Failure Rate and Associated Factors with Use of Mini-Screws in Orthodontic Treatments: A Systematic Review and Meta-analysis

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ABSTRACT

Aim and Background: This meta-analysis aimed to study the failure rate and related risk factors associated with the use of orthodontic mini-screws in anchorage reinforcement. Method and Materials: This meta-analysis was started with a search for keywords 'mini-screw', 'micro-screw', 'mini-implant' and 'failure rate' in the databases of several search engines, including Google Scholar, PubMed, Science Direct and Scopus. Articles were selected based on inclusion criteria (e.g. clinical trials, retrospective, and human studies) and exclusion criteria (e.g. on-plant, palatal and conventional implants). The quality of selected studies for this study was assessed by the PRISMA checklist. The mean and standard deviation of failure rates were determined. The random-effect model was used to evaluate the effect of each risk factor on the failure rate. This study aimed to calculate the failure rate, and identify the risk factors involved in the failure rate of using mini-screws by meta-analysis. Results: A total of 20 out of 1,995 studies were selected up to 2016, to assess the overall failure rate of mini-screw, and to investigate the associated risk factors. Of 4,826 mini-screw implants used in 2,327 patients, the overall failure rate was 15.08% (95% CI). The statistical significance was set at P<0.01. Failures of mini-screw were not associated with the mini-screw insertion site (right or left), growth pattern, Gender, type of malocclusion and mini-screw length. They were significantly associated with the jaw insertion, age, and type of gingiva (attached or movable) (P<0.006). Conclusion: The overall mean of the failure rate in this study was 15.08 %. Related risk factors such as jaw insertion, age, and type of gingiva affected the failure rate. Collectively, the results of this study indicate that mini-screws with low failure rates are the best alternative for anchorage reinforcement.

Key Words: *Failure rate, Mini-screw, Mini-implant, Meta-analysis, Anchorage.*

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INTRODUCTION

Bone anchorages have proven to play an essential role in the successful completion of certain orthodontic treatments [1]. Anchorage is one of the limiting factors in orthodontics, and its control is essential for successful treatment outcomes [2]. In orthodontics, Miniscrews have been mainly used for anchorage without patient compliance in orthodontic treatment [3]. In particular, miniscrews have become a popular method for achieving maximum anchorage without compliance from the patients because miniscrews can be inserted into the bones rapidly and easily [4]. Orthodontic mini-screw implants are very popular due to their easy insertion and removal, low-cost, and minimum need for patient cooperation [5]. As the name implies, the use of fixed orthodontic appliances relies on bonding them to tooth structures [6]. In 1990, the use of surgical screws (mini-screws, mini-implants and micro-screws) dramatically increased in creating anchorage in orthodontic tooth movements [7]. Tseng et al investigated the stability of 45 mini-screws in orthodontic treatments and reported a success rate of 91% compared to other studies reporting success rates of less than 90%, including

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89% by Cheng et al, 87.5% by Costa et al, 84% by Miyawaki et al, 75% by Freudenthaler et al, and 70% by Fritz et al. [8]. In 1983, Eklud and Greakmore first introduced screws in clinical orthodontic, merely to create orthodontic anchorage [7]. The term "orthodontic anchorage" is indicative of the nature and degree of resistance to displacement by one unit of anchorage, and it is used to maximize tooth movement and minimize adverse effects [9]. Conventional orthodontic anchorage often causes loss of anchorage, which is a major side effect of orthodontic mechanotherapy, and the loss of anchorage of more than 2 mm can diminish treatment effects, especially in specific cases [8]. Ever since 2005, there has been huge interest in systematic reviews and meta-analyses regarding failure rates of mini-screws and associated factors [6, 7, 9-11], which is indicative of how frequently mini-screws are being used in clinical orthodontics. Gainsforce and Higley proposed the use of metallic screws as an anchorage in 1945 [7].

A meta-analysis in 2005 showed that use of conventional implants had declined after 2000 and have been extensively replaced by mini-screws [7]. In a meta-analysis conducted by Crismani et al, the success rate of mini-screws was reported to be 83.8%, and patient's gender had no relationship with this finding; however, a significant difference was observed in patients older than 30 years of age [11]. In a study by Papadopoulos et al on 8 types of research, a success rate of 87.7% was reported for mini-screws, which showed significant differences in the mandible as compared with maxilla, and in older patients as compared with younger patients [12]. In a meta-analysis by Dalessandari et al, the failure rate of TAD was reported to be more than 80%. The success rate was higher in the maxilla compared with mandible, and the failure rate was lower in people older than 16 and 20 years of age [13].

Shortening the length of mini-screws substantially reduces the chances of injury or contact with the roots of adjacent teeth. Moreover, treatment failure rate increases with a decrease in mechanical retention created by short mini-screws. Several reasons have been proposed for the failure of mini-screws. Some consider mini-screws as the cause of failure. In a study, where the failure rates of two mini-screws of the same length but with different diameters were compared, mini-screws with smaller diameter exhibited greater stability. The larger diameter resulted in closer proximity to the roots of adjacent teeth and caused its failure. In other words, the length of mini-screw had the least effect on its failure [5]. Another factor affecting the failure of mini-screws is bone density [5]. Additionally, these mini-screws were infamous for their high failure rate. The shortcomings, described in the discussion section, encouraged writing this article.

Here a meta-analysis was conducted on qualified articles that had used general meta-analysis, and meta-analysis was found for each one. In addition, the role of associated factors such as patient-related factors including age, gender, jaw, dental malocclusion and growth pattern, and implant-related factors of the type of implant in terms of length and location-related factors of side of placement, vertical position (attached or movable gingiva) with failure was examined.

METHOD AND MATERIALS:

This study was conducted in 2016, using the systematic review approach adopted from the book entitled 'A Systematic Review to Support Evidence-Based Medicine' [14]. Also, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist was completed during this review [15].

This systematic review and meta-analysis was carried out using PubMed, EMBASE, Google Scholar, Scopus and Science Direct databases by first searching 'success rate of mini-screws in orthodontic treatment', and then by searching keywords such as 'success rate', 'failure rate', 'orthodontic anchorage' and 'mini-screws'. Finally, of 1,995 results, 20 articles were extracted for this meta-analysis (Figure 1).

Inclusion and Exclusion Criteria

Articles published up to 2016 (as an inclusion criterion), and articles that qualified for inclusion criteria were included in this study. Furthermore, articles investigating the non-manual use of mini-screws and sections on manual methods were also used in this study, irrespective of the journal, author, authors' place of work and their credibility. Articles in English were also selected. Articles that utilized mini-screws measuring less than 2.5 mm in diameter for orthodontic anchorage were chosen. Data were extracted from retrospective and randomized clinical trials in humans. Study exclusion criteria consisted of articles on the use of conventional implants, on-plants and palatal mini-plates as orthodontic anchorage, as well as systematic reviews, letters, introducing techniques, case reports, articles in languages other than English, non-clinical trials, no-access full texts, and articles on follow-ups of the use of mini-screws with less than 1 month.

Data Extraction

Data were collected by two independent reviewers (Mos.S., Val. N.), using the above factors. In addition, the names of authors and other specifications, including the year of publication, the number of mini-screws and failures were recorded.

Assessment of the Quality of Studies

The authors in this research did not have any articles, therefore, there was no bias for this purpose and as a result, there was no need for blinding. We used the checklists and diagrams of PRISMA. PRISMA focuses on the reporting of reviews evaluating randomized trials, but can also be used as a basis for reporting systematic reviews of other types of research, particularly for evaluation of interventions [15].

RESULTS:

Characteristics of the Study

A total of 20 eligible articles, involving 4,826 mini-screws, 2,327 patients, 728 males and 1,599 females, met all the inclusion and exclusion criteria. If OR = 1, the mini-screw failure was considered independent of each risk factor. Table 1 presents year of publication, type of study, failure rates, and associated risk factors of each study. Table 2 presents the risk factors related to failure rates, studies for that risk factor, pooled OR, P-values of pooled OR and P-values for tests of publication bias.

Meta-analysis Results

Gender (Male vs. Female)

There were no significant differences in failure rates between males and females. In total, fifteen studies were involved with OR (95% CI) = 0.925 (range: 0.657–1.3) and P = 0.652 (Table 2). The overall OR of 0.925 in this meta-analysis showed the independence of mini-screw failure from sex (CI=0.657–1.3, weight=100%). It is assumed that the OR magnitude of the effect in all studies is a variable with the normal probability distribution. When there is no homogeneity, fixed effect should be used rather than a random effect. In this meta-analysis, chi-squared test was used for the variable heterogeneity of sex, and the assumed homogeneity was rejected at P= 0.012. The level of heterogeneity, I^2=50.7%, showed that 50% of the studies examined here were heterogeneous in terms of OR. Approximation or estimation of the variance between studies was t^2=0.187. PQ (or Adjustable Kendal Score) of 45 and p-value of 0.029 for publication bias refuted the hypothesis of the constant correctness of results, i.e. the correctness of results was not constant and depends on further studies.

Side of Placement

The right vs. left side of jaw

Failure rate on the right side was not significantly different from that on the left side; in total, eleven studies were involved, OR (95% CI) = 0.874 (range: 0.437–1.75), P = 0.704. Failure rate in Cl I malocclusion was not significantly different from that in Cl II; in total, six studies were involved, OR (95%CI) = 1.406 (range: 0.625–3.165), P = 0.411. The meta-analysis of malocclusions Cl I and Cl II in six studies along with OR, CI, and weight are provided in the output table. Pooled OR and the calculated random effect in which OR = 1 pooled was not rejected, i.e. there was no significant difference between Cl I and Cl II in terms of the failure rate. The heterogeneity was tested using chi-squared test, with the results indicating heterogeneity between studies; the index I^2 =82.7% showed the studies were highly heterogenic for cut-off points 25%, 50% and 75%. Moreover, t^2=76% was calculated for determining the variance between studies based on total indexes (the number of mini-screws without failures, the number of samples, etc.). In malocclusion (Cl I vs. Cl III), failure rate in Cl I malocclusion was not significantly different from that in Cl III; in total, six studies were involved, OR (95% CI) = 0.683 (range: 0.311–1.498), P= 0.342 (Table 2).

Type of Growth Pattern (HMPA vs. LMPA)

Failure rate in high mandibular plane angle (HMPA) was not significantly different from that in the low mandibular plane angle (LMPA); in total, six studies were involved, OR (95% CI) = 0.813 (range: 0.459–1.442), P= 0.479 (Table 2).

Length of Mini-screws (6 mm vs. 8 mm)

Failure rate in patients with mini-screws of 6 mm in length was not significantly different from that in mini-screws of 8 mm in length; in total, three studies were involved, OR (95% CI) = 0.780 (range: 0.131–4.651), P= 0.785 (Table 2).

The Effect of Jaw (Maxilla vs. mandible)

Failure rate in the mandible was significantly different from that in the maxilla; in total, sixteen studies were involved, OR (95% CI) = 1.743 (range: 1.192–2.549), P=0.004 (Table 2). In the analysis using METAN command, the output table for OR, CI, their weight and the statistical test OR=1 showed the independent effect of maxilla and mandible on failure rate. Moreover, the I^2index showed the heterogeneity between ORs of the examined studies (t^2= 0.391), which reveals that the mini-screw failure rate in the mandible was significantly higher than that of the maxilla. The level of heterogeneity was X^2=55.7% and I^2 =73.1%, i.e. the OR effect size of the studies differs from one another by 74%.

Age <20 vs. >20

Failure rate in patients under 20 years of age was significantly different from that in patients over 20 years of age; in total, 16 studies were involved, OR (95% CI) = 0.746 (range: 0.600–0.926), P= 0.008 (Table 2).

Type of Gingiva (Attached G vs. Movable G)

Failure rate in movable gingiva was significantly different from that in attached gingiva; in total, six studies were involved, OR (95% CI) = 4.045 (range: 2.131–7.677), P< 0.001 (Table 2).

Figures 2, 3 and 4 present plots of risk factors that are effective in the failure rate of mini-screws.

Synthesis of the Analyzed Data

The data were analyzed using STATA software for the Random Effect Model. The ORs pooled with 95% confidence intervals were obtained.

Evaluation of Publication Bias

The publication bias was evaluated through observing an asymmetry in funnel plot (Light &P illemer). Begg's test was used to observe the negative correlation between standard effect size and standard error [16]. These effects were evaluated using Kendal and one-tailed significance tests. Linear tests based on the regression model, introduced by Egger et al, were used for quantitative evaluation of the publication bias in the funnel plot.

Evaluation of Heterogeneity

The heterogeneity was evaluated using I^2 statistical test. The heterogeneity with cut-off point of <50% (low) and cut-off point of >50% (high) was determined by Dersimonian and Laird [17].

Sensitivity of Analysis

The sensitivity of analysis was performed by the elimination of certain studies. The pooled ORs of the associated factors did not change after elimination, indicating that our results were statistically robust.

Statistical Analysis

The correlation between the risk factors and failure of the mini-screws was determined based on the incidence of failure rate in each subgroup and effect size (odds ratio). For each individual factor, the pooled OR and range of 95% confidence interval were reported. Statistical test of risk factors associated with the failure rate of mini-screws used Z (Wald Statistic), and $P< 0.05$ were considered statistically significant. For consideration of heterogeneity between studies, we used random effect based on the method used by Dersimonian and Laird [18]. All the statistical analyses were carried out by STATA 11 software (STATA Corp. LP).

DISCUSSION:

A systematic review with precise strategy was performed for collection of data on failure rates of mini-screws and risk factors affecting failures. In this study, 4,826 mini-screws from 20 different types in 2,327 patients in 20 articles were evaluated. The overall failure rate was 15.08%, and this failure rate was the same as that in a study by Kim et al. [19]. The failure rate was affected by age, gingival location and Jaw. However, there were no significant differences in failure rates between the left and right sides, or between the vertical and horizontal growth patterns, gender, types of malocclusions and mini-screw lengths. Failure rates less than or greater than the mean (15.08%) showed no significant differences between males and females.

In terms of the number of mini-screws (4,826) and patients (2,327), this study was similar to a meta-analysis conducted by Papdopolous, Zagakis and Papaheorgeon [5], with 4,987 mini-screws and 2,281 patients. In the present study, the failure rate was 15.08%, which was close to that in the above study (13.5%). A significant difference was observed in failure rate between males and females, which was similar to 3 other studies [8, 19, 20] but this difference was not significant in 7 other studies [20-27]. In the present study, there was a significant difference in failure rates between jaws, which was similar to the study by Papdopolous, Zagakis and Papaheorgeon [5].

In 11 articles [8, 19, 21-29] evaluated in this meta-analysis, no significant differences were found in failure rates of mini-screws between different age groups, but in 11 articles [8, 19, 21, 22, 24, 28, 30-34], failure rate was lower in older patients compared to younger subjects [5, 7, 8-11, 13, 21]. Data extracted from 8 articles [7-10, 19, 24, 31, 34] showed a significant difference between jaws in terms of failure rate of mini-screws. In the present study, failure rate was higher in mandible (18%) than in Maxilla (12%), which was similar to Papdopolous, Zagakis and Papaheorgeon [5]. Higher failure rate in the mandible might be due to: Higher mandibular bone density and the need for greater torque in the mandible; More heat produced during implantation; Less cortical bone formation around mini-screws and the mandible; and Poor oral hygiene in the mandible compared to the maxilla [5]. There was no difference between the anterior and posterior regions of the jaw in terms of failure rate in 6 articles [8, 21, 22, 27, 29, 31]. However, there were significant differences between anterior and posterior mini-screw failure rates in 6 articles [19, 20, 24, 26, 32, 34]. In terms of length, there were significant differences in failure rates in 4 articles [19, 24, 26, 33]. However, this difference was not significant in 7 other articles [8, 22, 23, 27, 30-32, 34, 35].

There were significant differences in failure rates between different types of mini-screws, except in one article [31], but no significant differences were noted in other cases [27], but no significant differences were noted in other cases [21, 23, 24, 32, 35].

In a study by Dalesandari et al. [23], failure rate (20%) was higher compared to the present study. Failure rate showed no significant differences in associated factors of gender, type of attached and mobile gingiva, type of mini-screw, but significant differences were observed in younger age compared to older age, left less than right side, and maxilla less than mandible.

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In a systematic review by Crismani et al on 14 articles, the failure rate was 17%, which was slightly higher compared with the present study [11]. This might be attributed to fewer articles selected in the study. In the following associated factors, the difference was significant: maxilla less than mandible, which was similar to the present study.

CONCLUSION

The overall mean of the failure rate in this study was 15.08%. Failures of mini-screw were not associated with the mini-screw insertion site (right or left), growth pattern, gender, type of malocclusion, and length of mini-screw, whereas they were significantly associated with the jaw of insertion, age and type of gingiva (attached or movable). In conclusion, mini-screws with low failure rates are the best alternative for anchorage reinforcement.

REFERENCES

[1] Alantar A, Andreani JF, Audi G, Tondelier C, Pruvost JL. The use of mini-anchorage screws in the surgical orthodontic treatment of stage-III periodontitis: a clinical case. Journal of Oral Medicine and Oral Surgery. 2018 Oct 1;24(3):125-8.

[2] Loli D. Temporary anchorage devices (TADs): failure rates and risk factors. WebmedCentral Orthodontıcs. 2017;8(11):WMC005392. 5 pages.

[3] Alharbi F, Almuzian M, Bearn D. Miniscrews failure rate in orthodontics: systematic review and meta-analysis. European Journal of Orthodontics. 2018;40(5),519–30. https://doi.org/10.1093/ejo/cjx093.

[4] Uesugi S, Kokai S, Kanno Z, Ono T. Stability of secondarily inserted orthodontic miniscrews after failure of the primary insertion for maxillary anchorage: Maxillary buccal area vs midpalatal suture area. American Journal of Orthodontics and Dentofacial Orthopedics. 2018 Jan 1;153(1):54-60.

[5] Papageorgiou SN, Zogakis IP, Papadopoulos MA. Failure rates and associated risk factors of orthodontic miniscrew implants: a meta-analysis. American Journal of Orthodontics and Dentofacial Orthopedics. 2012 Nov 1;142(5):577-95.

[6] Mousavi SM, Ghorani PS, Chitsazi S. Effect of Algınate Impressıon Takıng on Shear Bond Strength of Orthodontıc Brackets. Annals of Dental Specialty. 2018;6(2), 128-131.

[7] Labanauskaite B, Jankauskas G, Vasiliauskas A, Haffar N. Implants for orthodontic anchorage. Meta-analysis. Stomatologija. 2005;7(4):128-32.

[8] Lim H-J, Eun C-S, Cho J-H, Lee K-H, Hwang H-S. Factors associated with initial stability of miniscrews for orthodontic treatment. American Journal of Orthodontics and Dentofacial Orthopedics. 2009;136(2):236-42.

[9] Chen Y, Kyung HM, Zhao WT, Yu WJ. Critical factors for the success of orthodontic mini-implants: a systematic review. American Journal of Orthodontics and Dentofacial Orthopedics. 2009;135(3):284-91.

[10] Hoste S, Vercruyssen M, Quirynen M, Willems G. Risk factors and indications of orthodontic temporary anchorage devices: a literature review. Australian orthodontic journal. 2008;24 (2):140-8.

[11] Crismani AG, Bertl MH, Čelar AG, Bantleon H-P, Burstone CJ. Miniscrews in orthodontic treatment: review and analysis of published clinical trials. American Journal of Orthodontics and Dentofacial Orthopedics. 2010;137(1):108-13.

[12] Papadopoulos M, Papageorgiou S, Zogakis I. Clinical Effectiveness of Orthodontic Miniscrew Implants a Meta-analysis. Journal of dental research. 2011;90(8):969-76.

[13] Dalessandri D, Salgarello S, Dalessandri M, Lazzaroni E, Piancino M, Paganelli C, Maiorana C, Santoro F. Determinants for success rates of temporary anchorage devices in orthodontics: a meta-analysis (n> 50). European journal of orthodontics. 2014 Jun 1;36(3):303-13.

[14] Khan K, Kunz R, Kleijnen J, Antes G. Systematic reviews to support evidence-based medicine. Crc Press; 2011 Feb 25.

[15] Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. Annals of internal medicine. 2009;151(4):264-9.

[16] Begg CB, Mazumdar M. Operating characteristics of a rank correlation test for publication bias. Biometrics. 1994 Dec 1:1088-101.

[17] DerSimonian R, Laird N. Meta-analysis in clinical trials Control Clin Trials 7: 177–188. Find this article online. 1986.

[18] DerSimonian R, Laird N. Meta-analysis in clinical trials. Controlled clinical trials. 1986 Sep 1;7(3):177-88.

[19] Kim JS, Choi SH, Cha SK, Kim JH, Lee HJ, Yeom SS, et al. Comparison of success rates of orthodontic mini-screws by the insertion method. The Korean Journal of Orthodontics. 2012;42(5):242-8.

[20] Chen YJ, Chang HH, Huang CY, Hung HC, Lai EHH, Yao CCJ. A retrospective analysis of the failure rate of three different orthodontic skeletal anchorage systems. Clinical oral implants research. 2007;18(6):768-75.

[21] Sharma P, Valiathan A, Sivakumar A. Success rate of microimplants in a university orthodontic clinic. ISRN surgery. 2011 Apr 26;2011.

[22] Antoszewska J, Papadopoulos MA, Park HS, Ludwig B. Five-year experience with orthodontic miniscrew implants: a retrospective investigation of factors influencing success rates. American Journal of orthodontics and dentofacial orthopedics. 2009 Aug 1;136(2):158-e1.
[23] Lai T-T, Chen M-H. Factors affecting the clinical success of orthodontic anchorage: Experience with 266 temporary anchorage devices. Journal of Dental Sciences. 2014;9(1):49-55.
[24] Topouzelis N, Tsaousoglou P. Clinical factors correlated with the success rate of miniscrews in orthodontic treatment. International journal of oral science. 2012;4(1):38.
[25] Arora A., Gupta S.D., Prakash A., Kumar P. Success Rate of Dıfferent Mıcro Implant Systems. International Journal of Medical Dentistry. 2014 Jan 1;18(1).
[26] Tseng Y-C, Hsieh C-H, Chen C-H, Shen Y-S, Huang I-Y, Chen C-M. The application of mini-implants for orthodontic anchorage. International journal of oral and maxillofacial surgery. 2006;35(8):704-7.
[27] Wu T-Y, Kuang S-H, Wu C-H. Factors associated with the stability of mini-implants for orthodontic anchorage: a study of 414 samples in Taiwan. Journal of Oral and Maxillofacial Surgery. 2009;67 (8):1595-9.
[28] Suzuki M, Deguchi T, Watanabe H, Seiryu M, Iikubo M, Sasano T, et al. Evaluation of optimal length and insertion torque for miniscrews. American Journal of Orthodontics and Dentofacial Orthopedics. 2013;144(2):251-9.
[29] Bali Z, Mittal S, Sehgal V, Sharma S, Gupta R. Factors influencing the clinicalstability of microscrew implants used for orthodontic anchorage-an in vivo study. Journal of Indian Orthodontic Society. 2010;44(3):42.
[30] Kuroda S, Sugawara Y, Deguchi T, Kyung H-M, Takano-Yamamoto T. Clinical use of miniscrew implants as orthodontic anchorage: success rates and postoperative discomfort. American journal of orthodontics and dentofacial orthopedics. 2007;131(1):9-15.
[31] Park H-S, Jeong S-H, Kwon O-W. Factors affecting the clinical success of screw implants used as orthodontic anchorage. American journal of orthodontics and dentofacial orthopedics. 2006;130(1):18-25.
[32] Moon C-H, Lee D-G, Lee H-S, Im J-S, Baek S-H. Factors associated with the success rate of orthodontic miniscrews placed in the upper and lower posterior buccal region. The Angle orthodontist. 2008;78(1):101-6.
[33] Sarul M, Minch L, Park H-S, Antoszewska-Smith J. Effect of the length of orthodontic mini-screw implants on their long-term stability: A prospective study. The Angle orthodontist. 2014;85(1):33-8.
[34] Dobranszki A, Faber J, Scatolino IVMC, Dobranszki NP, Cordeiro A, Toledo OAd. Analysis of Factors Associated with Orthodontic Microscrew Failure. Brazilian dental journal. 2014;25(4):346-51.
[35] Baik UB, Bayome M, Han KH, Park JH, Jung MH, Kook YA. Evaluation of factors affecting the success rate of orthodontic mini-implants by survival analysis. World Journal of Stomatology. 2013 Aug 20;2(3):56-61.