Original Article

Factors Associated with the Success Rate of Orthodontic Miniscrews Placed in the Upper and Lower Posterior Buccal Region

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ABSTRACT

Objective: To determine the success rate and the factors related to the success rate of orthodontic miniscrew implants (OMI) placed at the attached gingiva of the posterior buccal region.

Materials and Methods: Four hundred eighty OMI placed in 209 orthodontic patients were examined retroactively. The sample was divided into young patients (range 10–18 years, N = 108) and adult patients (range 19–64 years, N = 109). The placement site was divided into three interdental areas from the first premolar to the second molar in the maxilla and mandible. According to soft tissue management, the samples were divided into incision and nonincision groups. Chi-square tests and multiple logistic regression analyses were used.

Results: The overall success rate was 83.8%. Dislodgement of the OMI occurred most frequently in the first 1–2 months, and more than 90% of the failures occurred within the first 4 months. Sex, age, jaw, soft tissue management, and placement side did not show any difference in the success rate. Placement site, however, showed a significant difference in the mandible of adult patients. There was no difference in the success rate in the maxilla.

Conclusions: Placement site is one of the important factors for success rate of OMI.

KEY WORDS: Miniscrew; Success rate; Placement site

INTRODUCTION

The orthodontic miniscrew implants (OMI) offer several advantages such as sufficient anchorage in noncompliant patients, simplicity of insertion and removal, and relatively low cost.[1,2]

Long-term studies report success rates of more than 90% for prosthetic implants.[3–5] However, the long-term success rates of OMI have reported a variety of success rate from 37% to 94%.[1,6–11] The success rates differ because: (1) There are significant differences in the duration of use, patient age, level, and direction of the applied force, and placement site between the OMI and the prosthetic implants. For example, while the OMI has to be removed after completion of the mission, the prosthetic implants should be maintained semi-permanently. (2) OMI have been used in younger patients rather than the prosthetic implants. (3) Although the prosthetic implants sustain multi-directional and heavy occlusal force, the OMI bear a smaller force with a more regular direction. (4) Several products from different manufacturers with various types of length, diameter, design, and material of the OMI have been combined in the previous studies.[6–13]

To determine objectively the success rate of the OMI, it is necessary to confine the sample to the same type of OMI from one manufacturer. Also, in order to find the factors related to the OMI success rate, the clinical characteristics including patient sex, age, jaw, placement site, soft tissue management, and placement side have to be examined.[1,14–16] Therefore, the purposes of this study were to determine the success rate of OMI and to determine which factors were re-

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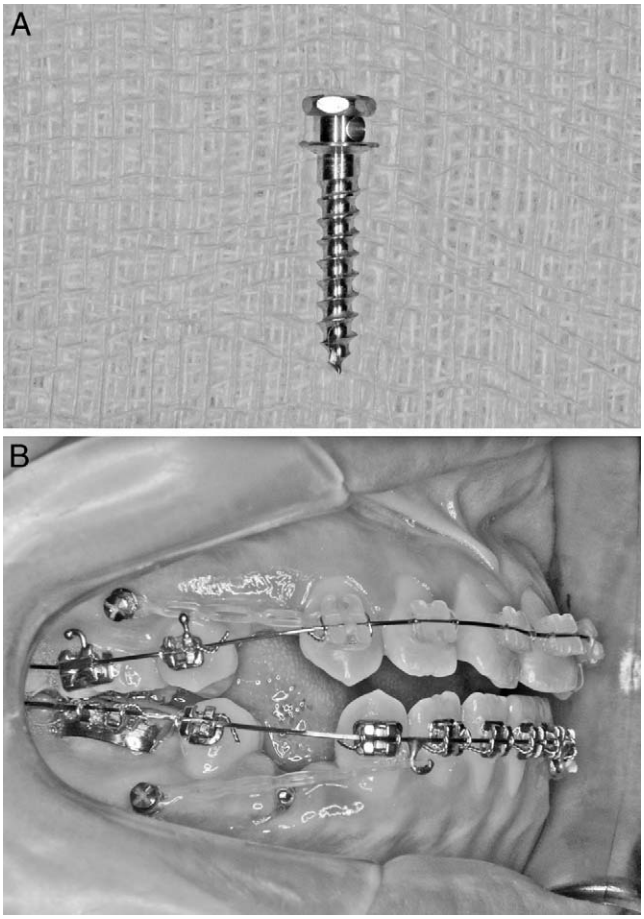

Figure 1. The orthodontic miniscrew used in this study. (A) 1.6 mm in diameter and 8 mm in length. (B) The orthodontic miniscrews were placed for the purpose of anchorage reinforcement.

lated to the success rate of OMI placed at the attached gingiva of the posterior buccal region.

MATERIALS AND METHODS

The subjects involved in this study were 209 patients (male = 78, female = 131) who visited the Department of Orthodontics at G dental hospital for orthodontic treatment and received at least one OMI (Dual-Top Anchor system, 1.6 mm diameter, 8 mm length, self-drilling style, Jeil Medical Co, Seoul, Korea) in either the upper or lower buccal posterior regions for the purpose of anchorage reinforcement (Figure 1). The total number of OMI used in this study was 480 (Table 1).

Table 1. Distribution of Patient and Miniscrews

	Number of Patients	Number of Miniscrews
Male	78	157
Female	131	323
Total	209	480

Table 2. The Distribution of Patients According to Age

	Young Patient (n = 108)			Adult Patient (n = 109)			
	Range	Mean	SD	Range	Mean	SD	*P* value
Age, years	10–18	14.40	2.50	19–64	26.21	7.11	.000
Screw, n		253			227		

The OMI were placed at the attached gingiva just adjacent to the mucogingival junction at a 70° to 80° angle to the long axis of the teeth in both the maxilla and mandible. Insertions were performed by four clinicians and were checked by the one supervisor in the Department of Orthodontics at the G dental hospital. To reduce the error incurred by lack of experience, the first ten miniscrews inserted by each clinician were not included in this study.

An orthodontic force less than 200 grams was applied to the OMI from 2–3 weeks after placement using elastic chains or nickel-titanium closed-coil springs. If the OMI did not show any mobility after the first 8 months of orthodontic force application, it was defined as a success.

To assess the effect of patient age on the success rate, the patients were divided into two groups according to age: young patients less than 18 years of age (N = 108; mean age = 14.4 years; range = 10–18 years) with 253 OMI, and adult patients who were older than 19 years of age (N = 109; mean age = 26.2 years; range 19–64 years), with 227 OMI (Table 2).

To assess the effect of the placement site on the success rate, the locations where OMI were placed at the buccal attached gingival area were divided into six groups: Mx1 (area between the maxillary first and second premolars); Mx2 (area between the maxillary second premolar and first molar); Mx3 (area between the maxillary first and second molars); Mn1 (area between the mandibular first and second premolars); Mn2 (area between the mandibular second premolar and first molar); and Mn3 (area between the mandibular first and second molars).

To measure the effect of the soft tissue management on the success rate, the patients were divided into two groups: incision method (local anesthesia, '+' shape stab incision [3–4 mm], reflection of the gingival flaps, and placement of the OMI [note: the soft tissue was not sutured]); and nonincision method (insertion of the OMI was performed without soft tissue incision).

The success rates according to age, sex, jaw (maxilla or mandible), placement side and site, soft tissue management, and the overall success rate were calculated. Chi-square tests and multiple logistic regression analyses were used to estimate differences in the

Table 3. The Success and Failure of Screws According to Sex, Age, Jaw, Placement Site, Soft Tissue Management, and Placement Side[a]

Variables		Success, n	Failure, n	Success Rate, %	*P* value
Sex	Male	132	25	84.1	.892
	Female	270	53	83.6	
Age	Young patient	208	45	82.2	.335
	Adult patient	194	33	85.5	
Jaw	Maxilla	233	46	83.5	.868
	Mandible	169	32	84.1	
Placement site	P1	126	11	91.8	.001
	P2	202	57	78.0	
	P3	74	10	88.1	
Soft tissue management	Nonincision	195	37	84.1	.862
	Incision	207	41	83.5	
Placement side	Left	210	40	84.0	.877
	Right	192	38	83.5	
Total		402	78	83.8	

[a] Placement site of miniscrew was divided into three subgroups. P1 means miniscrews which were placed between first premolar (P1) and second premolar (P2), miniscrews which were placed between the second premolar and the first molar; P3, miniscrews which were placed between the first molar and second molar.

success rate and to determine which factors were related with the success rate of the OMI.

In this study, the odds ratio was also calculated. The odds ratio is defined as the ratio of the probability that success occurs to the probability that it does not. An odds ratio of 1 implies that success is equally likely between the interest group and the reference group. An odds ratio greater than 1 implies that the success is more likely in the interest group. An odds ratio less than 1 implies that the event is less likely in the interest group.

RESULTS

The overall success rate was 83.8% (402 of 480 OMI) (Table 3). Dislodgement of OMI occurred most frequently in the first 1–2 months, and more than 90% of failures happened within the first 4 months (Table 4).

When compared to the overall success rate, there was no significant difference in the success rate according to sex, age, jaw, soft tissue management, and sidedness. However, placement site showed a significant difference in the success rate in adult patients ($P < .001$) (Table 3). Placement site showed a significant difference in the success rate in adult patients, but not in young patients, especially in the area between the mandibular second premolar and the first molar (Table 5). The area between the second premolar and the first molar showed a significantly lower success rate than the area between the first and second premolars in the mandible (Table 6).

There was no significant difference in the success rate according to the odds ratio of sex, age, placement site, soft tissue management, and placement side in the maxilla (Table 7). Although there was no significant difference in odds ratio between the maxilla and mandible, the odds ratio in the maxilla and mandible showed an opposite tendency according to sex, age, and placement side (Tables 6 and 7).

Table 4. The Distribution of Miniscrews According to Used Duration in Failure Case

Duration, Months	Number of Miniscrews	Percentage, %	Accumulation Percentage, %	Mean and SD of Duration, Months
<1	11	14.1	14.1	
≥1–<2	32	41.0	55.1	
≥2–<3	18	23.0	78.1	
≥3–<4	11	14.1	92.2	1.65 (1.27)
≥4–<5	3	3.9	96.1	
≥5–<6	2	2.6	98.7	
≥6–<7	1	1.3	100	
≥7	0	0	100	
Total	78	100		

DISCUSSION

Ever since Kanomi[12] and Costa et al[13] suggested titanium miniscrews as intraoral anchorage devices, various kinds of miniscrews were used for orthodontic anchorage reinforcement.[2,6,17,18] Therefore, it is necessary to compare the success rate among the miniscrews. The total success rate in this study (83.8%, Table 3) was higher than the 37.0% reported by Kim and Choi[7] and 78.6% by Moon,[1] and was similar to the 83.9%–85.0% by Miyawaki et al[9] and the 81.1%–88.6% reported by Kuroda et al.[19] However, it was lower than the 80.0%–93.6% reported by Park et al[8] for four types of miniscrews, and the 93.3% reported by Park.[10]

Dislodgement of OMI occurred most frequently in the first 1–2 months, and more than 90% of the failures

Table 5. Success Rate of Screws According to Location[a]

	Number of Success/Total Cases (Success Rate, %)						
	Mx1	Mx2	Mx3	Mn1	Mn2	Mn3	*P* value
YP	37/43 (86.0)	60/76 (78.9)	20/26 (76.9)	31/34 (91.2)	50/63 (79.4)	10/11 (90.9)	0.511
AP	26/28 (92.9)	64/77 (83.1)	26/29 (89.7)	32/32 (100.0)	28/43 (65.1)	18/18 (100.0)	0.000

[a] Mx1 means miniscrews which were placed between the maxillary first premolar and second premolar; Mx2, miniscrews which were placed between the maxillary second premolar and first molar; Mx3, miniscrews which were placed between the maxillary first molar and second molar; Mn1, miniscrews which were placed between the mandibular first premolar and second premolar; Mn2, miniscrews which were placed between the mandibular second premolar and first molar; Mn3, miniscrews which were placed between the mandibular first molar and second molar; YP, young patient; AP, adult patient.

happened within the first 4 months (Table 4). The average duration of the failure cases in this study was 1.65 months, which was shorter than 3.40 months of Park et al.[8] It is likely, therefore, if the OMI withstands more than a 4-month period of force application, it can be considered successful and stable.

In this study, patient sex was not related to the success rate (Table 3), which was in accord with the results of Park et al[8] and Miyawaki et al.[9] Therefore, we assumed that sex was not related to the clinical success of the OMI.

Regarding the criteria to separate into different age groups, Park et al[20] reported that the under 15-year-old patient group suffered a lower success rate than the over 15-year-old patient group because they had thin cortical bone and poor bone quality. Park[10] insisted that the success rate for the under 20 age group was higher than that of the over 20 age group, but Miyawaki et al[9] stated that there was no significant difference in the success rates of the under 20 age group, 20-to-30 age group, and the over 30 age group. In this study, the samples were divided into the young patient group under 18 years of age and the adult patient group older than 19 years of age. This division was based on the fact that growth has been achieved in most of the girls and in the majority of boys at 18 years of age.[21]

Although there was no significant difference between adult and young patient groups, the adult patient group showed a higher success rate in the maxilla, but the young patient group showed a higher success rate in the mandible (Tables 3, 6, and 7).

With regard to the jaw and success rate, Park et al[8] reported that the maxilla had a higher success rate than the mandible. However, Miyawaki et al[9] stated that the placement site of the miniscrews in the maxilla or mandible was not related to the success rate. This was in accord with our results (Table 3). It was interesting that, in spite of the statistical insignificance, the maxilla and mandible showed an opposite tendency for the success rate according to age. Further studies are needed in terms of the relationship between age, jaw, and success rate.

There was no significant difference in the success rate between the right and left side (Tables 3, 6, and 7). This is in disagreement with the results of Park et al[8] who reported that the left side had a significantly higher success rate than the right side. In our opinion, if the miniscrews were properly placed in the attached gingiva according to the protocol, and if the oral hygiene care was well done, the chance of soft tissue inflammation around the miniscrew could be decreased. Therefore, there would be no difference in the success rate between the right and left sides.

Table 6. Odds Ratios of Independent Variables for Success by Multiple Logistic Regression Analysis in the Mandible[a]

Variables		Odds Ratio	95% CI
Sex	Male	Reference	
	Female	1.085	0.471–2.503
Age	Young patient	Reference	
	Adult patient	0.765	0.341–1.717
Placement site	Mn1	Reference	
	Mn2	0.126	0.036–0.439
	Mn3	1.318	0.129–13.424
Soft tissue management	Nonincision	Reference	
	Incision	0.813	0.216–3.055
Placement side	Left	Reference	
	Right	0.547	0.145–2.060

[a] CI indicates confidence interval. Placement site of miniscrew was divided into three subgroups. Mn1 means miniscrews which were placed between the mandibular first premolar and second premolar; Mn2, miniscrews which were placed between the mandibular second premolar and first molar; Mn3, miniscrews which were placed between the mandibular first molar and second molar.

Table 7. Odds Ratios of Independent Variables for Success by Multiple Logistic Regression Analysis in the Maxilla[a]

Variables		Odds Ratio	95% CI
Sex	Male	Reference	
	Female	0.896	0.437–1.834
Age	Young patient	Reference	
	Adult patient	1.688	0.875–3.258
Placement site	Mx1	Reference	
	Mx2	0.515	0.219–1.214
	Mx3	0.594	0.208–1.697
Soft tissue management	Nonincision	Reference	
	Incision	0.706	0.257–1.942
Placement side	Left	Reference	
	Right	1.019	0.374–2.775

[a] CI indicates confidence interval. Placement site of miniscrew was divided into three subgroups. Mx1 means miniscrews which were placed between the maxillary first premolar and second premolar; Mx2, miniscrews which were placed between the maxillary second premolar and first molar; Mx3, miniscrews which were placed between the maxillary first molar and second molar.

Regarding the placement site of the OMI, the areas between the first and second premolars in the maxilla and between the first and second premolars in the mandible of both young and adult patients had the highest success rate. The area between the second premolar and the first molar in adult patients had the lowest success rate (Table 5). In particular, there was a significant difference in the success rate according to the placement site in the mandible (Tables 5 and 6).

In the maxilla, although there was no significant difference, Mx1 had a higher success rate than Mx2 and Mx3 (Table 6). In the mandible, Mn1 had a significantly higher success rate than Mn2 (Table 6). However, Mn1 and Mn3 did not show a significant difference (Table 6). Therefore, Mx1 could be considered as the most stable placement site in the maxilla, and Mn2, the most unstable site in the mandible.

Bone quality is known to be one of the major factors in the stability of miniscrews.[22] Since Mn2 has thinner cortical bone than Mn3,[22] Mn2 could show a lower success rate than Mn3 in this study. However, Mx2 showed a lower success rate than Mx1 even though Mx2 has thicker cortical bone than Mx1.[22,23] The success rates in the maxillary molar region, which had the lowest success rate for prosthetic implants due to bone quality,[24,25] were not significantly different from other sites in this study (Table 5). These results suggested that other factors beyond bone quality such as soft tissue thickness,[23] oral hygiene,[22] and root proximity[23] might affect the success rate of the miniscrews.

Park[2] pointed a narrow interradicular space as the reason for failure. Deguchi et al[22] recommended that miniscrews less than 1.5 mm in diameter could reduce the failure rate at the upper and lower posterior teeth in cases where the roots of the adjacent teeth are too close. Poggio et al[26] reported that the amount of mesiodistal bone existing between the first and second premolars in the maxilla and mandible could guarantee a high success rate at Mx1 and Mn1 (Table 5).

Park et al[20] suggested that wider interradicular space could be obtained in cases of insertion with angulation. To avoid the contact between roots and miniscrew and to increase the amount of cortical bone thickness, Park[2] recommended an angle of 30° to 40° to the long axis of the teeth in the maxilla and 20° to 60° in the mandible. However, severe angulation to the cortical bone surface during insertion of the miniscrews can create soft tissue irritation[2] and slippage of the miniscrew at its contact with cortical bone.[20] In this study, after check up the root proximity with the periapical radiograph, we established that the miniscrews were inserted at 70° to 80° angles to the long axis of the teeth both maxilla and mandible. This more horizontal insertion technique eliminated the problems associated with more vertical insertion methods.

Reports indicate that insertion methods of the OMI are diverse. Costa et al[13] inserted miniscrews by the pilot-drilling method without soft tissue incision; Moon[1] by the self-drilling method without soft tissue incision; and Kanomi,[12] Park,[6] and Park[17] by the pilot-drilling method after soft tissue incision. Kim et al[27] and Kim and Chang[28] reported that after soft tissue incision, the self-drilling group was more stable than the pilot-drilling group, and Kim and Choi[7] reported that the pilot-drilling method had a higher failure rate than the self-drilling method.

Since the OMI used in this study had self-drilling capacity, pilot drilling was not performed in both groups in order to compare exclusively the effect of soft tissue management between the incision group and the nonincision group. Park[2] indicated that soft tissue impingement during insertion of the miniscrews could be a cause of failures, but Miyawaki et al[9] reported that the flapless (nonincision) group had a higher success rate than the flap surgery (incision) group.

In this study, there was no difference between the non-incision and incision groups (Tables 3, 6, and 7).

Miyawaki et al[9] reported 0% success with 1.0 mm diameter miniscrews and, therefore, it was not suitable for clinical use. However, the 1.2 mm, 1.3 mm, or 1.5 mm diameter miniscrew had similar or higher success rates than the 1.6 mm miniscrew.[8,9,19] Since our study was confined to 1.6 mm diameter miniscrews, we could not compare the effect of the diameter of miniscrews to the success rate. Miyawaki et al[9] and Lim et al[14] reported that the diameter affected the success rate, but Park et al[8] reported that it did not have any effect. The miniscrews with a smaller diameter would decrease the chance of root damage. Direct comparisons of these results are impossible because these success rates are based on various insertion methods and sizes of screw.[8]

CONCLUSIONS

- If OMI withstands more than a 4-month period of force application, it can be considered successful and stable.
- Sex, age, jaw, soft tissue management, and placement side were not related to the success rate of OMI.
- Placement site could be considered one of the important factors to get a better result of OMI when clinicians decide to use OMI, especially in the mandible of the adult patients.

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