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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.

Materials and 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,[1] canine retraction[2] and molar distalization[3] since they can be placed in a wide range of locations. They can also be used for more complex tooth movements, including molar intrusion[4] and correction of the occlusal plane.[5]

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 factor 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 premolars on both sides; and en masse closure of the space. Finally, data of 244 miniscrews in 122 patients (99 females and 23 males, with a mean age of 19 years and 6 months) were evaluated. Of 244 miniscrews 182 were the products of General-Implant Company (GmbH, Germany) with a length of 11 mm and a diameter of 1.6 mm, and 62 were the products of Jeil Company (Korea) with a length of 10 mm and a diameter of 1.6 mm. miniscrew failure was defined as miniscrew mobility more than 0.5 mm.

The aim was to valuate factors affecting miniscrew loosening, including patient age and gender, insertion torque and miniscrew insertion side.

Statistical Analysis

SPSS 19 was used for data analysis. Since the variables were two-state qualitative variables, logistic regression was used to evaluate the effect of age, gender, placement side, insertion torque and miniscrew brand on the success rates of miniscrews. 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 1. Clinical characteristics of the subjects (age, insertion torque and loosening time)

	N	Mean	SD	Range
Age (year)	244	19.5	6.13	10.9–42.4
Insertion torque (Ncm)	244	11	4.77	5–30
Loosening time (week)	244	35.5	7.93	3–38

Table 2. Logistic Regression analysis of factors affecting the failure rate of miniscrews

	Beta	SE	Wald	*P**	Exp (B)	95% CI of Exp (B)
Sex	1.29	0.79	2.68	0.102	3.63	0.77–17.06
Age groups	1.89	0.50	14.38	0.0	6.65	2.50–17.70
Side	-0.39	0.47	0.68	0.409	0.68	0.27–1.70
IT <10	-1.13	0.48	5.53	0.019	0.32	0.13–0.83
Screw type	-0.31	0.51	0.35	0.552	0.74	0.27–2.02

******P, P*-value<0.05 is significant.

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 Costa[20] 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 miniscrew;[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

Table 3. Miniscrew success and failure rates (%), P-values, OR statistics in two age groups ≤16 and >16 years of age in terms of the insertion torque groups (IT)

	Success n (%)	Failure n (%)	*P**	Odds ratio	95% CI
≤ 16 y					
IT≤5	19 (95%)	1 (5%)	0.058	5.82	0.72–47.14
IT>5	49 (76.6%)	15 (23.4%)			
Total	68 (81%)	16 (19%)			
IT≤10	56 (87.5%)	8 (12.5%)	0.011	4.67	1.46–14.91
IT>10	12 (60%)	8 (40%)			
Total	68 (81%)	16 (19%)			
Over 16 y					
IT≤5	32 (97%)	1 (3%)	0.558	1.59	0.18–13.66
IT>5	121 (95.3%	6 (4.7%)			
Total	153 (95.6%)	7 (4.4%)			
IT≤10	100 (96.2%)	4 (3.8%)	0.468	1.415	0.30–6.56
IT>10	53 (94.6%)	3 (5.4%)			
Total	153 (95.6%)	7 (4.4%)			

******P, P*-value<0.05 is significant.

process, endangering the secondary stability.

Some clinicians have reported a relationship between miniscrew failure and insertion torque.[11,31,32] Some other researchers have reported that a high insertion torque results in a higher primary stability,[29] 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.[33] 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,[28] 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.[34] 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.[30,35] 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.[36] The results of a study suggested that lower insertion torques were more favorable than higher torques for osseointegration.[37]

Some previous studies have shown that a certain amount of insertion torque is necessary to achieve initial anchorage at miniscrew–bone interface.[11,37] Consistent with the results of the present study,[11] 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 to10 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.[15] 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.[24,38]

Based on the results of the present study, the incidence of miniscrew loosening on the left and rights sides was the same, consistent with the results of a study by Moon.[6] However, in a study by Park[7] 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[6,39–41] 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[9] reported a lower success rate of miniscrews in patients under 16. Chen reported that younger patients run a higher risk of miniscrew failure.[35] In addition, Motoyoshi showed the success rate of miniscrews is significantly higher in adult patients compared to adolescents.[23] 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.[7] Some researchers, too, have reported that age does not have a significant role in the success or failure of miniscrews.[6,40] However, it appears that the results of the majority of studies indicate that the success rate is lower in younger patients.[39] 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

1. Giancotti A, Greco M, Mampieri G, Arcuri C. The use of titanium miniscrews for molar protraction in extraction treatment. *Prog Orthod* 2004;5:236-47.
2. Herman RJ, Currier GF, Miyake A. Mini-implant anchorage for maxillary canine retraction: a pilot study. *Am J Orthod Dentofacial Orthop* 2006;130:228-35. doi: 10.1016/j.ajodo.2006.02.029
3. Gracco A, Luca L, Siciliani G. Molar distalisation with skeletal anchorage. *Aust Orthod J* 2007;23:147-52.
4. Razavi MR. Molar intrusion using miniscrew palatal anchorage. *J Clin Orthod* 2012;46:493-8.
5. Jeon YJ, Kim YH, Son WS, Hans MG. Correction of a canted occlusal plane with miniscrews in a patient with facial asymmetry. *Am J Orthod Dentofacial Orthop* 2006;130:244-52.
6. Moon CH, Lee DG, Lee HS, Im JS, Baek SH. Factors associated with the success rate of orthodontic miniscrews placed in the upper and lower posterior buccal region. *Angle Orthod* 2008;78:101-6. doi: 10.2319/121706-515.1
7. ParkHS, Jeong SH, Kwon OW. Factors affecting the clinical success of screw implants used as orthodontic anchorage. *Am J Orthod Dentofacial Orthop* 2006;130:18-25.
8. Kim JW, Ahn SJ, Chang YI. Histomorphometric and mechanical analyses of the drill-free screw as orthodontic anchorage. *Am J Orthod Dentofacial Orthop* 2005;128:190-4. doi: 10.1016/j.ajodo.2004.01.030
9. Miyawaki S, Koyama I, Inoue M, Mishima K, Sugahara T, Takano-Yamamoto T. Factors associated with the stability of titanium screws placed in the posterior region for orthodontic anchorage. *Am J Orthod Dentofacial Orthop* 2003;124:373-8. doi: 10.1016/s0889-5406(03)00565-1
10. Cheng SJ, Tseng IY, Lee JJ, Kok SH. A prospective study of the risk factors associated with failure of mini-implants used for orthodontic anchorage. *Int J Oral Maxillofac Implants*2004;19:100-6.
11. Motoyoshi M, Hirabayashi M, Uemura M, Shimizu N. Recommended placement torque when tightening an orthodontic mini-implant. *Clin Oral Implants Res* 2006;17:109-14. doi: 10.1111/j.1600-0501.2005.01211.x
12. Chen CH, Chang CS, Hsieh CH, Tseng YC, Shen YS, Huang IY, et al. The use of microimplants in orthodontic anchorage. *J Oral Maxillofac Surg* 2006;64:1209-13.
13. Dobranszki A, Faber J, Scatolino IV, Dobranszki NP, Toledo OA. Analysis of factors associated with orthodontic microscrew failure. *Braz Dent J* 2014;25:346-51. doi: 10.1590/0103-6440201300125
14. Manni A, Cozzani M, Tamborrino F, De Rinaldis S, Menini A. Factors influencing the stability of miniscrews. A retrospective study on 300 miniscrews. *Eur J Orthod* 2011;33:388-95. doi: 10.1093/ejo/cjq090
15. Lim SA, Cha JY, Hwang CJ. Insertion torque of orthodontic miniscrews according to changes in shape, diameter and length. *Angle Orthod* 2008;78:234-40. doi: 10.2319/121206-507.1
16. LimHJ, Eun CS, Cho JH, Lee KH, Hwang HS. Factors associated with initial stability of miniscrews for orthodontic treatment. *Am J Orthod Dentofacial Orthop* 2009;136:236-42.
17. Wilmes B, Drescher D. Impact of bone quality, implant type , and implantation site preparation on insertion torques of mini-implants used for orthodontic anchorage. *Int J Oral Maxillofac Surg* 2011;40:697-703. doi: 10.1016/j.ijom.2010.08.008
18. Heidemann W, Gerlach KL, Grobel KH, Kollner HG. Influence of different pilot holesizes on torque measurements and pullout analysis of osteosynthesis screws. *J Craniomaxillofac Surg*1998;26:50-5.
19. Chen YJ, Chen YH, Lin LD, Yao CC. Removal torque of miniscrews used for orthodontic anchorage--a preliminary report. *Int J Oral Maxillofac Implants* 2006;21:283-9.
20. Costa A, Raffainl M, Melsen B. Miniscrews as orthodontic anchorage: a preliminary report. *Int J Adult Orthodon Orthognath Surg* 1998;13:201-9.
21. Marquezan M, Souza MM, Araujo MT, Nojima LI, Nojima Mda C. Is miniscrew primary stability influenced by bone density? *Braz Oral Res* 2011;25:427-32. doi: 10.1590/s1806-83242011000500009
22. Cehreli MC, Kokat AM, Comert A, Akkocaoglu M, Tekdemir I, Akca K. Implant stability and bone density: assessment of correlation in fresh cadavers using conventional and osteotome implant sockets. *Clin Oral Implants Res* 2009;20:1163-9. doi: 10.1111/j.1600-0501.2009.01758.x
23. Motoyoshi M, Matsuoka M, Shimizu N. Application of orthodontic mini-implants in adolescents. *Int J Oral Maxillofac Surg* 2007;36:695-9. doi: 10.1016/j.ijom.2007.03.009
24. Friberg B, Sennerby L, Roos J, Lekholm U. Identification of bone quality in conjunction with insertion of titanium implants. A pilot study in jaw autopsy specimens. *Clin Oral Implants Res* 1995;6:213-9. doi: 10.1034/j.1600-0501.1995.060403.x
25. Song YY, Cha JY, Hwang CJ. Mechanical characteristics of various orthodontic mini-screws in relation to artificial cortical bone thickness. *Angle Orthod* 2007;77:979-85.
26. Chen Y, Kyung HM, GaoL, Yu WJ, Bae EJ, Kim SM. Mechanical properties of self-drilling orthodontic micro-implants with different diameters. *Angle Orthod* 2010;80:821-7.
27. Uemura M, Motoyoshi M, Yano S, Sakaguchi M, Igarashi Y, Shimizu N. Orthodontic mini-implant stability and the ratio of pilot hole implant diameter. *Eur J Orthod* 2012;34:52-6. doi: 10.1093/ejo/cjq157
28. Inoue M, Kuroda S, Yasue A, Horiuchi S, Kyung HM, Tanaka E. Torque ratio as a predictable factor on primary stability of orthodontic miniscrew implants. *Implant Dent* 2014;23:576-81. doi: 10.1097/id.0000000000000138
29. Wilmes B, Rademacher C, Olthoff G, Drescher D. Parameters affecting primary stability of orthodontic mini-implants. *J Orofac Orthop* 2006;67:162-74. doi: 10.1007/s00056-006-0611-z
30. Huja SS, Roberts WE. Mechanism of osseointegration: characterization of supporting bone with indentation testing and backscattered imaging. *Seminars in Orthodontics* 2004;10:162-73.
31. Papageorgiou SN, Zogakis IP, Papadopoulos MA. Failure rates and associated riskfactors of orthodontic miniscrew implants: a meta-analysis. *Am J Orthod Dentofacial Orthop* 2012;142:577-95.e7.
32. Chaddad K, Ferreira AF, Geurs N, Reddy MS. Influence of surface characteristics on survival rates of mini-implants. *Angle Orthod* 2008;78:107-13. doi: 10.2319/100206-401.1

33. Migliorati M, Benedicenti S, Signori A, Drago S, Barberis F, Tournier H, et al. Miniscrew design and bone characteristics: an experimental study of primary stability. *Am J Orthod Dentofacial Orthop* 2012;142:228-34. doi: 10.1016/j.ajodo.2012.03.029
34. Yadav S, Upadhyay M, Liu S, Roberts E, Neace WP, Nanda R. Microdamage of the cortical bone during mini-implant insertion with self-drilling and self-tapping techniques: a randomized controlled trial. *Am J Orthod Dentofacial Orthop* 2012;141:538-46. doi: 10.1016/j.ajodo.2011.12.016
35. Chen YJ, Chang HH, Huang CY, Hung HC, Lai EH, Yao CC. A retrospective analysis of the failure rate of three different orthodontic skeletal anchorage systems. *Clin Oral Implants Res* 2007;18:768-75. doi: 10.1111/j.1600-0501.2007.01405.x
36. Sakoh J, Wahlmann U, Stender E, Nat R, Al-Nawas B, Wagner W. Primary stability of a conical implant and a hybrid, cylindric screw-type implant in vitro. *Int J Oral Maxillofac Implants* 2006;21:560-6.
37. Suzuki EY, Suzuki B. Placement and removal torque values of orthodontic miniscrew implants. *Am J Orthod Dentofacial Orthop* 2011;139:669-78. doi: 10.1016/j.ajodo.2010.11.017
38. Huja SS, Litsky AS, Beck FM, Johnson KA, Larsen PE. Pull-out strength of monocortical screws placedin the maxillae and mandibles of dogs. *Am J Orthod Dentofacial Orthop* 2005;127:307-13. doi: 10.1016/j.ajodo.2003.12.023
39. Lee SJ, Ahn SJ, Lee JW, Kim SH, Kim TW. Survival analysis of orthodontic mini-implants. *Am J Orthod Dentofacial Orthop* 2010;137:194-9.
40. Wu TY, Kuang SH, Wu CH. Factors associated with the stability of mini-implants for orthodontic anchorage: a study of 414 samples in Taiwan. *J Oral Maxillofac Surg* 2009;67:1595-9. doi: 10.1016/j.joms.2009.04.015
41. Kuroda S, Sugawara Y, Deguchi T, Kyung HM, Takano-Yamamoto T. Clinical use of miniscrew implants as orthodontic anchorage: success rates and postoperative discomfort. *Am J Orthod Dentofacial Orthop* 2007;131:9-15. doi: 10.1016/j.ajodo.2005.02.032