# Success Rate and Risk Factors Associated with Mini-Implants Reinstalled in the Maxilla

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**ABSTRACT**

**Objective:** To determine the difference in the success rate for two types of oral installed mini-implants (OMIs): one type of initially installed OMI and a new implant of the same type that is reinstalled.

**Materials and Methods:** The subjects consisted of 58 patients (19 male, 39 female; mean age = 21.78 ± 5.85 years) who had received at least one OMI (self-drilling type, conical shape with 2.0-mm upper diameter and 5-mm length) in the attached gingiva of the upper buccal posterior regions for maximum anchorage during en masse retraction. If an OMI failed, a new one was immediately installed in the same area after 4 to 6 weeks or in an adjacent area immediately. The total number of initially installed OMIs (II-OMI) was 109 and the total number of reinstalled OMIs (RI-OMI) was 34. Statistical analysis was performed using $\chi^2$ test, Kaplan-Meier method, log-rank test, and Cox proportional hazards regression model.

**Results:** The success rate and mean duration were 75.2% and 10.0 months, respectively, for II-OMI and 66.7% and 6.4 months, respectively, for RI-OMI. Age, vertical skeletal pattern, and site and side of implantation were not related to the success rates of II-OMI and RI-OMI. Log-rank test showed that II-OMI in males and Class III malocclusions were more prone to failure. The relative risk of II-OMI failure in Class III malocclusions as opposed to Class I malocclusions was 5.36 (95% confidence interval, 2.008 to 14.31, *P* = .001).

**Conclusion:** The success rate of the II-OMI was not statistically different from that of the RI-OMI. Sex and ANB angle might be more important factors for better II-OMI results.

**KEY WORDS:** Success rate; Risk factor; Orthodontic mini-implant; Reinstallation

## INTRODUCTION

Recently, there has been a dramatic increase in the use of orthodontic mini-implants (OMIs; also known as

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micro screws or mini screws) to allow maximum anchorage, decrease the need for patient compliance, and further simplify the treatment procedure.[1–5]

According to experimental and clinical studies, OMIs can provide sufficient and stable anchorage for orthodontic treatment.[2,6–10] However, the success rates of OMIs have been reported to range from 37% to 97%.[11–22] Studies have found that the stability of OMIs is affected by age, sex, craniofacial skeletal pattern, site and side of implantation, latent period, loading protocol, dimension of OMI, angulation of OMI to bone, insertion torque, degree of OMI-bone contact, quality and quantity of the cortical bone, degree of inflammation of the peri-OMI tissue, thickness and mobility of the soft tissue, and root proximity.[6,14,15,19–21,23–26]

If an OMI fails, there are two options: reinstall a new one in the same area after 4 to 6 weeks or install a new one in an adjacent area immediately.[5] However, few studies have focused on the fate of the reinstalled OMI (RI-OMI).

To determine objectively the success rate of RI-OMI, it is necessary to confine the sample to the same

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**Figure 1.** The orthodontic mini-implant used in this study (2005H, ORTHOplant, BioMaterials Korea, Seoul, Korea; self-drilling type, conical shape with 2.0-mm upper diameter, 5-mm length).

**Table 1.** Demographic Data of the Initial Installation of Orthodontic Mini-implants (OMIs)

| Gender | Young Patients (<18 years old) 15.07 ± 2.11 years | | Adult Patients (>18 years old) 24.34 ± 4.65 years | | Sum 21.78 ± 5.85 years | |
|---|---|---|---|---|---|---|
| | No. of Subjects | No. of OMIs | No. of Subjects | No. of OMIs | No. of Subjects | No. of OMIs |
| Male | 6 | 12 | 13 | 25 | 19 | 37 |
| Female | 10 | 16 | 29 | 56 | 39 | 72 |
| Sum | 16 | 28 | 42 | 81 | 58 | 109 |

**Table 2.** Number of Orthodontic Mini-implants According to Side and Site of Implantation of the Initial Installation

| Side and Site of Implantation[a] | Young Patients (<18 years old) | | Adult Patients (>18 years old) | | Subtotal | | |
|---|---|---|---|---|---|---|---|
| | Right | Left | Right | Left | Right | Left | Total |
| Mx1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 |
| Mx2 | 14 | 11 | 23 | 25 | 37 | 36 | 73 |
| Mx3 | 2 | 1 | 15 | 17 | 17 | 18 | 35 |
| Subtotal | 16 | 12 | 39 | 42 | | | |
| Total | 28 | | 81 | | 109 | | |

[a] Mx1 indicates area between the upper first and second premolars; Mx2, area between the upper second premolar and first molar; Mx3, area between the upper first and second molars.

**Table 3.** Definition and Mean and Standard Deviation of the Craniofacial Skeletal Variables

| | Subgroup (No. of Patients) | Definition | Mean ± SD |
|---|---|---|---|
| ANB (°) | 1 (28) | >0, <4 | 2.31 ± 1.04 |
| | 2 (18) | >4 | 6.05 ± 5.74 |
| | 3 (12) | <0 | −3.31 ± 3.68 |
| FMA (°) | 1 (13) | <25 | 19.31 ± 3.79 |
| | 2 (30) | >25, <35 | 28.96 ± 2.95 |
| | 3 (15) | >35 | 40.05 ± 5.85 |

type of OMI from one manufacturer with the same implantation protocol and purpose. Also, to determine the risk factors associated with the failure rate, clinical characteristics, including sex, age, craniofacial skeletal pattern, and site and side of implantation, have to be examined. Most OMIs are used in the upper arch for the maximum posterior anchorage during retraction of the upper anterior teeth. Therefore, the purpose of this study was to assess the success rate and the risk factors associated with RI-OMIs placed in the upper buccal attached gingiva (BAG) after initial failure.

## MATERIALS AND METHODS

Subjects were 58 patients (19 male, 39 female; mean age = 21.78 ± 5.85 years; range = 12.5 to 42.7 years) who received at least one OMI (2005H, OR-THOplant, Biomaterials Korea, Seoul, South Korea; self-drilling type, conical shape with 2.0-mm upper diameter and 5-mm length, Figure 1) in the upper BAG for the purpose of maximum posterior anchorage during en masse retraction of the upper anterior teeth.

The total number of initially installed OMI (II-OMI) was 109 (37 males, 72 females; 28 young patients (<18 years), 81 adult patients (>18 years); 55 on the right side, 54 on the left side; 1 in the area between the upper first and second premolars (Mx1), 73 between the upper second premolar and first molar (Mx2), and 35 between the upper first and second molars (Mx3); Tables 1 and 2). Craniofacial skeletal variables are listed in Table 3.

OMIs were installed by one operator without a soft-

tissue incision or pilot drilling. They were placed in the BAG just adjacent to the mucogingival junction of MX1, Mx2, and MX3 with a 90° angle to the long axis of the teeth after leveling and alignment.

A 0.0220-in straight wire appliance was used. The orthodontic force of less than 200 g was applied to the OMI 2–3 weeks after placement using elastic chains or nickel-titanium closed-coil springs (medium, 9 mm, Ormco, Glendora, Calif), which stretched from the OMI head to the crimpable hook between the upper lateral incisor and canine in 0.019 × 0.025-in stainless steel archwire.

The criteria for success of an OMI were absence of inflammation, absence of clinically detectable mobility, and capability of sustaining the anchorage function throughout the course of orthodontic treatment (more than 8 months or until completion of treatment purposes). Failure was defined as mobility or loss of OMI

**Table 4.** Success Rate of the Initially Installed Orthodontic Mini-implants (OMIs)[a] and Reinstalled OMIs

| | | Initially Installed OMIs | | | Reinstalled OMIs | | | |
|---|---|---|---|---|---|---|---|---|
| | | Success Number | Success Rate | P | Success Number | Success Rate | P | P |
| Sex | Male | 23/37 | 62.2% | .0235* | 11/17 | 64.7% | .7242 | .0344* |
| | Female | 59/72 | 81.9% | | 10/17 | 58.8% | | |
| Age | Young | 20/28 | 71.4% | .5889 | 7/9 | 77.8% | .4267 | .4057 |
| | Adult | 62/81 | 76.5% | | 14/25 | 56.0% | | |
| Site of implantation | Mx1 | 1/1 | 100.0% | | 1/1 | 100.0% | | |
| | Mx2 | 56/73 | 76.7% | .5528# | 9/15 | 60.0% | .9481 | .1267# |
| | Mx3 | 25/35 | 71.4% | | 11/18 | 61.1% | | |
| Side of implantation | Right | 39/57 | 76.7% | .2917 | 12/23 | 52.2% | .1398 | .4333 |
| | Left | 43/64 | 67.2% | | 9/11 | 81.8% | | |
| ANB | 1ʃʃ | 45/51††† | 88.2% | | 4/8 | 50.0% | | |
| | 2 | 26/35† | 74.3% | .0010** | 5/11 | 45.5% | .1365 | .0000*** |
| | 3ʃ | 11/23 | 47.8% | | 12/15 | 80.0% | | |
| FMA | 1 | 19/26 | 73.1% | | 6/8 | 75.0% | | |
| | 2 | 42/56 | 75.0% | .9230 | 10/19 | 52.6% | .5665 | .8758 |
| | 3 | 21/27 | 77.8% | | 5/7 | 71.4% | | |
| Area of reimplantation | Same place | — | — | | 13/19 | 68.4% | .3687 | — |
| | Adjacent place | — | — | | 8/15 | 53.3% | | — |
| Total | | 82/109 | 75.2% | — | 21/34 | 66.7% | — | .1267 |
| Mean and SD (months) | | 10.03 ± 5.64 | | | 6.44 ± 3.69 | | | .0000*** |

[a] χ² test; Mx1 indicates area between the upper first and second premolars; Mx2, area between the upper second premolar and first molar; Mx3, area between the upper first and second molars.

* $P < .05$; ** $P < .01$; *** $P < .001$; # comparison between Mx2 and Mx3; ††† comparison between subgroup 1 and 3 in initially installed OMI, $P < .001$; †† comparison between subgroup 2 and 3 in initially installed OMI, $P < .05$; ʃʃ comparison between initially installed OMI and reinstalled OMI in subgroup 1, $P < .01$; ʃ comparison between initially installed OMI and reinstalled OMI in subgroup 3, $P < .05$.

in less than 8 months or before completion of treatment. If the OMI failed, the new one was installed at the same area after 4 to 6 weeks or at the adjacent area of the same side immediately. The total number of RI-OMIs was 34.

The variables were age, sex, ANB angle, FMA angle, site and side of implantation and area of implantation. The success rates of II-OMI and RI-OMI were calculated according to variables. A χ² test or Fisher exact test was used to estimate differences in the success rate. Cumulative survivals of the II-OMI and RI-OMI over time were analyzed using the Kaplan-Meier method. Comparison of cumulative survival between groups was performed using the log-rank test. Risk factors affecting survival were assessed by a Cox proportional hazards regression model.

## RESULTS

Female patients were more common regardless of the age group (Table 1). The majority of the II-OMIs were placed at Mx2 followed by Mx3. Only one OMI in this series was placed in Mx1 (Table 2). However, Mx3 was advocated less frequently in young patients (n = 3) than in adult patients (n = 32) ($P < .05$, Table 2).

The success rate for II-OMIs (75.2%) was not statistically different from the success rate for RI-OMIs (66.7%). However, the mean duration of II-OMI use (10.0 months) was significantly longer than the mean duration of RI-OMI use (6.4 months) ($P < .001$, Table 4).

There was no significant difference in age, side of implantation, and FMA in II-OMI versus RI-OMI. However, in II-OMIs, significantly higher success rates were found for females versus males ($P < .05$) and Class I and II malocclusions versus Class III malocclusions ($P < .01$) (Table 4). On the contrary, in RI-OMIs, significantly higher success rates were found for males versus females ($P < .05$) and Class III malocclusions versus Class I and II malocclusions ($P < .001$) (Table 4). When the success rate for II-OMIs was compared between angle classifications, there was a significant difference between Class I and III malocclusions ($P < .001$) and Class II and III malocclusions ($P < .05$) (Table 4). Compared with the success rate between II-OMIs and RI-OMIs, there was a significant difference in Class I malocclusions ($P < .01$) versus Class III malocclusions ($P < .05$) (Table 4).

The success rates in II-OMIs and RI-OMIs showed a significant difference in sex ($P < .05$) and ANB ($P < .001$) (Table 4). Other variables, such as age and side of implantation, also showed an opposite tendency for II-OMIs versus RI-OMIs, although there was no significant difference (Table 4).

The number of OMIs at Mx1 was too small to com-

**Table 5.** Distribution of Failure Time of the Initially Installed and Reinstalled Orthodontic Mini-implants (OMIs)

| Failure Time (months) | Number | Percentage | Accumulation Percentage | Mean ± SD of failure time (months) | P |
|---|---|---|---|---|---|
| Initially installed OMI | | | | | |
| ≤1 | 7 | 25.93% | 25.93% | 2.85 ± 1.90 | .0268* |
| >1 ~ ≤2 | 8 | 29.63% | 55.56% | | |
| >2 ~ ≤3 | 6 | 22.22% | 77.78% | | |
| >3 ~ ≤4 | 0 | 0% | 77.78% | | |
| >4 ~ ≤5 | 2 | 7.41% | 85.19% | | |
| >5 ~ ≤6 | 2 | 7.41% | 92.59% | | |
| >6 ~ ≤7 | 2 | 7.41% | 100.00% | | |
| sum | 27 | 100% | | | |
| Reinstalled OMI | | | | | |
| ≤1 | 3 | 13.64 | 13.64 | 4.14 ± 2.03 | |
| >1 ~ ≤2 | 3 | 13.64 | 27.27 | | |
| >2 ~ ≤3 | 2 | 9.09 | 36.36 | | |
| >3 ~ ≤4 | 3 | 13.64 | 50.00 | | |
| >4 ~ ≤5 | 6 | 27.27 | 77.27 | | |
| >5 ~ ≤6 | 1 | 4.55 | 81.82 | | |
| >6 ~ ≤7 | 4 | 18.18 | 100.00 | | |
| sum | 22 | 100.00 | | | |

[a] Independent *t*-test.

pare the success rate according to site of implantation. Therefore, implants at Mx2 and Mx3 were compared. Implants at Mx2 and Mx3 did not show any significant differences for II-OMIs versus RI-OMIs (Table 4). Although II-OMIs had a higher success rate than RI-OMIs, there was no significant difference according to site of implantation (Table 4). Also, there was no difference in the success rate for RI-OMIs between the same place and adjacent places (Table 4).

Although the success rate for RI-OMIs was not significantly different from the success rate for II-OMIs (Table 4), mean failure time was significantly longer for RI-OMIs than for II-OMIs ($P < .05$, Table 5). Most of the II-OMIs were lost within the first 3 months (77.78%) whereas most of the RI-OMIs were lost within 5 months (77.27%; Table 5).

A Kaplan-Meier analysis and log-rank test showed that failure was more likely in II-OMIs in males ($P = .018$; Figure 2) and Class III malocclusions ($P = .037$; Figure 3). The Cox proportional hazards regression model was used to assess the prognostic value of II-OMI failure. The risk ratio for failure of II-OMIs in Class III malocclusion versus Class I malocclusion was 5.36 (95% confidence interval, 2.008 to 14.31; $P = .001$, Table 6). However, neither method revealed any significant difference or a prognostic factor for RI-OMIs.

## DISCUSSION

### Success Rate

The success rate for II-OMIs in this study (75.2%, Table 4) was lower than that reported in some studies (80 to ~90%,)[14,19,20] higher than that reported in anoth-
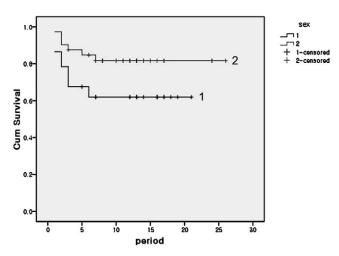


**Survival Functions**

**Figure 2.** Kaplan-Meier analysis of failure of the initially installed orthodontic mini-implant (OMI) according to sex. Duration of survival was measured from OMI placement to the time of failure (complete) or to the last follow-up or completion of treatment (censored). Cumulative survival for OMIs in females (group 1, blue) was significantly longer than for those in males (group 2, green) ($P = .018$; log-rank test).

er study (37.0%),[11] and similar to that reported in yet another (78.6%).[12] The OMI used in this study was the first version of ORTHOplant (2005H, BioMaterials Korea, Seoul), which was self-drilling type and conical shape with 2.0 mm upper diameter and 5 mm length. To increase the success rate, the design was changed to increase the upper diameter to 2.5 mm (model number 2505P).

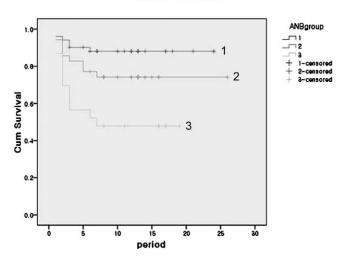Although the success rate for II-OMIs was not sta-

**Figure 3.** Kaplan-Meier analysis of failure of the initially installed orthodontic mini-implant (OMI) according to ANB group. Duration of survival was measured from OMI placement to the time of failure (complete) or to the last follow-up or completion of treatment (censored). Cumulative survivals for OMIs of Class I malocclusion (group 1, blue, $P = .000$; log-rank test) and Class II malocclusion (group 2, green, $P = .037$; log-rank test) were significantly longer than for Class III malocclusion (group 3, brown).

tistically different from the success rate for RI-OMIs, the success rate for RI-OMIs (66.7%) was lower than that for II-OMIs (75.2%, Table 4). Because the host factors such as age, sex, and craniofacial skeletal pattern were the same, the degree of bone remodeling at the same area and the bone density and thickness of the adjacent area in the same side before reinstallation could affect this difference.

## Sex and Success rate

In II-OMIs, the females showed a higher success rate than the males ($P < .05$, Table 4), which did not agree with other results.[14,19] However, RI-OMIs showed the opposite tendency. The reason for the difference in success rate for females between II-OMIs and RI-OMIs might be attributable to the conical shape of the OMI used in this study, which could produce higher insertion torque than other shapes. In female patients, the lower bone density and/or thin cortical bone, especially in young patients,[27] could be com-

pensated for by the higher value of insertion torque in the conical-shaped OMI. However, too strong an insertion torque could induce microfractures around the OMI in the cortical bone and eventually bone remodeling might loosen the OMI.[16]

## Age and Success Rate

The criteria for age groups in this study was based on the fact that growth has ended in most girls boys at 18 years of age.[28] As the boundary for minimum age, Park et al[29] used 15 years and Park[30] used 20 years. Both studies reported that the older groups had higher success rates. However, the result in this study showed that there was no statistically significant difference in success rates between young (<18 years) and adult (>18 years) patients (Table 4). This is in accord with Miyawaki et al,[14] who stated that there was no significant difference in the success rates of the under 20 age group, the 20 to 30 age group, and the over 30 age group.

## Craniofacial Skeletal Pattern and Success Rate

The finding that vertical type (FMA) did not affect the success rate of II-OMIs and RI-OMIs among subgroups (Table 4) does not agree with the results of Miyawaki et al,[14] who stated that patients with high mandibular plane angles were associated with OMI failure because of thin cortical bones. Other factors, such as soft-tissue thickness, oral hygiene, and root proximity, have been cited in the success of OMIs.[20,31,32]

A striking finding of the present study is that Class III malocclusions showed the least success compared with Class I and II malocclusions in II-OMIs ($P < .01$, Table 4). This means that in Class III patients, the posterior maxilla might have a lower bone density and/or thin cortical bone, narrow BAG, deficient interradicular space, and differences in bite force that could affect the success rate. However, there was no statistically significant difference in RI-OMIs. Further study is needed to discover the reason.

## Sidedness and Success Rate

There was no significant difference in the success rate between the right and left side (Table 4). This dis-

**Table 6.** Cox Proportional Hazards Regression Model for Overall Survival in the Initially Installed Orthodontic Mini-implant with Prognostic Factor (ANB)

| ANB Group | B | SE | Wald | df | P | Risk Ratio: Exp(B) | 95% CI for Exp(B) | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower | Upper |
| Class I (reference) | — | — | 11.741 | 2 | .003 | 1 | — | — |
| Class II | 0.826 | .527 | 2.453 | 1 | .117 | 2.283 | 0.813 | 6.415 |
| Class III | 1.679 | .501 | 11.234 | 1 | .001 | 5.361 | 2.008 | 14.310 |

agrees with the results of Park et al,[19] who reported that the right side had a significantly higher failure rate than the left side.

### Site and Success Rate

The site of implantation differs, and the amount of interradicular space, cortical bone thickness and BAG can be changed. Therefore, it is necessary to consider the narrow interradicular space, thin cortical bone, and narrow BAG to prevent the failure of an OMI. In this study, after checking the root proximity, the OMIs were inserted at 90° angles to the long axis of the teeth. The horizontal insertion of the OMI with short length and conical shape could minimize problems such as root damage and/or periodontal ligament injury. In addition, Chen et al[18] insisted that screw length did not influence the outcome of an OMI. With respect to the site of implantation, II-OMIs and RI-OMIs did not reveal any difference in success rate because of the same host factors (Table 4).

### Area of Reimplantation and Success Rate

The reason why there was no difference in the success rate of RI-OMIs between the same place and an adjacent place (Table 4) seems to be attributable to the absence of any difference in host factors such as age, sex, skeletal patterns, and side of implantation.

### Failure Time

Because more than 77% of II-OMIs failed within first 3 months and more than 77% of RI-OMIs failed within the first 5 months in RI-OMI, the OMIs that withstand more than a 4–6 month period of force application can be considered successful and stable (Table 5). Although the average duration of failure in II-OMIs (2.85 months) was shorter than 3.40 months found by Park et al,[19] the average duration in RI-OMIs (4.14 months) was longer than the duration reported by Park et al.[19]

A reason why the mean failure time for RI-OMIs was significantly longer than the failure time for II-OMIs ($P < .05$, Table 5) might be the use of a more cautious procedure during reinstallation and continuous bone remodeling around the OMI.

### Survival Analysis

Kaplan-Meier analysis with log-rank test showed that sex and ANB angle had an effect on the failure rates of II-OMI (Figures 2 and 3). The Cox proportional hazards regression model showed that ANB could be a prognostic value of II-OMI failure (Table 6). Therefore, it is necessary to pay attention when installing OMIs in male patients with Class III malocclusion.

### CONCLUSIONS

- The success rate of RI-OMIs was not statistically different from that of II-OMIs. Reinstalling the OMI immediately into the adjacent area after failure of the II-OMI will reduce the time lost for OMI usage.
- Age, vertical skeletal pattern, and site and side of implantation were not related to the success rates of II-OMIs and RI-OMIs.
- Sex and ANB might be considered important factors in achieving a better result for the II-OMIs.

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