Histologic and biomechanical characteristics of orthodontic self-drilling and self-tapping microscrew implants

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Objective: The purpose of this study was to compare the histological and biomechanical characteristics of self-tapping and self-drilling microscrew implants. **Methods:** 112 microscrew implants (56 self-drilling and 56 self-tapping) were placed into the tibia of 28 rabbits. The implants were loaded immediately with no force, light (100 gm), or heavy force (200 gm) with nickel-titanium coil springs. The animals were sacrificed at 3- and 5-weeks after placement and histologic and histomorphometric analysis were performed under a microscope. **Results:** All microscrew implants stayed firm throughout the experiment. There was no significant difference between self-drilling and self-tapping microscrew implants both in peak insertion and removal torques. Histologic examinations showed there were more defects in the self-tapping than the self-drilling microscrew implants, and newly formed immature bone was increased at the interface in the self-tapping 5-week group. There was proliferation of bone towards the outer surface of the implant and/or toward the marrow space in the self-drilling group. Histologically, self-drilling microscrew implants provided more bone contact initially but the two methods became similar at 5 weeks. **Conclusion**: These results indicate the two methods can be used for microscrew implant placement, but when using self-tapping microscrew implants, it seems better to use light force in the early stages. **(Korean J Orthod 2006;36(4):295-307)**

Key words: Microscrew implant, Pilot drill, Bone-implant contact, Removal torque

INTRODUCTION

The advent of skeletal anchorage has now changed the paradigm of anchorage in orthodontics. Endosseous implants[1,2] were introduced long ago but they failed to gain popularity because of anatomical limitations owing to its bulky size and long waiting time needed for osseointegration.

The mini- or micro-screw implants[3-10] are now used most frequently thanks to the tiny size, immediate loading possibilities, and low cost. Their small size enables them to be used in expanded clinical applications. Several successful studies and clinical reports have also been published.[5-8,10]

There are two methods of placing surgical screws into the bone, the self-tapping[11] and self-drilling methods.[12-14] Self-tapping requires pre-drilling prior to placement of screws whereas self drilling can be placed without pre-drilling a hole. The self-tapping method has

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Table 1. Distribution of experimental animals

Groups	Histologic measurements		Torque measurements (5 weeks)
	3 weeks	5 weeks	
Number of rabbits	9	9	10

long been used but it has disadvantages such as damage to tooth roots, drill bit breakage and thermal necrosis of bone.[15] The self drilling method is much easier to place and manipulate, requires decreased operating time and causes less thermal damage. Heidemann et al[14] reported that the screw-bone contact area of drill free screws was wider than that of self-tapping screws. However Sowden and Schmitz[11] found more bone damage in the self-drilling screws than in the self-tapping screws.

The orthodontic screw implants need to be loaded with very light orthodontic loads over a long duration. The surgical screws, however, require resistance to very heavy force but over a comparatively short duration. Therefore the response of the bone surrounding the orthodontic screw implants may be different from surgical screws. However there was no research which compared the differences between self-tapping and self-drilling microscrew implants in the orthodontic field.

The purpose of this study was to compare the histological and biomechanical characteristics of the self-drilling and self-tapping microscrew implants as orthodontic anchorage.

MATERIAL AND METHODS

Experimental protocol was submitted, reviewed and approved by the institutional review board.

Experiment animals

Thirty adult rabbits weighing 3-3.5 kg were used as experiment subjects and are shown in Table 1. One animal in each 3 and 5 week histologic measurement groups died during the experiment, so the total number of animals was 28. Each animal received 4 microscrew implants, two into the left leg and two into the right leg. To compare the effects of type of screws, pairs of self-drilling and self-tapping microscrew implants were placed into each leg. To elucidate the effects of magnitude of load, the microscrew implants were loaded with no force, light force (approximately 100 gm), or heavy force (approximately 200 gm). In seven animals, the microscrew implants placed in the left leg in the 3 week group were not loaded, and the microscrew implants placed into the right leg were loaded with heavy or light force. Two animals received heavy force on the left leg and light force on the right leg. Resultantly, in the 3 week group, no force was applied to 7 pairs of microscrew implants in 7 animals, light force to 6 pairs in 6 animals, and heavy force to 5 pairs in 5 animals. In the 5 week group, no force was applied to 7 pairs of the microscrew implants in seven animals, light force to 5 pairs, and heavy force to 6 pairs (Table 2). In 10 rabbits allocated to torque measurements, no force was applied and sacrificed 5 weeks after placement of microscrew implants.

Surgical procedure

Anesthesia was performed through intramuscular injection of ketamine cocktail, composed of ketamine (Ketara, Yuhan, Seoul, Korea) at a dose of 44 mg/kg of body weight, xylazine (Rompun Bayer Korea, Seoul, Korea) at a dose of 7 mg/kg of body weight and saline.

A total of 120 microscrew implants made of titanium alloy (Table 3) were used. The size of the self-drilling microscrew implant (SH1312-06, Absoanchor, Dentos, Daegu, Korea) was 1.3 mm at the neck and 1.2 mm at the apex in external diameter and 6 mm in length. The self-tapping microscrew implant (AX12-106, Absoanchor, Dentos, Daegu, Korea) was 1.2 mm in

Table 2. Distribution of microscrew implants

	Histologic analysis												Torque	
	Self-drilling						Self-tapping						Self-drilling	Self-tapping
Duration	3 weeks			5 weeks			3 weeks			5 weeks			5 weeks	
Force	N	L	H	N	L	H	N	L	H	N	L	H	N	N
Number of microscrew implants	7	6	5	7	5	6	7	6	5	7	5	6	20	20

N, no force; L, light force; H, heavy force.

Table 3. Chemical compositions of the microscrew implants

	C	Fe	Al	N	H	O	Vanadium	Ti
Percentage (%)	0.01	0.21	6.25	0.01	0.033	0.11	3.96	89.417

external diameter and 6 mm in length. The self-drilling microscrew implants are tapered in shape (neck 1.3 mm and apex 1.2 mm) and have a cutting flute at the apex, whereas the self-tapping microscrew implants are cylindrical and have no cutting flute. Because two animals died during the experiment, the total number of microscrew implants used was 112.

After the tibia of each rabbit was exposed by hair shaving, and incisions made through the skin, fascia and periosteum through an aseptic procedure, a self-tapping microscrew implant was placed into the bone. After preparation of a hole with a 0.9 mm pilot drill under abundant saline irrigation, the self-tapping microscrew implant was screwed into the hole. The drill speed was 500 rpm. The self-drilling microscrew implant was placed into the bone without prior pilot drilling. Thus each rabbit received two self-tapping and two self-drilling microscrew implants.

After insertion, a force of approximately 100 gm was applied immediately in the light force group with a NiTi coil spring (Sentalloy, Tomy International, Tokyo, Japan) and a force of approximately 200 gm in the heavy force group, while force was not applied to microscrew implants in the no force group.

The surgical site was closed by layer sutures, using absorbable silk with interrupted knots. After surgery, all animals were injected with intramuscular antibiotics (Baytril, Bayer Korea, Seoul, Korea) at a dose of 0.3 mg per animal, and analgesics (Nobin, Bayer Korea, Seoul, Korea) at 1 mg per animal.

After 3 and 5 weeks, the experimental animals were sacrificed by injecting air into the heart. The tibia was cut into pieces which contained one microscrew implant. The specimens with a total of 76 microscrew implants with the surrounding tissue were fixed with 70% alcohol.

For a Vilanueva bone stain, the specimens were dyed for one week in the solution and gradually dehydrated in 50% ~ 100% alcohol. To obtain a micro slice of the microscrew implant, it was embedded in EPON resin and the specimen was prepared in the axial plane. A slice of 500 ㎛ thickness was made, then a slice of 50 ㎛ thickness was fabricated with a polisher (RotoPol-35, Struers, Willich, Germany).

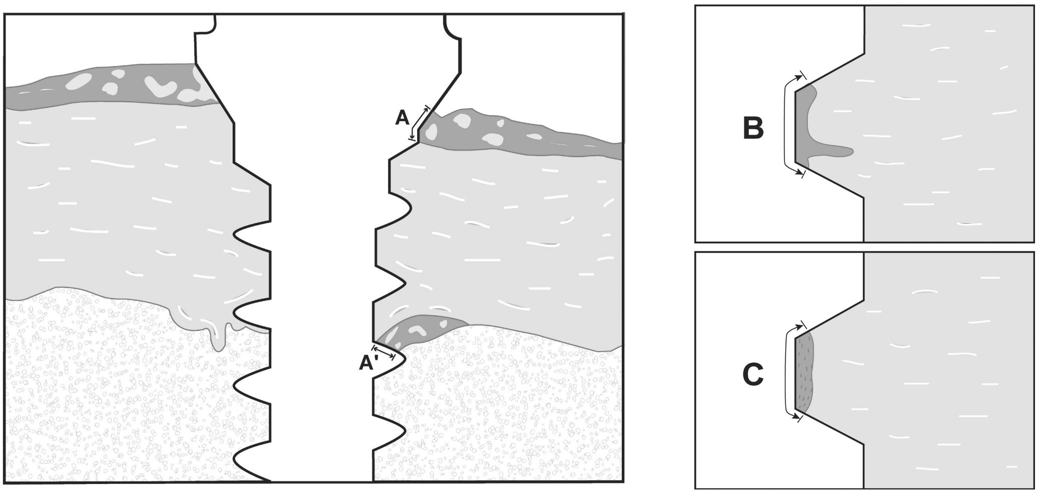

Fig 1. Histologic measurements. **A**, New bone proliferation through implant surface; **B**, surface area of defects at the interface; **C**, surface area of newly formed immature bone at the interface.

Gross observation

At sacrifice, tibias of rabbits were removed and mobility of the microscrew implants was checked. If there was any discernible mobility evident when checked with a cotton plier, the microscrew implant was considered as failure. The success rate of micro-implants was also checked.

Histologic analysis

General observation was done under light microscope. After taking microscopic photographs under × 100 magnification, images were stored into a personal computer. The following parameters were measured using an image-analyzing software (Scion image for windows beta 3b, Scion, Frederick, MD, USA); (A) new bone proliferation toward the outer surface and/or into the marrow from the microscrew implant; (B) surface area of defects at the interface of implant and bone; (C) newly formed immature bone at the interface between implant and bone (Fig 1).

Torque measurements

10 rabbits were used for measuring insertion and removal torque. The peak insertion torque, which indicates the full tightness of the microscrew implants, was measured with a digital torque gauge (EMT D 17000 Series, SEEC, Seoul, Korea) (Fig 2), for all microscrew implants in the two groups. The peak removal torque was also measured with the digital torque gauge. The measurements were performed by one investigator to minimize errors. When a microscrew implant was unscrewed, the peak torque value fell abruptly after the rupture at the interface. After rupture, the continued unscrewing required low torque. Therefore, peak removal torque indicated the maximum

Fig 2. Digital torque gauge.

Table 4. Peak insertion and removal torque between groups (unit, Ncm)

	(Mean ± SD)		p-value
	Self-drilling (n = 20)	Self-tapping (n = 20)	
Peak insertion torque	8.64 ± 1.74	8.80 ± 1.84	0.6331
Peak removal torque	−4.53 ± 1.89	−4.05 ± 1.23	0.2601

force of breaking the interface between the microscrew implant and the bone. Because there was outgrowth of the bone over the head of microscrew implants, the bone on the head was carefully removed with a scalpel, and removal torque was measured.

Statistical analysis

For statistical analysis, SAS 8.0 (SAS, Cary, NC, USA) was used. To evaluate the role of the three factors (time, force, methods) on each measurement between each group, a three-way ANOVA was preformed. And to compare differences in insertion and removal torque between groups, student t-test was used. To find the relationship between insertion torque and removal torque, Pearsons coefficient was calculated.

RESULTS

Gross observation

All microscrew implants stayed firm throughout the experiment. None of the microscrew implants showed mobility. There was outgrowth of bone over the head of microscrew implants in several samples.

Peak insertion and Removal torque

There was no significant difference between self-drilling and self-tapping microscrew implants for peak insertion and peak removal torques. There was no statistically significant correlation between peak insertion torque and peak removal torques ($p < 0.05$) (Table 4).

Overall histologic findings

There was tight adaptation between the implants and surrounding bone in all groups with very small differences. There was bending of the cortical bone at 3 weeks after placement in the self-drilling microscrew implant group (Figs 3-5). Bending of the cortical bone was not evident in the self-tapping microscrew implant group (Figs 6-8). Because of bone chips which arise from the hole during placement,[11] there was proliferation of woven bone on the outer surface of the bone and into the marrow in the 3 week self-drilling microscrew implant (Fig 3, *C*), while there was minimal proliferation of bone in the self-tapping group. This outgrown bone tended to be resorbed at 5 weeks of placement (Fig 4, Table 7). At 5 weeks after placement in the self drilling group, some parts of the bent bone was resorbed (Fig 5). So the bone distant to the interface also showed resorption (Fig 5, *C*). Some of the bone kept in contact with the implants and some outgrew toward the marrow space and toward the head of the microscrew implants (Fig 5, *B*).

In the self tapping group, there were more defects at the interface between implant and bone in the 3 week group (Fig 6 and 8, *A*). The defects tended to be filled with new immature bone after 5 weeks (Fig 7 and 8, *B*). Immature remodeled bone was run parallel to the implant body and demarcated from old not remodeled bone.

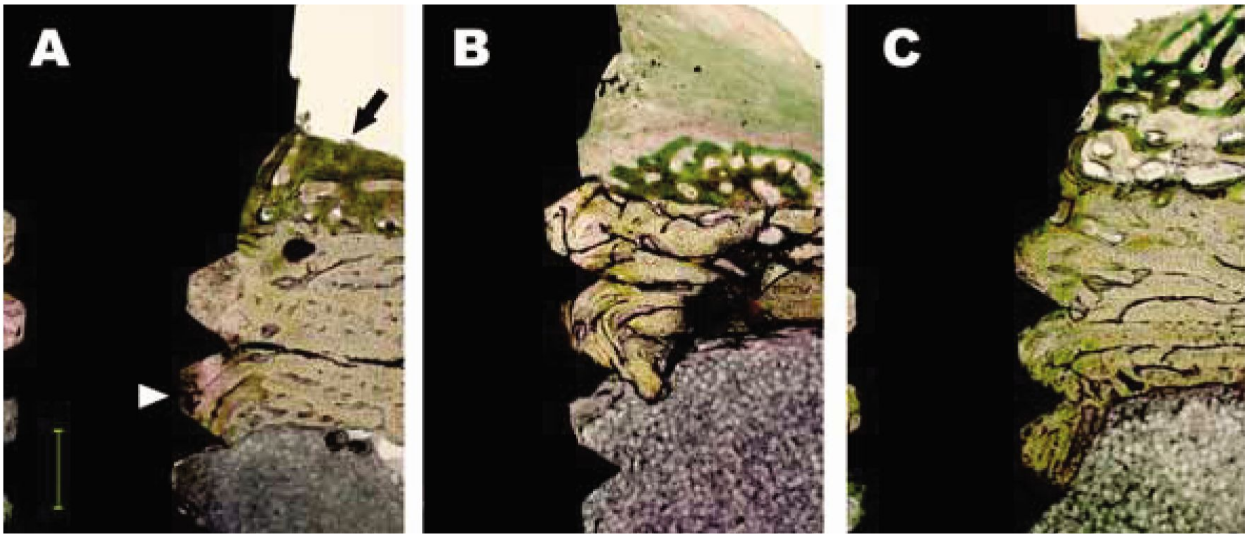

Fig 3. Microscopic photos of self-drilling microscrew implants 3 weeks after placement; new bone proliferation on the implant surface (arrow) and bending of bone (arrow head) was observed. **A**, No force. H-E stain, X 100; **B**, light force. H-E stain, X 100; **C**, heavy force. H-E stain, X 100, scale bar = 200 μm.

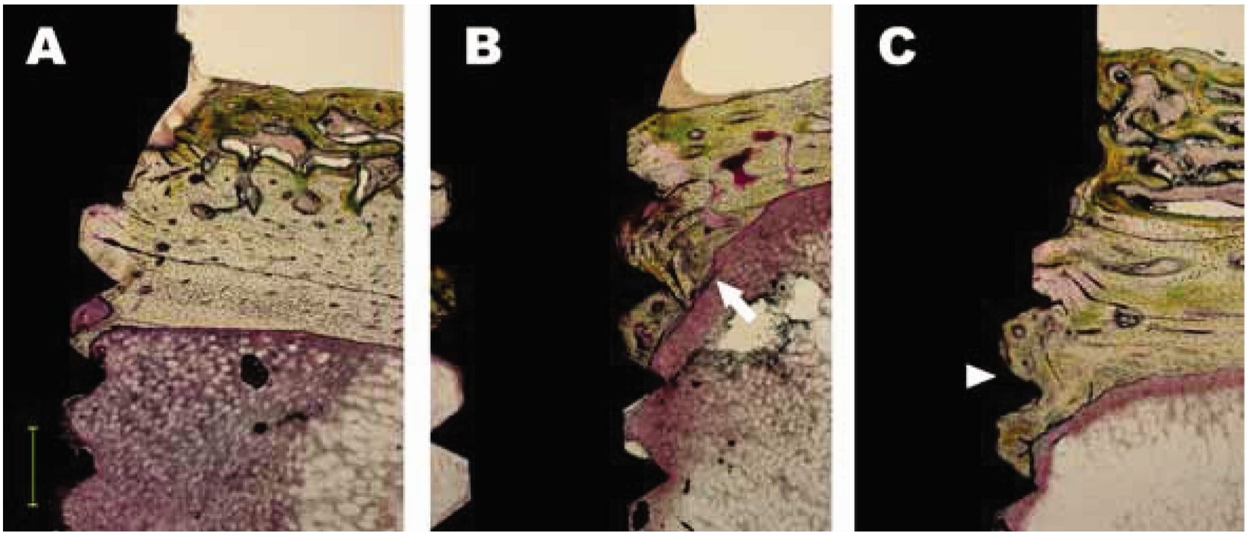

Fig 4. Microscopic photos of self-drilling microscrew implants 5 weeks after placement. **A**, No force, cortical bone was bent toward the marrow space and kept in contact with the microscrew implant (arrow head); **B**, light force. H-E stain, X 100; **C**, heavy force, bone showed extensive resorption where bending of the bone occurred (arrow) (X 100), scale bar = 200 μm.

Histometric analysis

Regarding the amount of defect at the interface between the microscrew implants and the bone, the self-drilling group had less defects than the self-tapping group ($p < 0.0001$) (Table 5). There were no statistically significant differences between force and time. Newly formed immature bone at the interface between the microscrew implants and the bone was significantly higher in the self-tapping group than in

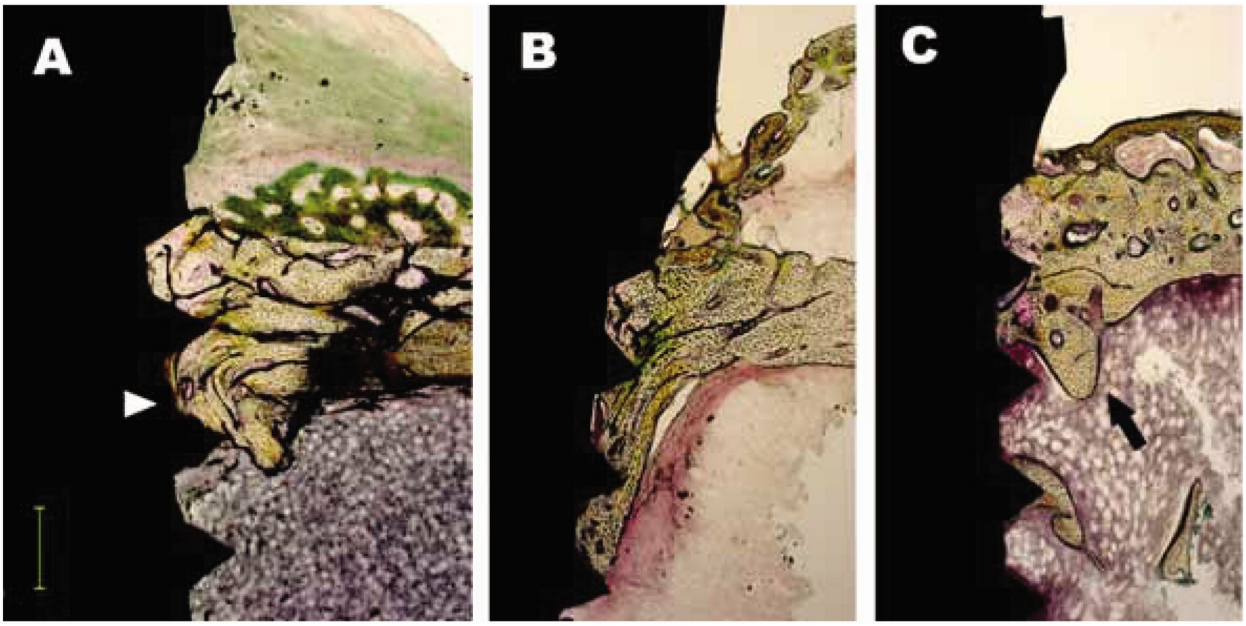

Fig 5. Microscopic photos of self-drilling microscrew implants. **A**, photo at 3 weeks after placement showing bone bending (arrow head); photos at 5 weeks after placement showing surface bone resorption (**B**), and extensive bone resorption (arrow) (**C**) (X 100), scale bar = 200 μm.

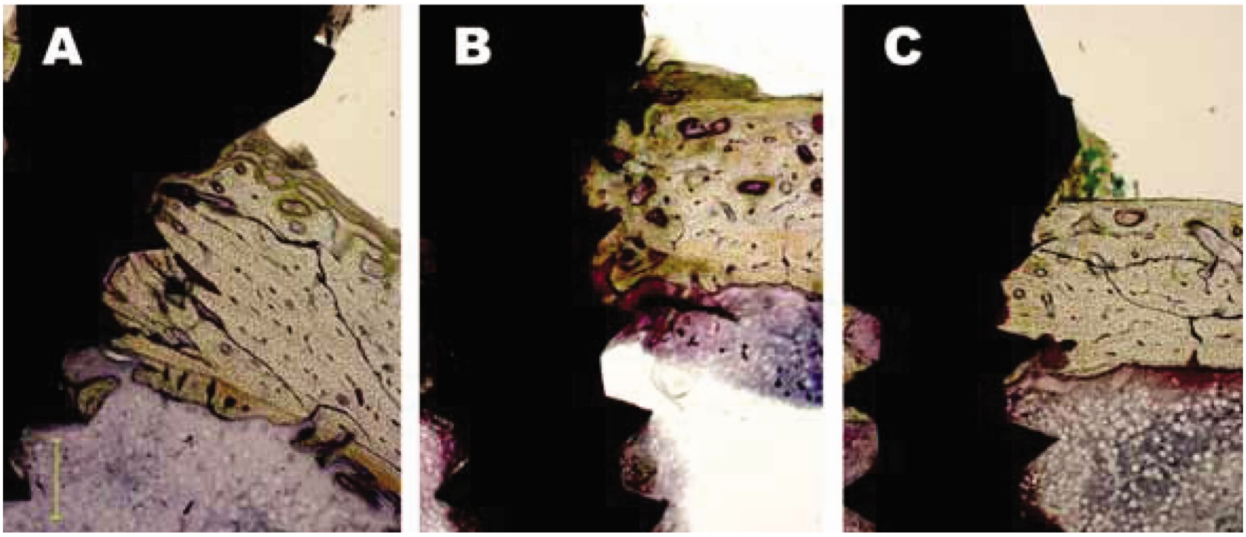

Fig 6. Microscopic photos of self-tapping microscrew implants 3 weeks after placement. **A**, No force. H-E stain, X 100; **B**, light force. H-E stain, X 100; **C**, heavy force. H-E stain, X 100, scale bar = 200 μm.

the self-drilling group (p = 0.0004) (Table 6). And the 5 week group had more immature bone over the 3 week group (p = 0.0119). New bone proliferation through the implant surface in the self-drilling group was higher than that in the self-tapping group (p = 0.0189) (Table 7).

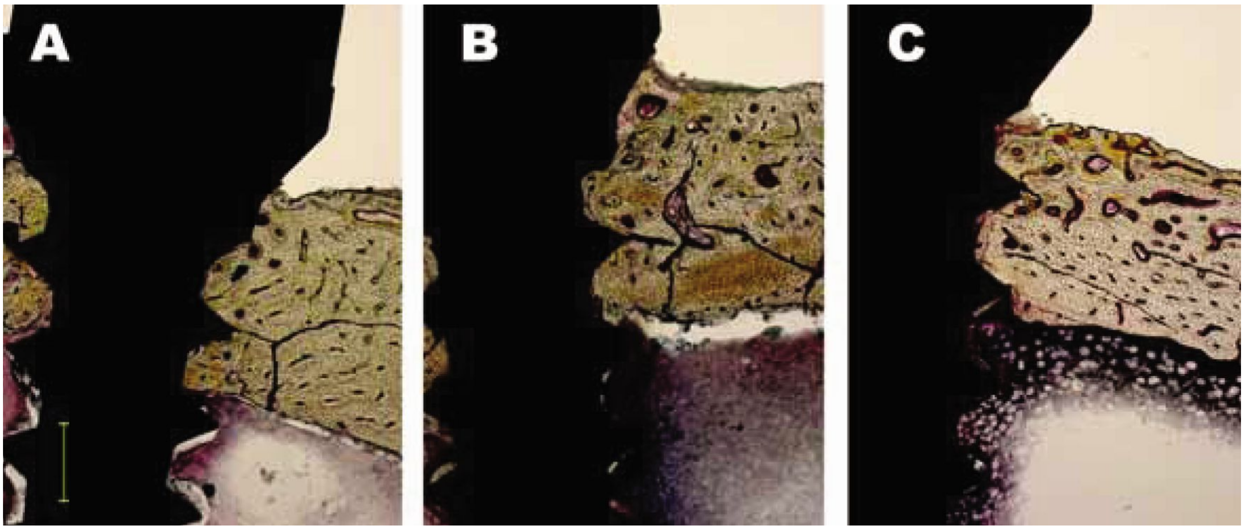

Fig 7. Microscopic photos of self-tapping microscrew implants 5 weeks after placement. **A**, No force. H-E stain, X 100; **B**, light force. H-E stain, X 100; **C**, heavy force. H-E stain, X 100, scale bar = 200 μm.

Table 5. Comparisons of the surface area of the defects at the interface of the microscrew implants and bone between groups (unit, μm)

Method	Week	Force	Defects (mean ± SD)	*p*-value
Self-drilling	3	No force (n = 7)	9.00 ± 5.03	<0.0001*
		Light (n = 6)	17.52 ± 1.41	0.0899†
		Heavy (n = 5)	24.22 ± 18.95	0.4096‡
	5	No force (n = 7)	15.63 ± 9.59	
		Light (n = 5)	24.94 ± 15.32	
		Heavy (n = 6)	13.24 ± 8.31	
Self-tapping	3	No force (n = 7)	37.82 ± 20.24	
		Light (n = 6)	46.99 ± 6.44	
		Heavy (n = 5)	37.13 ± 13.54	
	5	No force (n = 7)	27.54 ± 16.08	
		Light (n = 5)	27.85 ± 14.46	
		Heavy (n = 6)	27.53 ± 7.78	

*Denotes significance between self-drilling and self-tapping by 3-way ANOVA; † Denotes significance between 3 and 5 weeks by 3-way ANOVA; ‡ Denotes significance among no force, light and heavy force by 3-way ANOVA.

DISCUSSION

In maxillofacial surgery, transition is now taking place from traditional self-tapping screws to self-drilling screws. Because of frequent fracture of screws and incapability of placing it obliquely to the bone surface, self-drilling screws are not the most commonly used type. However, their ease of placement, less requirements for equipment, and shortened surgical time provide many benefits to orthodontists who are not familiar with the surgery. However, there are still controversies with self-drilling screws and self-tapping

Table 6. Comparisons of surface area of newly formed immature bone at the interface of the microscrew implants and the bone groups (unit, μm)

Method	Week	Force	Immature bone (mean ± SD)	*p*-value
Self-drilling	3	No force (n = 7)	7.47 ± 8.68	0.0004*
		Light (n = 6)	4.38 ± 5.70	0.0119†
		Heavy (n = 5)	3.39 ± 6.77	0.9734‡
	5	No force (n = 7)	15.00 ± 11.21	
		Light (n = 5)	8.02 ± 8.92	
		Heavy (n = 6)	13.63 ± 11.09	
Self-tapping	3	No force (n = 7)	26.20 ± 19.82	
		Light (n = 6)	11.33 ± 7.79	
		Heavy (n = 5)	12.31 ± 22.93	
	5	No force (n = 7)	20.67 ± 11.25	
		Light (n = 5)	35.39 ± 29.52	
		Heavy (n = 6)	37.47 ± 15.43	

*Denotes significance between self-drilling and self-tapping groups by 3-way ANOVA; † Denotes significance between 3 and 5 weeks by 3-way ANOVA; ‡ Denotes significance among no force, light and heavy force by 3-way ANOVA.

Table 7. Comparisons of new bone proliferation through the microscrew implants between groups (unit, μm)

Method	Week	Force	New bone (mean ± SD)	*p*-value
Self-drilling	3	No force (n = 7)	108.13 ± 40.24	0.0189*
		Light (n = 6)	88.09 ± 44.83	0.0644†
		Heavy (n = 5)	93.29 ± 44.76	0.3531‡
	5	No force (n = 7)	115.41 ± 56.49	
		Light (n = 5)	83.77 ± 19.35	
		Heavy (n = 6)	108.98 ± 61.06	
Self-tapping	3	No force (n = 7)	46.84 ± 20.77	
		Light (n = 6)	54.42 ± 25.57	
		Heavy (n = 5)	73.72 ± 18.02	
	5	No force (n = 7)	65.47 ± 23.58	
		Light (n = 5)	90.55 ± 43.02	
		Heavy (n = 6)	116.54 ± 41.84	

*Denotes significance between self-drilling and self-tapping groups by 3-way ANOVA; † Denotes significance between 3 and 5 weeks by 3-way ANOVA; ‡ Denotes significance among no force, light and heavy force by 3-way ANOVA.

screws regarding bone damage.[11,14] And because the mini or microscrew implants in the orthodontic field require being loaded with light force for a long duration as compared to surgical screws, there may be different bone responses. Therefore in the current study, we aimed to compare two commonly used methods of placing microscrew implants histologically and biomechanically.

In the self-drilling group, the microscrew implant threads push bone chips out of the hole as it is implanted.[11] Because of this, there was more proliferation of bone on the outer surface of the bone and/or toward the marrow space from the implant surface than the self-tapping microscrew implants. Tapered implants showed higher insertion torque and better primary stability than the standard type implant.[16] Therefore tapered self-drilling microscrew may cause more bone chip formation, because of their shape. In the self-tapping group, the hole was prepared before screwing the microscrew implants which may prevent bone chip formation. When considering that removing torque measurements are proportionate to bone contact area and amount of compact bone,[17] the outgrown bone consisting of mostly woven bone seemed not to have a large influence on removing torque. And this outgrown bone showed resorption at 5 weeks. Therefore this outgrown bone seems not to influence removal torque or stabililty of the microscrew implants.

At 3 weeks, the self drilling microscrew implants showed more bone contact with less defect than the self-tapping microscrew implants. And there was bending of cortical bone in the self-drilling microscrew implants. This is because the self-drilling microscrew implants push on the bone when being screwed into bone, the bone is bent and some are cut and pushed out as bone chips.[11] The self-tapping microscrew implants showed more defect at the interface than the self-drilling microscrew implants. This means that there was more damage for the bone located at the interface of self-tapping microscrew implants at 3 weeks. Therefore, we may say that in 3 weeks self drilling microscrew implants may provide more stability than self-tapping microscrew implants.

However, in 5 weeks the bent bone of the self-drilling microscrew implants showed resorption in some samples from the surface or inside the bone. This may be indicative of bone damage caused by pressure from self-drilling microscrew implants.[18] Too much pressure at the interface may produce microcracks or microdamage of the trabecular bone,[19] which will resorb later. And the outgrown bone of the self-drilling microscrew implants also showed resorption and decrease in thickness (Fig 5 and Table 7). However, in the self-tapping microscrew implants, the defect, loose stromal type connective tissue, not dense fibrous connective tissue, was filled with newly formed immature bone and partly remodeled into lamellar bone. This finding was similar to the study by Roberts et al.[20]

The bone turnover rate of rabbits is known to be three times faster than humans. A sigma, total elapsed time needed to resorb and deposit new bone, is 4 to 5 months in human ribs[21] whereas it is 6 weeks in rabbits.[20] The tibia of a rabbit has very thick and dense cortical bone and almost no cancellous bone, and it is similar to the mandible of humans. For the mandible, clinicians wait three months after placement before installation of protheses. Therefore we chose a 3 week period to evaluate the healing process of bone damage during placement, and a 5 week period to assess the healed state of damaged bone at the interface of bone and microscrew implants.

In regard to removal torque which was measured at 5 weeks, there was no statistically significant difference between the two groups. Because removal torque is dependent on the amount of compact bone surrounding the implants, deposition of new immature bone into the defects at the interface in self-tapping microscrew implants and resorption of bone in the self-drilling group may explain the lack of difference in removal torque at 5 weeks between the two groups. However, if we were to measure the removal torque at 3 weeks or earlier, the removal torque may be different. This should be elucidated with further studies. There seems to be no difference in pull out strength between self-drilling and self-tapping screws. Rather the difference may be originated from the difference in bone mineral density.[22]

It was considered as one of most important factors for osseointegration to have initial stability after placement.[23] The loading of low force which do not produce overload resorption of the surrounding bone, may increase the rate of success of microscrew implants by obtaining suitable osseointegration. Furthermore, when considering a study in which 87% of the screws showing partial or extensive osteolysis around the screw hole in histologic examination were fixed clinically in the bone,[24] if the load is light, the microscrew implants can be used as anchorage even though minimal mobility is evident.[25]

In a study in dogs, there was increased bone contact in the self-drilling screw implants.[26] The differences between the dog study and this current study may be explained by the difference in bone quality between animals. Dogs have very thin cortical and abundant cancellous bone as compared with rabbits which have very thick and dense cortical bone and almost no cancellous bone. The dog bone can be comparable to maxillary bone in humans and the tibial bone of rabbits may be comparable to the mandible. As suggested by Heidemann et al,[13] the self-drilling microscrew implants can be placed with more stability than the self-tapping microscrew implants in the maxilla. However, in the mandible with thick and dense cortical bone, self-drilling microscrew implants may produce more bone damage than the self-tapping microscrew implants. Therefore it was proposed that screws be placed with the pre-drilling method in the dense and thick cortical bone area.[27]

Heat generated during drilling was known to produce bone damage,[28] and several factors influencing heat generation were elucidated as follows, pressure during drilling,[29] intermittent or continuous drilling,[30] speed of drill,[29] and time of drilling.[31] There was no agreed opinion on the suitable pressure and speed of the drill. Clinically low speed and high torque (1500-2000 rpm) was recommended in implant site development.[29] Because the depth of drilling for the placement of the microscrew implant is shallower than the dental implants, we chose 500 rpm. This speed provided ease of manipulation. In order to minimize the differences of applied pressure and/or other conditions, one investigator placed all microscrew implants.

Pilot drilling in the self-tapping method may produce heat during placement.[15] However, abundant saline irrigation did not produce bone damage at the interface.[30] In this experiment, coolant was irrigated abundantly. Therefore although there was damage of bone at the interface in self-tapping microscrew implants, it was minimal. The old bone was kept in contact with the microscrew implants at 5 weeks as well as 3 weeks. Therefore with careful consideration for prevention of heat during drilling, we may maintain bone contact with self-tapping microscrew implants even though some defects are inevitable. By using a small diameter pilot drill smaller than the inner diameter of microscrew implants,[32] we may increase the capture of bone into the threads of microscrew implants.

Even though bone defects in the self-tapping microscrew implants at 3 weeks was evident, all loaded microscrew implants did not show mobility and stayed firm. If the amount of load increases upto a certain level which produces too much stress on the edge of the bone, overload bone resorption may take place.[33] Therefore, it is recommended to apply light force at the beginning, with the load being increased to heavy force after 4 months in clinical situations.

CONCLUSION

Self-drilling microscrew implants produce bending of cortical bone at 3 weeks with some of the bent bone showing resorption. There was more proliferation of woven bone through the implants toward the outer surface and/or marrow space in self-drilling microscrew implants than in self-tapping microscrew implants.

In self-tapping microscrew implants, there were more defects at the interface than self-drilling microscrew implants, and it was filled with immature bone or remodeled lamellar bone at 5 weeks.

There was no statistical difference in peak removal torque between self-drilling and self-tapping microscrew implants. There was no statistically significant correlation between insertion and removal torque.

It is recommended to apply light force to self-tapping microscrew implants in the early stages with the force being increased later. In the dense cortical bone area, self-drilling microscrew implants may produce more bone bending or damage, which can be prevented by making a hole with a pilot drill.

- 국문초록 -

Self drilling과 Self-tapping microscrew implants의 조직학적 및 생역학적인 비교

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이 연구의 목적은 교정용 고정원으로 사용된 self-drilling과 self-tapping microscrew implants를 조직학적 및 생역적으로 비교하는 것이다. 28 마리의 가토에 112개의 microscrew implants (56개의 self-drilling microscrew implants 와 56개의 self-tapping microscrew implants)를 식립하였다. Self-tapping microscrew implants는 0.9 mm 드릴로서 홈을 형성한 후 식립하였고 self-drilling microscrew implants는 홈을 형성하지 않고 바로 식립하였다. 교정력은 식립 직후 바로 NiTi coil spring을 연결하여 가하였으며 일부는 교정력을 가하지 않았고 일부는 100 gm정도의 약한 교정력을 일부는 200 gm정도의 강한 교정력을 가하였다. 실험동물은 3주 혹은 5주에 희생하였으며 72개의 비탈회 표본을 만들어 전반적인 조직학적 관찰과 조직 계측을 시행하였다. 토크 게이지로 최대 식립 토크와 최대 제거 토크를 측정하였다. 모든 microscrew implants는 실험기간 동안 안정되게 유지되었고 최대 제거 토크의 측정에는 self-drilling과 self-tapping microscrew implants 사이에 통계학적으로 유이한 차이가 없었다. 조직 관찰에서 self-tapping microscrew implants에서 골 임프란트 계면에 골결손이 더 많았고 5주에서는 새로이 형성된 미성숙 골이 더 많았다. Self-drilling microscrew implants에서 골표면 혹은 골내막으로의 골 형성이 많이 관찰되었으나 5주에서는 흡수되는 양상을 보였다. 3주에서는 self-drilling microscrew implants가 더 많은 골접촉을 보였으나 5주에서는 두 군사이에 차이가 관찰되지 않았다. 이 결과는 두 방법이 모두 microscrew implant의 식립에 사용될 수 있음을 시사하나 self-tapping microscrew implants의 경우 초기에는 약한 힘을 가하는 것이 좋을 것으로 생각된다.

주요 단어: 마이크로스크류 임플랜트, 자가식립, 골 임플랜트 계면, 제거 토크

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