Factors Associated with the Success of Orthodontic Miniscrews

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Abstract

Background and aims. Nowadays miniscrews are widely used as skeletal anchorage in orthodontics. However, the success rate of miniscrews is less than that of osseointegrated implants. The aim of this retrospective study was to evaluate factors influencing the success rate of orthodontic miniscrews.

Methods. Data of 244 miniscrews in 122 patients (99 females and 23 males, with a mean age of 19 years and 6 months) were collected. Logistic regression analysis was used to evaluate the effect of age, gender, placement side and insertion torque on the success rates of miniscrews.

Results. The overall success rate of miniscrews was 90.6% in the present study (221/244). Logistic regression analysis showed that the success rate of miniscrews was not under the influence of variables such as gender, placement side and miniscrew brand. However, age groups and insertion torques over 10 Ncm decreased miniscrew success rates. In this context, the success rates of miniscrews in patients under 16 years of age was less than those in patients over 16 years of age (P<0.001) and the success rates of miniscrews with insertion torques ≤10 Ncm were higher than those with insertion torques over 10 Ncm (P=0.019).

Conclusion. We concluded that patients under 16 years of age and insertion torques over 10 were increased the failure of orthodontic miniscrews.

Key words: Age, Insertion torque, Miniscrew, Success rate.

Introduction

It is desirable to use miniscrews as orthodontic anchorage due to the ease of their placement and removal. Miniscrews can be used for different purposes, including molar protraction, canine retraction and molar distalization since they can be placed in a wide range of locations. They can also be used for more complex tooth movements, including molar intrusion and correction of the occlusal plane.

Compared to dental implants, the principal advantages of miniscrews are their smaller size, minimum anatomic limitations, low cost, and easier placement and removal considering their partial osseointegration. However, the success rate of miniscrews has
been reported to be 84–92%, 6–11 which is less than that of osseointegrated implants. 7,10,12 Loosening and failure of miniscrews give rise to many problems in providing absolute anchorage. Therefore, improving the stability and success of miniscrews is one of the most important aims in this area.

Several studies have evaluated factors responsible for the failure of miniscrews.13,14 Failure of miniscrews might be due to inflammation resulting from a poor bone–screw contact;10 however, host-related factors such as age, gender, and cortical bone quality and thickness, and miniscrew-related factors such as diameter and length are considered important factors for the primary stability of miniscrews.15–17 One of the techniques used to evaluate the primary stability of miniscrews is to measure insertion torque at the time of screw placement.11,18,19 Previous studies have shown that there is an optimal range of insertion torque to achieve primary stability of miniscrews at bone–screw interface.11 However, some studies have not reported a relationship between insertion torque and miniscrew failure. Therefore, there are contradictions in the results of different studies. The present study evaluated factors affecting the success rate of miniscrews, including patient age, insertion torque, patient gender, placement side and the miniscrew type (brand). Therefore, the aim of this retrospective study was to determine the success rate of miniscrews, evaluate insertion torque as a predictive factor for primary stability and analyze factors affecting the success rate of miniscrews.

Materials and Methods

In the present retrospective study, the records of patients who had referred to a private orthodontic clinic from 2010 to 2014 were evacuated. The inclusion criteria consisted of the following: similar placement location of miniscrews in the maxilla between the second premolar and first molar teeth; cylindrical miniscrews, measuring 10 or 11 mm in length and 1.6 mm in diameter; registration of the insertion torque in the patient files by torque ratchet (torque ratchet; Orthonia, Jeil); a follow-up of miniscrew loosening for at least 40 weeks; registration of the time interval between miniscrew placement and its loosening in the patient file; a history of extraction of first premolar and first molar teeth; cylindrical location of miniscrews in the maxilla between the second premolar and first molar teeth; registration of the insertion torque. Chi-squared test was used to evaluate the differences in success rates of miniscrews placed using insertion torques of less than or equal to 5 Ncm and those placed using insertion torques of more than 5 Ncm; and comparisons were made between insertion torques ≤10 Ncm and >10 Ncm. Statistical significance was defined at P<0.05.

Results

The overall success rate of miniscrews was 90.6% in the present study (221/244) and only 23 miniscrews became loose and failed. The mean torque insertion was 11.5 Ncm (Table 1). Based on patient records, the subjects were divided into two groups: those under 16 years of age and those over 16 years of age. In addition, the insertion torques were divided into two groups: under 10 Ncm and over 10 Ncm. This classification was also carried out based on 5-Ncm insertion torque. Chi-squared test did not reveal any significant differences in miniscrew success rates in patients under 16 years of age between insertion torques of ≤5 Ncm and insertion torques over 5 Ncm (Table 3). However, in patients under 16 years of age, with insertion torques of ≤10 Ncm the success rates were significantly higher than those with insertion torques over 10 Ncm (Table 3) (P=0.011).

There were no significant differences in the success rates of miniscrews in patients over 16 years of age between insertion torques less than or equal to 5 Ncm and those more than 5 Ncm (Table 3). In this age group, there were no significant differences in

<table>
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<th>Table 1. Clinical characteristics of the subjects (age, insertion torque and loosening time)</th>
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<td>Age (year)</td>
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<td>Insertion torque (Ncm)</td>
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<td>Loosening time (week)</td>
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success rates of miniscrews between insertion torques ≤10 Ncm and >10 Ncm (Table 3). Logistic regression analysis showed that the success of miniscrews was not under the influence of variables such as gender, placement side and miniscrew brand (Table 2). However, age and insertion torques under 10 Ncm affected miniscrew success rates; in this context, the success rates of miniscrews in patients under 16 years of age was less than those in patients over 16 years of age (P<0.001) and the success rates of miniscrews with insertion torques less than or equal to 10 Ncm were higher than those with insertion torques over 10 Ncm (Table 2) (P=0.019).

Discussion

In relation to factors affecting the stability and success of miniscrews in orthodontic anchorage, the results of the present study showed that the success of miniscrews had a relationship with the insertion torque values of ≥10 Ncm and the age group over 16 years of age. The primary stability of miniscrews is important because the majority of miniscrew failures occur during the initial stages.9 Based on the results of studies by Costa20 and Miyawaki,9 the quality and thickness of cortical bone are important factors in the primary stability of miniscrews, possibly due to the fact that the primary stability depends on the mechanical retention rather than osseointegration. Different techniques are used to evaluate primary stability of miniscrews, including the histological technique which evaluates the contact of bone with the implant and the mechanical method which measures the insertion and removal torque values of miniscrews.21,22 Therefore, one of the methods to predict the primary stability of miniscrews and evaluate bone quality is to measure the insertion torque,11,18,19,23 which was introduced by Frigberg.24 Other researchers, too, have used this parameter to evaluate the primary stability of miniscrews, reporting that it is an important factor for the clinical success of miniscrews. The insertion torque is under the influence of host- and miniscrew-related factors.15,25–27 Miniscrew-related factors include the form and the diameter of miniscrew, placement technique etc that are predictable and can be controlled by clinicians.28 However, host-related factors such as the thickness of the cortical bone, the density of the surrounding bone etc are different in different individuals and sometimes it is difficult to predict them.

Wilmes reported that the thickness of the cortical plate has a great role in the primary stability of miniscrews;29 an increase in the thickness and density of the cortical bone increases the primary stability of miniscrews. Insertion torque, too, is related to the thickness of the cortical bone. Motoyoshi and Huja showed that a decrease in the thickness of the cortical bone is associated with an increase in the insertion torque.11,30 On the other hand, thicker bone increases the strain and microfracture during miniscrew placement, which might affect the healing

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\text{Table 3. Miniscrew success and failure rates (%)}, \text{ P-values, OR statistics in two age groups ≤16 and >16 years of age in terms of the insertion torque groups (IT)} \\
\hline
\text{≤16 y} & & & & & & \\
\text{IT≤5} & 19 (95%) & 1 (5%) & 0.058 & 5.82 & 0.72–47.14 \\
\text{IT>5} & 49 (76.6%) & 15 (23.4%) & & & \\
\text{Total} & 68 (81%) & 16 (19%) & & & \\
\text{IT≤10} & 56 (87.5%) & 8 (12.5%) & 0.011 & 4.67 & 1.46–14.91 \\
\text{IT>10} & 12 (60%) & 8 (40%) & & & \\
\text{Total} & 68 (81%) & 16 (19%) & & & \\
\text{Over 16 y} & & & & & & \\
\text{IT≤5} & 32 (97%) & 1 (3%) & 0.558 & 1.59 & 0.18–13.66 \\
\text{IT>5} & 121 (95.3%) & 6 (4.7%) & & & \\
\text{Total} & 153 (95.6%) & 7 (4.4%) & 0.468 & 1.415 & 0.30–6.56 \\
\text{IT≤10} & 100 (96.2%) & 4 (3.8%) & & & \\
\text{IT>10} & 53 (94.6%) & 3 (5.4%) & & & \\
\text{Total} & 153 (95.6%) & 7 (4.4%) & & & \\
\end{array}
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\*P, P-value<0.05 is significant.
process, endangering the secondary stability.

Some clinicians have reported a relationship between miniscrew failure and insertion torque. Some other researchers have reported that a high insertion torque results in a higher primary stability, emphasizing that insertion torque has an important role in determining the mean resistance of miniscrew to movement, with higher insertion torques resulting in more resistance to movement. Therefore, they believed that insertion torques ≥4 Ncm are necessary to achieve adequate anchorage in miniscrews. However, in a study by Inoue et al, no relationship was observed between insertion torque and the success rate of miniscrews, reporting that the mean insertion torque varies based on the technique used and the miniscrew placement area. Therefore, it is not possible to determine proper insertion torque.

In the present study, since all the miniscrews were placed in one area, the miniscrew placement site variable, as a factor affecting the torque and the success of miniscrews, was eliminated. On the other hand, some studies have reported that placement of miniscrews with extra torque results in microcrack formation in the surrounding bone. Extra tightening forces result in higher mechanical stresses in the miniscrew and the surrounding bone, inducing additional creep and cracks around the miniscrew–bone interface during the miniscrew placement. Finally, more microfractures and ischemia are produced and more chemical inflammatory mediators are induced in the area, resulting in the miniscrew failure through loss of stability. The results of a study suggested that lower insertion torques were more favorable than higher torques for osseointegration.

Some previous studies have shown that a certain amount of insertion torque is necessary to achieve initial anchorage at miniscrew–bone interface. Consistent with the results of the present study, Motoyoshi reported that insertion torques of 5–10 Ncm increase the success rates of predrilling miniscrews in posterior maxillary alveolar bone. In the present study, too, insertion torques of less than or equal to 5 Ncm and more than 5 Ncm, less than or equal to 10 Ncm and more than 10 Ncm were evaluated in different groups and it was shown that the incidence of miniscrew loosening with torque values ≤10 Ncm was less than that with torque values >10 Ncm. Although some studies have shown that high insertion torque increases primary stability, it can result in screw failure, an increase in microdamage in bone and a decrease in secondary stability. Therefore, moderate insertion torque provides adequate primary stability without resulting in excessive bone compression and subsequent remodeling. Adequate insertion torque increases primary stability, decreasing the risk of micromotion and negative tissue responses such as formation of fibrotic scar at bone–miniscrew interface during the healing and loading periods.

Based on the results of the present study, the incidence of miniscrew loosening on the left and right sides was the same, consistent with the results of a study by Moon. However, in a study by Park, the incidence of failure on the right side was significantly higher than that on the left side, which might be attributed to the fact that in that study the miniscrews were placed in different sites, but in the present study the miniscrew placement sites were the same and equal on the left and right sides.

In some studies, gender has been reported as an effective factor. In a study, the success rate was higher in females; however, the majority of studies have not reported a significant relationship between gender and the failure of miniscrews, consistent with the results of the present study. The results of the present study showed that in patients under 16 years of age, the success rate of miniscrews was lower. Consistent with the results of the present study, Miyawaki reported a lower success rate of miniscrews in patients under 16. Chen reported that younger patients run a higher risk of miniscrew failure. In addition, Motoyoshi showed the success rate of miniscrews is significantly higher in adult patients compared to adolescents. Park reported, based on different age groups, that in patients under 15 years of age, the success rate was less than that in patients over 15 because younger patients had thinner cortical bone and lower bone quality. Some researchers, too, have reported that age does not have a significant role in the success or failure of miniscrews. However, it appears that the results of the majority of studies indicate that the success rate is lower in younger patients. It is suggested that such a difference might be attributed to the higher metabolic rate in adolescents compared to adults. In addition, such a difference might be attributed to the patients’ oral hygiene. It is possible that the oral hygiene improves with age.

**Conclusion**

1. The success rate of miniscrews was higher in patients over 16 years of age compared to those under 16.
2. In patients under 16 years of age, the success rate of miniscrews placed with an insertion torque of ≤10 Ncm was higher than over 10 Ncm.

3. The success rate of miniscrews was not under the influence of gender and placement side.

References


