of 18 specimens of cylindrical shank miniplates and 15 specimens of square shank miniplates were measured except 3 specimens showing desquamation.

III. Results

1. Gingival index

The increase and decrease patterns of both shank types were similar(Fig 6). At first week, both type miniplates showed considerable inflammations due to early healing response from surgical trauma, and the gingival indexes of both miniplate types were decreased until 4 weeks. Gingival indexes were increased on both shank types at 5 week after miniplate surgery (1 week after orthodontic force application). However, gingival indexes of square shank miniplate group were higher than that of cylindrical shank miniplate during whole 12 weeks from first week after miniplate implantation.

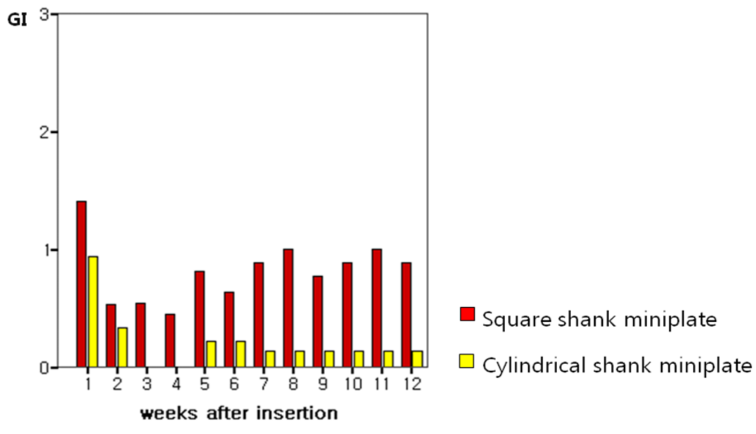


Fig 6. Gingival index(GI).

2. Histological evaluation

(1) Two weeks after miniplate implantation

a. Maxilla

At 2 weeks after miniplate implantation surgery, inflammatory cell infiltration was not examined on cylindrical miniplates of maxilla, but inflammatory cell infiltration was observed on 2 square shank miniplate (Fig 7−1, 7−2, Table I).

b. Mandible

Moderate inflammatory cell infiltration was examined on 2 cylindrical miniplates and a square shank miniplate of mandible at 2 weeks after miniplate implantation surgery (Fig 8−1, 8−2, Table I). Severe inflammatory cell infiltration was observed on a square shank miniplate (Fig 8−2).

At the early stage of 2 weeks after miniplate implantation surgery, there were inflammatory features on both cylindrical and square shank miniplates of mandible. Inflammatory cell infiltrations to soft tissue of square shank miniplate were greater than those of cylindrical shank miniplate on both maxilla and mandible.

Table I. Histological and Clinical examinations for assessing peri−miniplate inflammation at 2 weeks

		Cylindrical shank		Square shank	
	Dog No.	Inflammatory cell infiltration	Gingival Index	Inflammatory cell infiltration	Gingival Index
Maxilla	#1	No	0	Severe	3
	#2	No	0	No	0
	#3	No	0	Moderate	1
Mandible	#1	Moderate	0	Moderate	0
	#2	Moderate	1	Severe	3
	#3	No	0	No	0

(No: not detectable, Moderate: focalized inflammatory cells, Severe: diffused inflammatory cells)

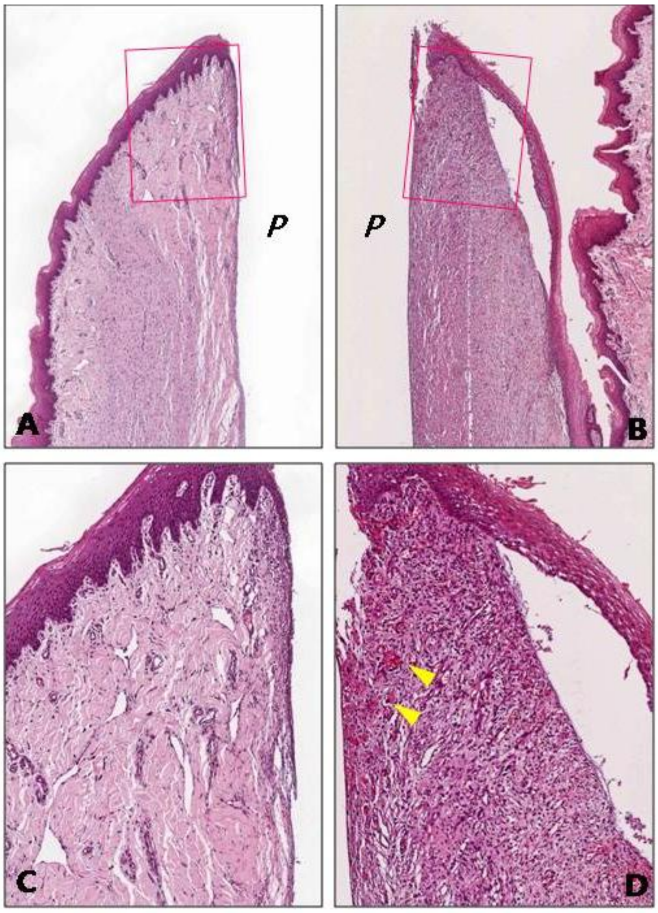


Fig 7−1. Histological feature of maxilla at 2 weeks.

(H & E stain, #1, ***P*** : miniplate area)

A : Cylindrical shank(x100), B : Square shank(x100),

C : Cylindrical shank(x400), D : Square shank(x400).

Severe inflammatory cell infiltration and hyperemia(arrows) were examined at square shank miniplate.

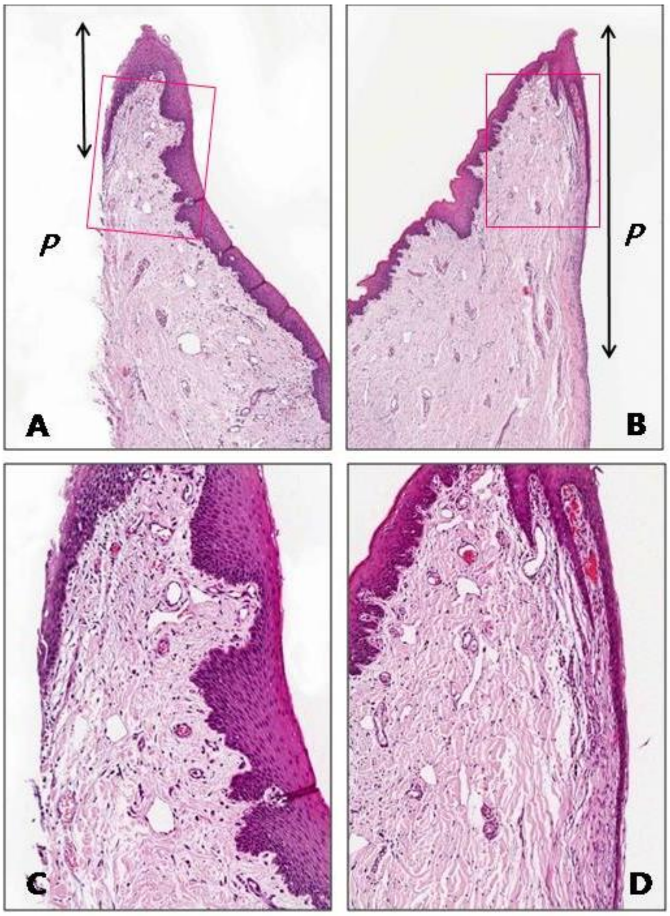


Fig 7-2. Histological feature of maxilla at 2 weeks.

(H & E stain, #2, *P* : miniplate area, ↕ : epithelial sulcus depth)

A: Cylindrical shank(x100), B: Square shank(x100),

C: Cylindrical shank(x400), D: Square shank(x400).

Inflammatory cell infiltration and hyperemia were not different between 2 different shank types, but epithelial sulcus depth of square shank miniplate was longer than that of cylindrical shank miniplate.

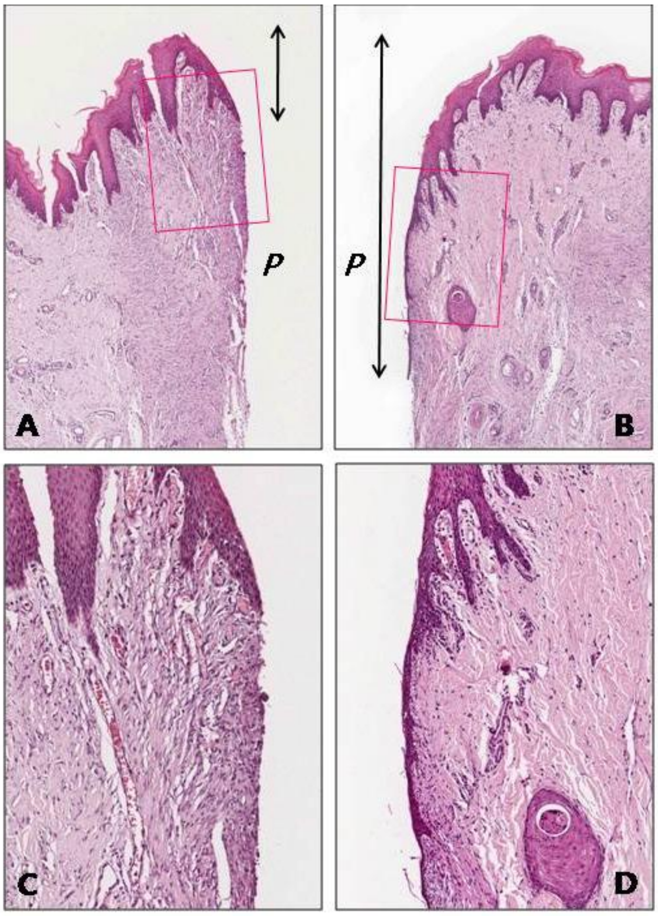


Fig 8−1. Histological feature of mandible at 2 weeks.

(H & E stain, #1, *P* : miniplate area, ↕ : epithelial sulcus depth)

A: Cylindrical shank(x100), B: Square shank(x100),

C: Cylindrical shank(x400), D: Square shank(x400).

Inflammatory cell infiltration and hyperemia were not different between 2 different shank types, but epithelial sulcus depth of square shank miniplate was longer than that of cylindrical shank miniplate.

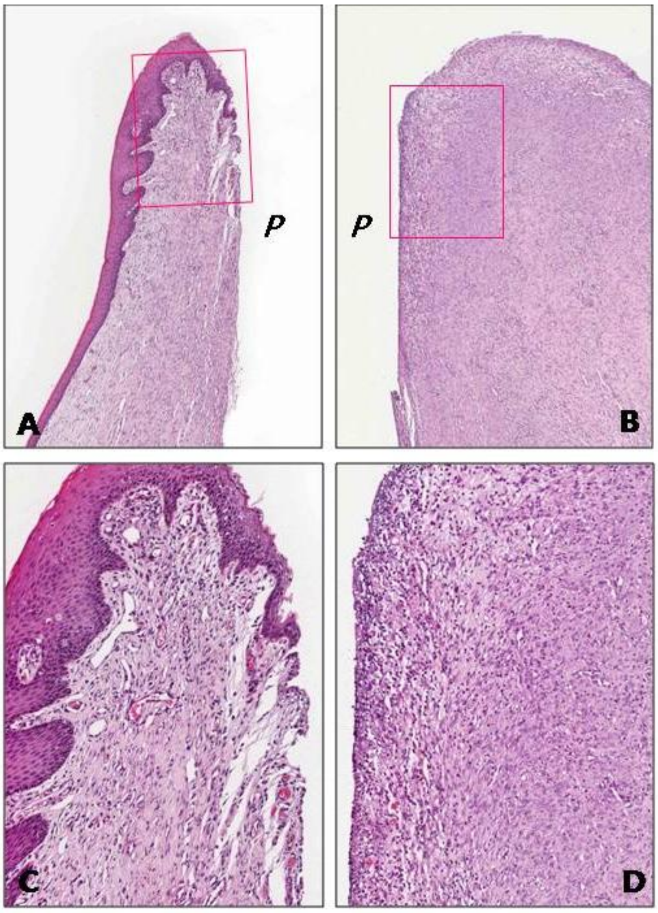


Fig 8-2. Histological feature of mandible at 2 weeks.

(H & E stain, #2, P : miniplate area)

A: Cylindrical shank(x100), B: Square shank(x100),

C: Cylindrical shank(x400), D: Square shank(x400).

Desquamation and severe inflammatory cell infiltration were occurred on square shank miniplate.

(2) Twelve weeks after miniplate implantation

a. Maxilla

At 12 weeks after miniplate implantation surgery, moderate inflammatory cell infiltration was examined on a cylindrical miniplate and 2 square shank miniplates of maxilla (Fig 9−1, 9−2, Table II).

b. Mandible

At 12 weeks after miniplate implantation, inflammatory cell infiltration was not examined on cylindrical miniplates of mandible, but moderate to severe inflammatory cell infiltrations were observed on 3 square shank miniplates (Fig 10−1, 10−2, Table II).

Inflammatory cell infiltrations of square shank miniplates were distinct compared to those of cylindrical shank miniplate on both maxilla and mandible at 12 weeks.

Table II. Histological and Clinical examinations for assessing peri−miniplate inflammation at 12 weeks

		Cylindrical shank		Square shank	
	Dog No.	Inflammatory cell infiltration	Gingival Index	Inflammatory cell infiltration	Gingival Index
Maxilla	#4	No	0	No	0
	#5	No	0	No	1
	#6	Moderate	1	Moderate	1
	#7	No	0	No	0
	#8	No	0	Moderate	2
	#9	No	0	No	0
Mandible	#4	No	0	No	0
	#5	No	0	Severe	2
	#6	No	0	Severe	3
	#7	No	0	No	0
	#8	No	0	Moderate	2
	#9	No	0	No	0

(No: not detectable, Moderate: focalized inflammatory cells, Severe: diffused inflammatory cells)

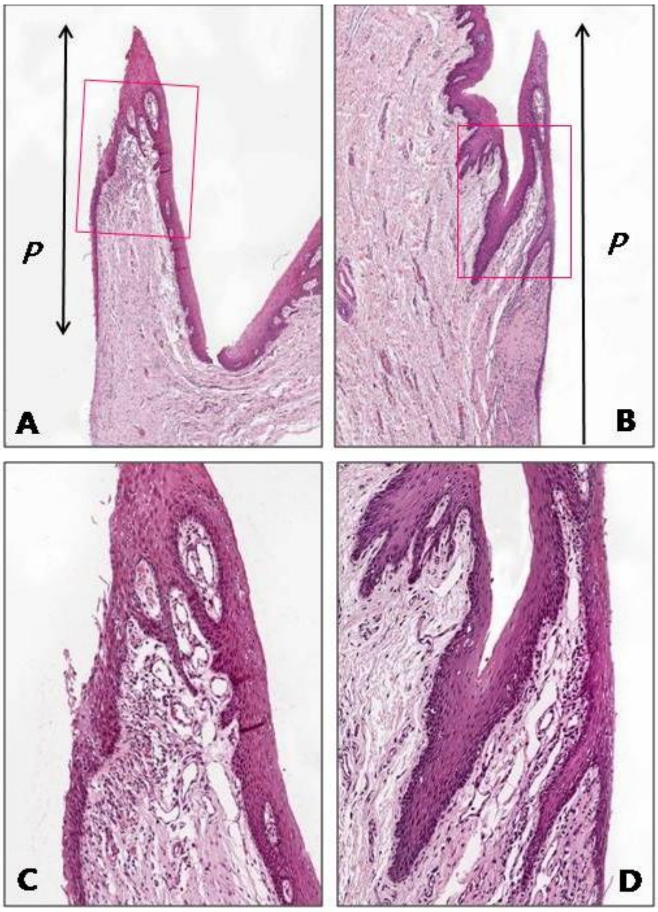


Fig 9-1. Histological feature of maxilla at 12 weeks.

(H & E stain, #6, P : miniplate area, ↕ : epithelial sulcus depth)

A: Cylindrical shank(x100), B: Square shank(x100),

C: Cylindrical shank(x400), D: Square shank(x400).

Inflammatory cell infiltration and hyperemia were not different between 2 shank types, but epithelial sulcus depth of square shank miniplate was longer than that of cylindrical shank miniplate.

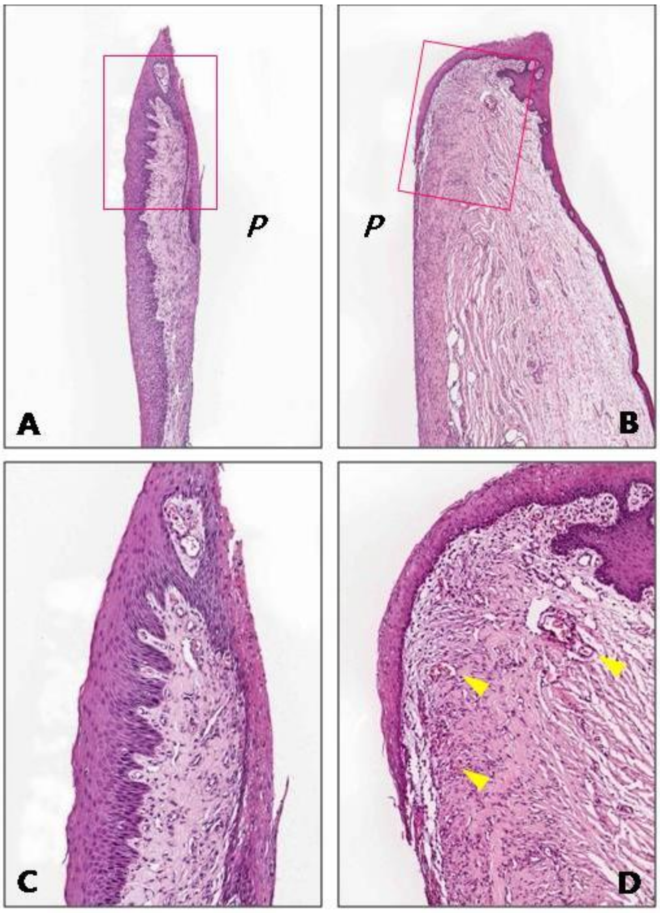


Fig 9−2. Histological feature of maxilla at 12 weeks.

(H & E stain, #8, *P* : miniplate area)

A: Cylindrical shank(x100), B: Square shank(x100),

C: Cylindrical shank(x400), D: Square shank(x400).

Moderate inflammatory cell infiltration and hyperemia(arrows) were occurred on square shank miniplate in contrast to cylindrical shank miniplate.

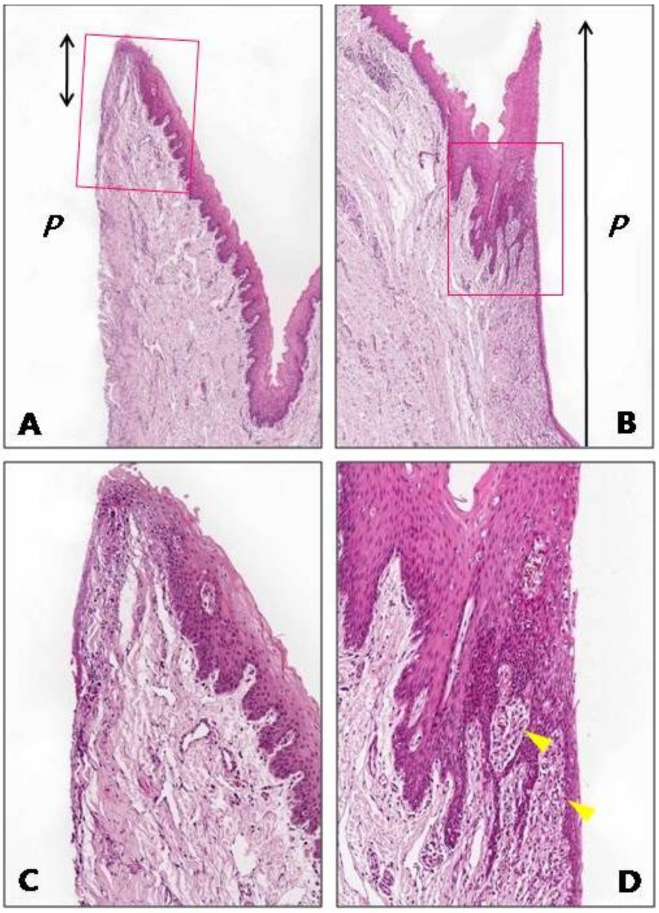


Fig 10−1. Histological feature of mandible at 12 weeks.

(H & E stain, #6, *P* : miniplate area, ↕ : epithelial sulcus depth)

A: Cylindrical shank(x100), B: Square shank(x100),

C: Cylindrical shank(x400), D: Square shank(x400).

Inflammatory cell infiltration and hyperemia(arrows) of square shank miniplate were severe and epithelial sulcus depth of square shank miniplate was longer than that of cylindrical shank miniplate.

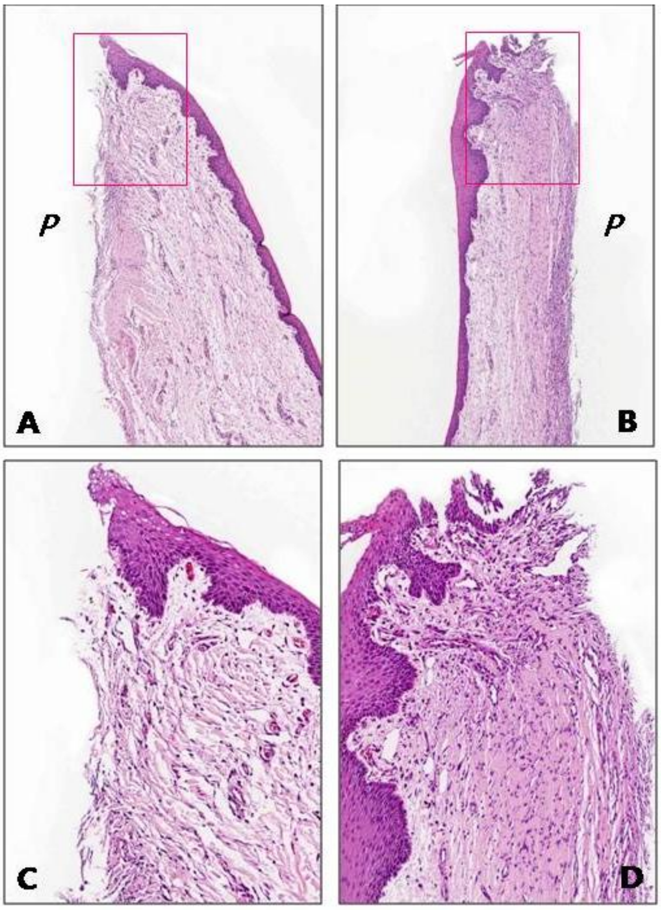


Fig 10−2. Histological feature of mandible at 12 weeks.

(H & E stain, #8, *P* : miniplate area)

A: Cylindrical shank(x100), B: Square shank(x100),

C: Cylindrical shank(x400), D: Square shank(x400).

Desquamation and inflammatory cell infiltration were occurred on square shank miniplate but not on cylindrical shank miniplate.

(3) Comparison of epithelial migration between 2 shank types

The epithelial sulcus of cylindrical shank type miniplate was shallow than that of square shank type miniplate, and it was statistically significant (Table III). The mean depth of sulcular epithelium was 0.65 millimeters in cylindrical shank miniplates and 1.37 millimeters in square shank miniplates. The mean epithelial sulcus depth of cylindrical shank type miniplate in mandible was 0.40 millimeters and standard deviation was 0.15 millimeters.

In 3 specimens with desquamation (1 specimen of square shank miniplate in maxilla, 2 specimens of square shank miniplate in mandible), measurements of epithelial sulcus depths were excluded.

Table III. Epithelial sulcus depth by Willcoxon signed ranks test

(unit: millimeter)

	Cylindrical shank				Square shank				Sig.
	Mean	SD	Max.	Min.	Mean	SD	Max.	Min.	
Maxilla n=9(Cylind.) n=8(Square)	0.90	0.41	1.63	0.44	1.55	0.61	2.62	0.86	*
Mandible n=9(Cylind.) n=7(Square)	0.40	0.15	0.53	0.16	1.17	0.89	2.20	0.14	*
Total	0.65	0.40	1.63	0.16	1.37	0.69	2.62	0.14	**

(Sig.: Significance, * $P < 0.05$, ** $P < 0.01$)

IV. Discussion

The ideal goals of better designed miniplate are easy to insert and removal, short surgical operation time, minimally invasive, no post−surgical swelling, not irritable to peri−miniplate mucosa, comfortable to patient, hygienic, high stability, and capable of multi−directional force application.

Previous investigators using square shank designed miniplates reported more or less inflammatory peri−miniplate soft tissue.[19−21] On the other hand, clinical studies using cylindrical shank design miniplates documented that the stability was excellent and peri−miniplate soft tissue was not inflammatory.[13,16] Cornelis et al. proposed that cylindrical shank design might contribute to healing of peri−miniplate soft tissue, and the advanced miniplate design, less invasive surgeries and delicate care decreased complications and patient discomforts.[13,22] Results of the present animal study proved that peri−miniplate mucosa of square shaped shank miniplate was more inflammatory compared to cylindrical shank miniplate according to both gingival index in clinical examination and inflammatory cell infiltration in histologic examination.

It is apparent that peri−implant gingiva sealing is critical to implant success, which prevents infiltration of microorganisms, toxins, and food impaction. Gingival sealing accompanying with shallow sulcus lined by epithelium is primary to successful prosthodontic implants.[23] It must be also important to orthodontic anchorage devices, which is exposed to the contaminated environment of the oral cavity similar to prosthodontic implants. The present study found that epithelial sulcus depths of cylindrical miniplates were shallower than those of square shank miniplate (Table III). Especially, the mean epithelial sulcus depth of cylindrical shank type miniplate in mandible was shallow and the standard deviation was low. It means peri-miniplate soft tissue response to cylindrical miniplates in mandible was stable and reliable. Epithelial sulcus depth data of 2 weeks specimen was added to 12 weeks specimen because epithelial migration was not different according to sacrifice time.

We consider the soft tissue healing in early stage is one of the critical factors which can contribute gingival protection to provide a seal against the contaminated environment of the oral cavity and affect inflammation and stability. Our experiments showed that better healing of soft tissue in early stage on the cylindrical shank miniplates compared to square shank miniplates. It must be due to that cylindrical shank is compatible to soft tissue because other conditions such as surgical procedure and hygiene care are completely same except shank design. The differences of soft tissue response were started from early stage and continued on both clinical and histologic examinations (Fig 6, Table I, II). During weeks of initial surgery trauma healing stage, the healing patterns according to gingival index were similar between two shank types even though cylindrical shank was better. Peri−miniplate soft tissue condition of cylindrical shank miniplates was stable, while that of square shank miniplates was unstable and inflammatory dependent on oral hygiene control.

Chen et al. published a study to clarify the factors that influence failure of temporary anchorage devices (TAD: 86 miniplates and 265 miniscrew implants).[4] The forward stepwise logistic regression analysis showed the statistically significant results that TAD failure was associated with inflammation of the soft tissue surrounding the TAD and early loading within 3 weeks. They pointed out orthodontic force application at early stage was not recommended because 3 week is the lowest stable period because primary bone contact is decreased during 3 week in the progress of surrounding bone remodeling. In our study, orthodontic force was applied 4 weeks after miniplate implantation, and all of miniplates were stable during 12 weeks. Interestingly, we found that gingival index was increased on both two shank types after orthodontic force application at 5 weeks after implantation (Fig 6). It implies that delayed loading is recommended not only due to the initial unstable period of bone remodeling, but also for early soft tissue healing and gingival sealing. Springs and elastics for orthodontic force application are not favorable for healing of peri−miniplate soft tissue. The histological evaluation of early response of soft tissue around TAD after orthodontic force application is necessary in the future.

Minimizing the size of miniplate is necessary to achieve less invasive surgery and to reduce surgical discomfort. Our study used miniplate with minimized size. The distance between centers of 2 holes for miniscrew insertion was 5.0 millimeters and height of miniplate between the center of miniscrew hole and center of button shape hook was 10.5 millimeters for mandible and 16.5 millimeters for maxilla (Fig 1). The minimized size made the surgery to be possible only by vertical incision without horizontal incision, incision length to be short (10 millimeters on mandible, 15 millimeters on maxilla), and periosteal elevation area to be small. Due to minimally invasive surgical procedure, insertion and removal surgeries became easy and simplified, surgical operation time was shortened, and post-surgical swelling was diminished. Moreover, vertical incision reduce vascular trauma because there is a tendency that main blood vessel of buccal mucosa in jaws drive vertically directed occlusally from basal bone.[24] Blood supply is interrupted less than horizontal incision, which beneficial to post-surgical healing and reducing cicatrization. In the present study, hook to engage elastic or spring for orthodontic force application was changed into button shape. It made it convenient to apply multi-directional orthodontic force: molar uprighting, distalization, mesialization, and intrusion simultaneously.

It is clear that meticulous oral hygiene care is important to keep the healthy peri−miniplate soft tissue.[25] Although the early stage after insertion surgery is critical phase for soft tissue healing, active oral hygiene control using tooth brush at implantation area is impossible. We suppose that it is essential that simple and less traumatic implantation surgery containing delicate suturing and lucrative miniplate design to early soft tissue healing.

V. Conclusion

Square shank miniplate showed more epithelial migrations and peri-miniplate inflammations compared to cylindrical shank miniplates. The contrast started from the early stage after implantation surgery. Cylindrical shank miniplate was beneficial to soft tissue healing of peri-miniplate mucosa, and it would be reliable device for orthodontic anchorage.

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국문요약

치아교정용 미니플레이트의 기둥 형태에 따른 조직학적 평가

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이정섭

교정용 미니스크류 임플란트는 교정학에서 널리 사용되는 편리한 골격성 고정원이다. 그러나, 그 안정성을 충분히 신뢰할 수 없으며, 치근 사이에 식립된 미니임플란트는 치아의 이동을 방해할 수 있다. 이에 반해, 미니플레이트는 치근 손상 가능성이 매우 적고, 치아 이동을 방해하지 않으며, 안정성이 높은 골격성 고정원이다. 그러나, 식립 및 제거 시 수술과정이 필요하며, 부종 및 염증이 동반되기 쉽다는 단점이 있다. 이러한 미니플레이트의 단점들을 개선하기 위해서 합병증의 원인 요소에 대한 과학적 근거가 부족한 실정이다.

이에 수컷 비글 성견 9마리에서 상하좌우에 대칭적으로 18개의 원통기둥형 미니플레이트(실험군)와 18개의 사각기둥형 미니플레이트(대조군)를 식립하였다. 미니플레이트 주변 연조직의 반응을 치은지수(Gingival index)로 매주 관찰하였고, 2주에 3마리, 12주에 6마리를 희생시켜 조직학적으로 관찰하였다. 조직학적

관찰에서 염증세포의 침윤을 반대측과 비교하여 보았으며 상피성 증식, 즉 열구상피의 길이를 측정하여 Wilcoxon signed rank test로 두 군간의 차이가 있는지 분석하였다.

연구결과 12주간 사각기둥형 미니플레이트의 치은지수는 원통기둥형보다 높았다. 조직학적 관찰에서 원통기둥형 미니플레이트보다 사각기둥형 미니플레이트에서 주위연조직으로의 염증세포의 침윤이 많이 관찰되었으며, 열구상피의 길이도 사각기둥형이 더 긴 양상을 보였다($P < 0.05$).

결론으로, 원통기둥형보다 사각기둥형 미니플레이트의 주변 연조직에서 열구내로의 상피성 증식과 염증세포의 침윤 양상이 심하다. 사각기둥형보다 원통기둥형에서 연조직의 염증성 반응이 적게 나타나는 양상은 식립 초기부터 지속되므로, 원통기둥형 미니플레이트는 보다 안정적인 골격성 고정원을 제공할 것이다.

핵심 되는 말 : 골격성 고정원, 미니플레이트 주위 연조직, 염증, 원통기둥형 미니플레이트, 사각기둥형 미니플레이트