# A prospective, split-mouth, clinical study of orthodontic titanium miniscrews with machined and acid-etched surfaces

Hyo-Jin Park

The Graduate School

Yonsei University

Department of Dentistry

# A prospective, split-mouth, clinical study of orthodontic titanium miniscrews with machined and acid-etched surfaces

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Hyo-Jin Park is approved.

Thesis Supervisor: Hyung-Seog Yu

Yoon Jeong Choi

Sung-Hwan Choi

Kwang-Mahn Kim

Young-Bum Park

The Graduate School

Yonsei University

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# 감사의 글

논문이 완성되기까지 많은 격려와 가르침을 주신 유형석 교수님과 최성환 교수님께 깊은 감사를 드립니다. 더 나은 방향으로 논문이 마무리 될 수 있도록 길을 제시해 주시고 많은 조언을 해주신 최윤정 교수님, 김광만 교수님, 박영범 교수님께도 진심으로 감사를 드립니다.

수련 과정 동안 교정과 의사로 성장할 수 있도록 기반을 만들어 주시고 이끌어 주신 황충주 교수님, 김경호 교수님, 이기준 교수님, 차정열 교수님, 정주령 교수님께도 다시 한번 감사의 말씀을 드리고 싶습니다. 또한 3년 동안 저의 삶의 일부이자 큰 힘이 되어 주었던 동기들에게도 감사의 마음을 전합니다.

2018년 6월

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## ABSTRACT

# A prospective, split-mouth, clinical study of orthodontic titanium miniscrews with machined and acid-etched surfaces

Hyo-Jin Park

Department of Dentistry

The Graduate School, Yonsei University

(Directed by professor Hyung-Seog Yu, D.D.S., Ph.D)

The aim of this study was to determine whether the success rate and primary stability of surface-treated miniscrews differed significantly from those of non-treated miniscrews.

Patients who required one or more miniscrews for the same reason in each quadrant were recruited into a single-blinded, split-mouth, randomized, controlled trial with a 1:1 allocation ratio. Self-drilling miniscrews with two surface types were used; with no surface treatment and with an acid-etched surface treatment. The cumulative success rate and primary stability of each type of miniscrew was examined, and factors potentially affecting the success and failure of miniscrews were investigated.

Forty patients were included in the study, with a total of 98 orthodontic miniscrews.

1. The overall success rate was 88.8 %, and the respective success rates for acid-etched and machined surface miniscrews were 91.8 % and 85.7 %.
2. The respective mean insertion torques were 13.62 ± 5.95 N·cm for acid-etched miniscrews and 13.38 ± 4 N·cm for machined surface miniscrews. Periotest values measured immediately after insertion were -0.50 ± 2.77 for acid-etched miniscrews and -0.28 ± 3.36 for machined surface miniscrews. There were no statistically significant differences between the two types of miniscrews
3. There was no significant difference in the mean insertion torques and periotest values according to surface treatment and jaw.
4. In the analysis of risk factors that affect the stability of orthodontic miniscrews, the success rate of miniscrews was low in cases of distalization and open bite group, which was statistically significant.

Neither the success rate nor the primary stability of acid-etched surface miniscrews and machined surface miniscrews differed significantly. There is a high possibility that miniscrews will fall out in patients who have an open bite or require total distalization.

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**Keywords: Acid-etched surface treatment, orthodontic miniscrew, primary stability, prospective study, success rate**

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## I. INTRODUCTION

Orthodontic miniscrews have been popularized to use for an absolute anchorage control because of their simplicity of placement and removal, low cost, and possibility for immediate force loading (Choi et al., 2016b; Miyawaki et al., 2003; Park et al., 2006; Yoo et al., 2014). Recently, the failure rates of miniscrews have been reported to be approximately 10-15 %, indicating that their usefulness is clinically acceptable (Papageorgiou et al., 2012). Nevertheless, previous studies have reported that patients with high mandibular plane angle had higher miniscrew failure rates than those with normal and low mandibular plane angles

(Jing et al., 2016; Miyawaki et al., 2003; Pithon et al., 2013; Tabuchi et al., 2015). Moreover, there is a great risk of failure of miniscrews in adolescent patients, due to active bone metabolism and low maturation of the bone (Chen et al., 2007; Hong et al., 2016; Jing et al., 2016; Motoyoshi et al., 2007). In addition to these host factors, several other factors affecting the success rate of miniscrews have been reported including screw design (taper or cylinder), (Choi et al., 2016b; Yoo et al., 2014), surface topography (Choi et al., 2016a; Gansukh et al., 2016; Kim et al., 2008; Vilani et al., 2015), diameter (Miyawaki et al., 2003; Park et al., 2006), length (Miyawaki et al., 2003; Park et al., 2006).

Various surface treatments for increasing the miniscrews' surface roughness or changing its nano-surface or topography to mimic that of natural bone have been developed to improve stability in patients with a high risk of miniscrew failure. Odontuya et al. reported that resorbable blasting media (RBM) treated miniscrews have better early stability than no treated miniscrews in rabbit model. This is because RBM treated miniscrews have a rougher surface and less initial lamellar bone resorption than miniscrews without surface treatment (Gansukh et al., 2016). Choi et al. reported that anodic oxidized miniscrews exhibited modified surface topography, but their biomechanical stability was similar to that of non-treated miniscrews in a beagle model (Choi et al., 2016a). Additionally, acid etched miniscrews showed higher success rate and proper osseointegration not to damage the surrounding tissues during unscrewing in vivo studies (Espinar-Escalona et al., 2016; Vilani et al., 2015).

To the best of our knowledge however, few prospective studies have evaluated differences in success rates and stability depending on the type of surface treatment in actual clinical situations. To determine whether surface-treated miniscrews are clinically more cost-effective than non-treated miniscrews, well-controlled prospective clinical studies are necessary. The

aim of this prospective clinical study was to determine whether the success rate and primary stability of surface-treated miniscrews differed significantly from those of non-treated miniscrews. Specifically, we investigated whether surface treatment of miniscrews may be one of the key factors that contribute to the success of miniscrews in clinical situations. The null hypothesis was that there is no difference in the success rate or primary stability of miniscrews regardless of surface treatment.

# II. MATERIALS AND METHOD

## 1. Study design and subjects

This prospective clinical study recruited patients who required the placement of miniscrews for orthodontic treatment at the Department of Orthodontics, Yonsei dental hospital (Seoul, Korea) between April 2016 and November 2016. Inclusion criteria for the study were the requirement of one or more miniscrews for the same reason in each quadrant of the maxilla or mandible during orthodontic treatment, complete fixed appliance treatment with or without premolar extraction and patients were also required to be aged over 13 years and exhibit all permanent teeth erupted—with the allowable exception of wisdom teeth. Exclusion criteria were severe craniofacial deformities such as a cleft lip and palate, a history of bone disease such as osteoporosis or diabetes, and cases where there was a high expectation of failure due to anatomical limitations such as pneumatization of the maxillary sinus, narrow interproximal alveolar bone, or attached gingiva deficiency were also excluded.

All patients (and their legal guardians in the case of minors) provided written informed consent to participate in this study prior to the placement of miniscrews. The study complied with the guidelines of the declaration of Helsinki, and was approved by the ethics committee of Yonsei dental hospital, Seoul, Korea. (IRB No. 2-2015-0023).

The study was a single-blinded, split-mouth, randomized, controlled trial with a 1:1 allocation ratio. Self-drilling miniscrews (diameter 1.6 mm, thread length 6 mm) were used. Miniscrews with two different surface types were included, those with no surface treatment (machined surface, OSSH1606; Osstem Implant, Busan, Korea) and those with an acid-etched surface (OSSH1606HE; Osstem Implant, Busan, Korea) (Figure 1).

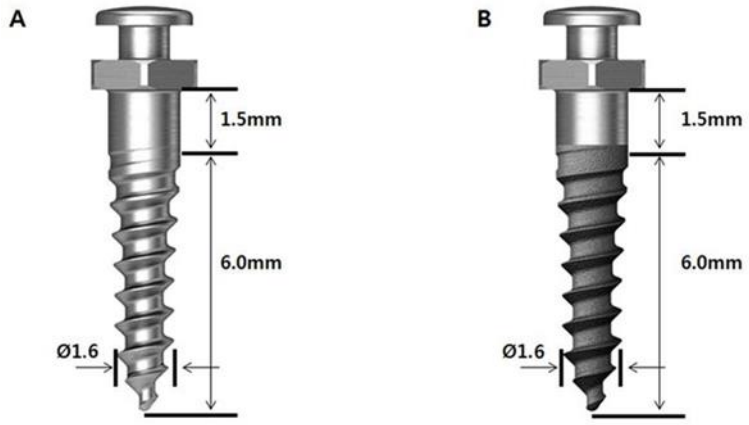


Figure 1. Schematic diagrams of orthodontic miniscrews with (**A**) machined and (**B**) acid-etched surfaces.

The patients did not know which type of miniscrew was placed at which location, which was determined via a random block design. Orthodontic miniscrews were placed in the symmetrical position, mainly in the posterior buccal area between the second premolar and the first molar in the maxilla or mandible. Two miniscrews were symmetrically placed on each side for the same purpose. The miniscrews were used as absolute anchorage for en-masse retraction, total arch distal movement, and intrusion of maxillary posterior teeth. Both types of miniscrews were placed with a manual hand driver directly, without predrilling. All miniscrews in the entire study were inserted by the same orthodontic specialist. The orthodontic load applied to the miniscrews was estimated to be 100–200 g approximately 4 weeks after surgery. The direction of the force loaded onto each pair of miniscrews within each patient was the same, and was perpendicular to the screw.

## 2. Scanning electron microscopy

To evaluate differences in surface topography between the two types of miniscrews, their surfaces were observed via scanning electron microscopy at magnifications of 50x and 1000x. (S3000N; Hitachi, Tokyo, Japan). They were coated with platinum by ion sputtering (IB-3, Eiko Engineering, Ibataki, Japan), 6 mA for 6 minutes, and were examined and photographed at 20 kV acceleration voltage. The middle thread was observed for each surface type.

## 3. Primary stability

To evaluate the stability of a miniscrew, the maximum insertion torque was measured using a torque sensor (Mark-10, MGT 12, USA). Periotest value (PTV) was measured via the Periotest® system (Siemens, Bensheim, Germany) in the form of mobility values, immediately after insertion and 6 months after insertion.

## 4. Success rate

The cumulative success rates of each of the two types of miniscrews were examined. Criteria for the success of miniscrews were absence of clinical detectable mobility (movement greater than 1 mm when gently luxated with forceps) (Choi et al., 2016a) and capacity to sustain the anchorage function throughout the orthodontic treatment. Furthermore, success of miniscrews was defined as inserted miniscrews that were maintained for > 6 months. (Wiechmann et al., 2007)

## 5. Statistical analysis

The cumulative survival of the miniscrews was analyzed using the Kaplan-Meier method. The Kolmogorov-Smirnov test was applied to assess data distribution and normality. Two-way analysis of variance (ANOVA) was used to compare the mean initial torque and PTV according to surface treatment and insertion site.

To investigate affecting factors that contributes to their success in clinical situations, a multivariate regression model was used. The independent variables were divided two categories; host-related variables and miniscrew-related variables. Host-related variables included age (< 20 years, ≥ 20 years), sagittal skeletal pattern (Class I, ANB 0−4°; Class II, > 4°; Class III, < 0°;), vertical skeletal pattern (high, SN-MP > 37°; normal, SN-MP 27–37°; low, SN–MP < 27°), overjet (normal, 0–4 mm; excessive overjet > 4 mm; crossbite < 0 mm) and overbite (normal, 0–4 mm; deep bite > 4 mm; open bite < 0 mm). Miniscrew-related variables included surface treatment type (machined vs. acid-etched), insertion site (maxilla vs. mandible), and miniscrew purpose (en-masse retraction anchorage, retraction; total arch distal movement, distalization; maxillary molar intrusion, intrusion). The model-building strategy involved the inclusion of any variable for which the bivariate test yielded a *P* value of < 0.05. A backward elimination was performed on any variable that did not contribute to the model on the grounds of the likelihood ratio test (logistic regression), using a *P* value cut-off of 0.05. Based on the dichotomized dependent variable, the adjusted odds ratios (OR) and 95 % confidence intervals (CI) were calculated. All statistical analyses were performed using IBM SPSS software for windows (version 23.0; SPSS, Chicago, IL, USA).

# III. RESULT

## 1. Characteristics of subjects

Forty patients (13 men and 27 women) were included in this study with a total of 98 orthodontic miniscrews (49 acid-etched and 49 machined surface), and their mean age was 22.16 ± 5.38 years. When the 40 patients were classified as described in the above section, 55 % were skeletal class II, 57.5 % exhibited a high mandibular plane angle, 67.5 % had a normal overjet, and 77.5 % had a normal overbite (Table 1). With regard to location, 63.3 % of the miniscrews were placed in the maxilla, and en-masse retraction was the most frequent purpose of placement (Table 2).

Table 1. Characteristics of patients

| Variables | |
|---|---|
| Sex (men/women) | 13 (32.5)/ 27 (67.5) |
| Age (years) (mean ± SD) | 22.16 ± 5.38 |
| Sagittal skeletal pattern | |
| Class I | 11 (27.5) |
| Class II | 22 (55) |
| Class III | 7 (17.5) |
| Vertical skeletal pattern | |
| Normal (SN-MP 27–37°) | 15 (37.5) |
| High mandibular plane angle (>37°) | 23 (57.5) |
| Low mandibular plane angle (< 27°) | 2 (5.0) |
| Overjet | |
| Normal overjet (0-4 mm) | 27 (67.5) |
| Excessive overjet (>4 mm) | 11 (27.5) |
| Crossbite (<0 mm) | 2 (5.0) |
| Overbite | |
| Normal overbite (0-4 mm) | 31 (77.5) |
| Deep bite (>4 mm) | 2 (5.0) |
| Open bite (<0 mm) | 7 (17.5) |

SN-MP, mandibular plane angle

Unless otherwise noted, the right column means number (%).

Table 2. Miniscrew related characteristics

| Variables | |
|---|---|
| Surface type of miniscrews | |
| Acid-etched surface | 49 (50.0) |
| Machined surface | 49 (50.0) |
| Insertion Site | |
| Maxilla | 62 (63.3) |
| Mandible | 36 (36.7) |
| Purpose of miniscrew | |
| Retraction | 56 (57.1) |
| Distalization | 34 (34.7) |
| Intrusion | 8 (8.2) |

The right column means number (%).

## 2. Scanning electron microscopy

Scanning electron microscopy analysis revealed different surface topography of the two types of miniscrews, and acid-etching surface treatment evidently changed the surface morphology resulting in a rough surface (Figure 2).

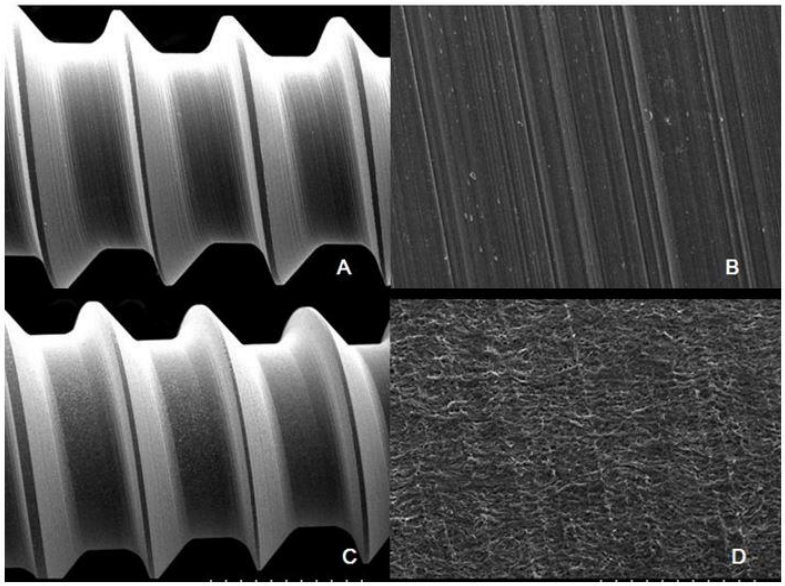


Figure 2. Scanning electron microscopy image of the lateral side of orthodontic miniscrews. **A**. SEM of a machined miniscrew(50 times) **B**. SEM of a machined miniscrew(1000 times) **C**. SEM of a acid-etched miniscrew(50 times) **D.** SEM of a acid-etched miniscrew(1000 times)

### 3. Primary stability

The maximum insertion torques were 13.62 ± 5.95 N·cm for the acid-etched miniscrews and 13.38 ± 4.0 N·cm for the machined miniscrews. PTVs measured immediately after insertion were -0.50 ± 2.77 for the acid-etched miniscrews and -0.28 ± 3.36 for the machined miniscrews. PTVs measured 6 months after insertion were 4.58 ± 5.15 for the acid-etched miniscrews and 6.42 ± 5.6 for the machined miniscrews. All measurements were not statistically significant. ($P$ = 0.733, $P$ = 0.647, $P$ = 0.066) When the mean insertion torque and PTV according to the surface treatment and jaw were compared, no interaction between surface treatment and jaws was found using a two-way ANOVA (Table 3).

Table 3. Mean and standard deviation of the insertion torque value and periotest value (PTV) according to the surface treatment and jaw.

| Variables | Jaw | Surface treatment | | Interaction (Surface treatment x Jaw) |
|---|---|---|---|---|
| | | Machined | Acid-etched | |
| Initial torque | Mx | 12.91 ± 4.52 | 13.4 ± 6.11 | 0.818 |
| | Mn | 14.18 ± 2.85 | 14.12 ± 5.79 | |
| PTV immediately after insertion | Mx | –0.93 ± 3.24 | –1.26 ± 2.82 | 0.862 |
| | Mn | 0.92 ± 0.81 | 0.81 ± 2.16 | |
| PTV 6 month after insertion | Mx | 6.26 ± 6.78 | 3.83 ± 4.34 | 0.871 |
| | Mn | 7.99 ± 6.37 | 5.13 ± 5.8 | |

Interaction (surface treatment x jaw) means $P$ value calculated with two-way ANOVA.
Mx, Maxilla; Mn, Mandible

## 4. Success rate

The overall success rate was 88.8 %, and the respective success rates for acid-etched and machined surface miniscrews were 91.8 % and 85.7 % (Figure 3). The difference in success rates was not statistically significant ($P$ = 0.323). With regard to associations between miniscrew success rates and host-related variables, higher success rates were associated with skeletal Class I, normal mandibular plane angle, normal overjet, and overbite. When considering miniscrew-related variables, acid-etched surface and en-masse retraction anchorage were associated with better success rates (Table 4). Notably however, there was no significant difference in the success rates in each group.

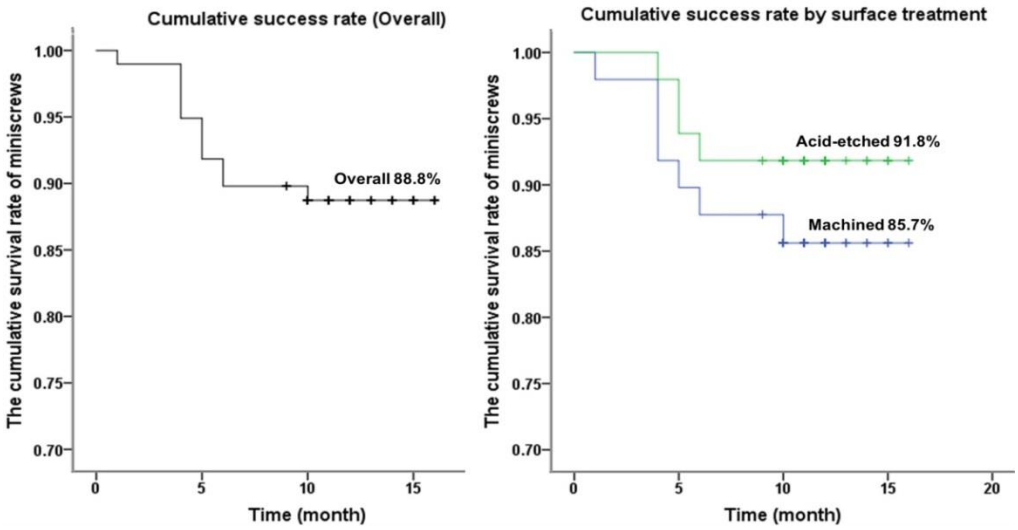


Figure 3. The Kaplan-Meier survival function curve (overall and by surface treatment)

Table 4. Success rate of miniscrew according to variables

| Clinical variables | Success/total (n) | Success rate (%) |
|---|---|---|
| Age (years) (Mean ± SD) | | |
| <20 | 23/26 | 88.5 |
| ≥20 | 64/72 | 88.9 |
| Sagittal Skeletal pattern | | |
| Class I | 27/28 | 96.4 |
| Class II | 44/50 | 88 |
| Class III | 16/20 | 80 |
| Vertical Skeletal pattern | | |
| Normal (SN-MP 27–37°) | 34/36 | 94.4 |
| High mandibular plane angle (>37°) | 48/56 | 85.7 |
| Low mandibular plane angle (< 27°) | 5/6 | 83.3 |
| Overjet | | |
| Normal overjet (0-4 mm) | 58/64 | 90.6 |
| Excessive overjet (>4 mm) | 26/30 | 86.7 |
| Crossbite (<0 mm) | 3/4 | 75 |
| Overbite | | |
| Normal overbite (0-4 mm) | 68/74 | 91.9 |
| Deep bite (>4 mm) | 7/8 | 97.5 |
| Open bite (<0 mm) | 12/16 | 75 |
| Surface type of miniscrews | | |
| Machined surface | 42/49 | 85.7 |
| Acid-etched surface | 45/49 | 91.8 |
| Insertion Site | | |
| Maxilla | 55/62 | 88.7 |
| Mandible | 32/36 | 88.8 |
| Purpose of miniscrew | | |
| Retraction | 52/56 | 92.9 |
| Distalization | 29/34 | 85.3 |
| Intrusion | 6/8 | 75 |

## 5. Risk factors that affect the stability of orthodontic miniscrews

To investigate the individual factors affecting miniscrew failure statistically, multivariate regression analysis was performed. On the basis of the adjusted analysis, if the purpose of the miniscrew was distalization (OR 7.49, 95 % CI 1.23–45.75, $P < 0.05$) and if the overbite was an open bite (OR 4.76, 95 % CI 1.78–63.39, $P < 0.05$), the possibility of miniscrew failure was high (Table 5).

Table 5. Summary of adjusted multivariate regression analysis predicting failure of miniscrews

| Clinical variables | Logistic regression | | |
|---|---|---|---|
| | OR | 95% CI | *P* value |
| (constant) | 0.013 | | |
| Purpose of miniscrew | | | |
| Retraction | 1 (reference) | | |
| Distalization | 7.49 | 1.23-45.75 | 0.029* |
| Intrusion | 4.43 | 0.59-33.50 | 0.149 |
| Overbite | | | |
| Normal overbite (0-4 mm) | 1 (reference) | | |
| Deep bite (>4 mm) | 4.76 | 0.37-61.07 | 0.231 |
| Open bite (<0 mm) | 10.62 | 1.78-63.39 | 0.010* |

OR, odd ratio; CI, confidence interval; *$P < 0.05$

# IV. DISCUSSION

Acid-etching surface treatment method has been shown to facilitate osteogenic cell and blood cell retention and allows for cell migration at the miniscrew surface, and as a result it improves the biocompatibility and stability of titanium miniscrews (Fernandes et al., 2017). Several animal studies have shown that acid-etched surface treatment improves the stability and success rate of miniscrews. However, most previous in vivo studies have been conducted in animals such as dogs or rabbits. In many cases, the force was not applied to the miniscrew, and the cortical bone thickness of dogs and rabbits differs from that of humans. Additionally, most human studies have been retrospective. For these reasons, this controlled, split-mouth, human clinical study represents a timely addition to the knowledge base.

The primary stability of miniscrews is regarded as mechanical retention at implantation, and is one of the important factors pertaining to clinical success. Primary stability was assessed by maximum insertion torque and PTVs in the current study, and insertion torque was 13.62 N·cm for the acid-etched miniscrews and 13.38 N·cm for the machined miniscrews. Motoyoshi et al. reported that a maximum insertion torque between 5 N·cm and 10 N·cm is appropriate (Motoyoshi et al., 2006). According to this criterion, the insertion torque in the current study was somewhat large. However, other studies have reported that there is no evidence on which to base specific recommendations of maximum insertion torque levels to obtain higher orthodontic miniscrew success rates (Meursinge Reynders et al., 2012; Tepedino et al., 2017). In addition, maximum insertion torque reportedly varies depending on whether or not pilot drilling is utilized, the diameter and length of the miniscrews, and the thickness of the cortical bone at the placement site (Meursinge Reynders et al., 2012; Lim et al., 2008).

PTVs have been used to evaluate the initial stability of mini-implants in terms of mobility, and it has been reported that PTVs immediately after insertion correlate significantly with insertion torque. In that study, values between -8 and +9 indicated that the miniscrew was stable. In the current study, the initial mean PTVs were -0.5 for acid-etched miniscrews and -0.25 for machined miniscrews. At 6 months after insertion, mean PTVs were 4.58 for acid-etched miniscrews and 6.42 for machined miniscrews indicating that they were relatively stable.

Host factors affecting the success rates of miniscrews were examined in this study. And of these the dominant factors were overbite and miniscrew purpose. Patients with an open bite had a high failure rate. All patients with an open bite were in the high mandibular plane angle group in this study. Several previous studies have also shown that miniscrew success rates are low in patients with high mandibular plane angle (Miyawaki et al., 2003; Jing et al., 2016). The reason is that the thickness of buccal cortical bone in subjects with a high mandibular plane angle is thinner than that in subjects with a low or normal mandibular plane angle (Chen et al., 2007). In the current study, the purpose of miniscrew placement was classified as retraction anchor, distalization, or intrusion, and the distalization group exhibited a lower success rate than the other groups. As distalization progresses, the miniscrew contacts the root of the tooth and the bone density around the miniscrew is reduced. For this reason, the failure rate within 6 months was higher in the distalization group, although initial torque and mobility were good.

One of the limitations of this study is the small number of participants, particularly with regard to assessing risk factors related with success of miniscrews. Logistic regression analysis yielded a rather broad 95 % CI. Regarding vertical pattern, the success rate of the

high mandibular plane angle group was 85.7 %, which was lower than that of the noramal mandibular plane angle group of 94.4 %. Nevertheless, caution must be utilized when drawing conclusions. In the skeletal Class III group, which had a lower success rate than the skeletal Class I or II groups, approximately 70 % of the patients belonged to the high mandibular plane angle group. In the open bite group, which exhibited a statistically significantly lower success rate, all patients belonged to the high mandibular plane angle group. If there had been a large number of patients in each group, logistic regressing analysis would have resulted in narrower 95 % CI than were obtained in the current study, and potential risk factors could have been investigated more thoroughly. Additionally, the removal torque of miniscrews was not examined in the current study. . Secondary stability and osseointegration of miniscrews can be assessed via removal torque. Of all the miniscrews used in the current study, 34.7 % were used as anchors for distalization. As mentioned earlier, it was decided that it was meaningless to examine the removal torque of miniscrews because they could contact the root, and the bone density around the miniscrews changed during the distalization process.

In the future, to apply the results of this study more generally, larger sample sizes are needed to assess associations between skeletal pattern and miniscrew success rate. Furthermore, to evaluate associations between the secondary osseointegration of miniscrews and different surface treatments, it would be better to recruit subjects based on more restricted criteria with regard to the purpose of the miniscrews, for example anterior teeth en-masse retraction cases where the relationship between the tooth and the miniscrew remains relatively unchanged over time.

# V. CONCLUSION

- The success rate of acid-etched surface miniscrews was 91.8% and that of machined surface miniscrews was 85.8% in the current study, but this difference was not statistically significant.
- There was also no significant difference in primary stability according to surface treatment and jaw.
- Patients with an open bite or those who require distalization of the total dentition are predicted to have a high possibility of miniscrew failure.

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## ABSTRACT (KOREAN)

# 표면 산처리 유무에 따른 교정용 미니스크류의 안정성 평가 : 전향적 임상 연구

박 효 진

연세대학교 대학원 치의학과

(지도 교수: 유 형 석)

최근 교정용 미니스크류의 성공률을 높이기 위하여 보철용 임플란트 표면처리기술에 기반을 둔 교정용 미니스크류의 표면처리 방법이 연구되어 왔다. 그러나 미니스크류의 표면 처리에 따른 성공률과 안정성을 실제 임상상황에서 전향적으로 진행한 연구가 드물다는 점에 착안하여 본 연구를 계획하게 되었다. 본 연구의 목적은 표면 산 처리 유무에 따른 교정용 미니스크류의 성공률과 초기 안정성에 대해 평가하는 것이다.

치료계획 상, 상악 또는 하악의 좌, 우측에 동일한 목적으로 미니스크류가 하나 이상 필요한 환자 40명을 대상으로, 교정용 미니스크류는 표면 산처리를 한 미니스크류 49개, 표면처리를 하지 않은 미니스크류 49개를 이용하여 전향적 임상 연구를 수행한 결과 다음과 같은 결과를 얻었다.

1. 본 연구에서의 교정용 미니스크류의 성공률은 88.8% 이며, 표면 산처리를 한 미니스크류는 91.8%, 표면 처리를 하지 않은 미니스크류는 85.7%의 성공률을 보였다.
2. 표면 산처리를 한 미니스크류의 평균 식립 토크는 13.62 ± 5.95 N·cm이며, 표면처리를 하지 않은 미니스크류의 평균 식립 토크는 13.38 ± 4 N·cm이다. 식립 직후 PTV는 표면 산 처리를 한 미니스크류에서 -0.50 ± 2.77이고, 표면처리를 하지 않은 미니스크류에서는 -0.28 ± 3.36이다.
3. 평균 식립 토크와 PTV는 표면처리와 식립 위치(상악 또는 하악)에 따른 통계적으로 유의미한 차이가 없었다.
4. 교정용 미니스크류의 안정성에 영향을 미칠 수 있는 위험인자 분석에서 Overbite 그룹의 개방교합 환자군과 Purpose of miniscrew 그룹에서 전 치열의 후방이동을 하는 경우 미니스크류의 성공률이 낮았으며, 이는 통계적으로 유의하였다.

본 연구에서 표면 산처리 유무에 따른 교정용 미니스크류의 성공률과 초기 안정성의 통계학적으로 유의미한 차이가 없었다.

개방교합 환자군 또는 치료 시 전 치열의 후방이동을 계획하는 경우, 미니스크류의 탈락률이 높을 것으로 판단되므로 치료 시 주의가 필요하다.

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**핵심이 되는 말: 미니스크류, 성공률, 전향적 임상 연구, 초기 안정성, 표면 산처리**