Original Article

INFLUENCE OF THREE DIFFERENT ORAL HYGIENE PRACTICES ON THE SUCCESS OF ORTHODONTIC MINISCREWS

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ABSTRACT

Context

The success of orthodontic mini-screws is multifactorial. Post-insertion oral hygiene choices play a gate-keeping role in the overall success of the mini-screws.

Aims: To evaluate the effect of three different oral hygiene practices in adult patients with miniscrews implanted for en-masse retraction of the anterior segment following first premolar extractions.

Setting and Design: A prospective study designed to assess the effectiveness of three oral hygiene practices on orthodontic miniscrews in patients undergoing fixed orthodontic appliance therapy in a tertiary hospital.

Materials and method: Selected participants were randomly assigned to three different oral hygiene practices: twice-daily brushing; twice-daily brushing with twice-daily warm saline mouth rinse gaggle; and twice-daily brushing with twice-daily gaggle with 0.12% chlorhexidine mouth rinse; all for 12

in the study.

weeks. At the 7th day, 4th, 8th and 12th week post-miniscrew insertion, gingival inflammation and implant mobility were assessed.

Statistical analysis: Analysis relied mainly on association determinations using the Chi-square test. The level of statistical significance was set at $P < 0.05$, and the 95% confidence level was adopted.

Results: A total of 60 miniscrews were inserted among 18 participants. Participants categorized into three groups of 6 participants each, represented the different types of oral hygiene practice. Peri-implant gingival inflammation were assessed at day 7 ($p = 0.010$), week 4 ($p = 0.010$), and week 12 ($p = 0.010$) post miniscrew insertion for anchorage.

Conclusion: Adjunctive use of warm-saline and chlorhexidine mouth rinses did not offer significant difference in miniscrew peri-implant stability and success compared to routine mouth brushing.

Key words: Oral Hygiene Practices, Miniscrews, Orthodontics, Anchorage, Peri-implantitis.

INTRODUCTION

Different terminologies have been used for orthodontic miniscrews. These include; mini-implants, miniscrew implants, microscrews and temporary anchorage devices.[1] Miniscrews are surgically placed through alveolar cortical bone and other bony structures in the oral cavity, serving as temporary anchorage devices in orthodontic treatment. Its acceptance in orthodontic practice has risen tremendously in the past decade as it confers several advantages compared to conventional intra-oral and extra-oral anchorage devices.[2] These titanium screws which come in various dimensions, designs and sizes, have gradually become a reliable source of absolute anchorage in orthodontics. Miniscrews have found applications in en-masse retraction,[3] intrusions of molar teeth, treatment of anterior open bite,[4] deep bite corrections,[5] alignments of

impacted canine teeth and in shortening of orthodontic treatment time.[6] There are numerous advantages of miniscrews that make them find this wide range of applications.[7]

Whereas, miniscrews have greatly increased orthodontic treatment options available in the management of adolescent and adult patients, as they also serve as a valuable tool in the elimination of unwanted tooth movement and also improving the effectiveness of orthodontic appliances.[8] Although scores of studies,[5–7] emphasized the merits of the orthodontic miniscrews as anchorage devices, which also include; ease of application, minimal specialists' expertise required, relative cost-effectiveness, use of miniscrew is associated with failure as well as complications such as heightened inflammation of the tissue surrounding the screws, and injuries to the root of the adjacent teeth. There could also be loosening and fracture of the screws.[7]

Whereas few clinical studies have examined success rates of miniscrews, [9–12] the multifactorial nature of these failures makes it difficult to elucidate the isolated influence of the various factors on failure. It is instructive that the orthodontist understands the interplay of the variables related to the mobility of the screws[13] which sometimes necessitates the removal of screws before or during anchorage tasks. Firstly, inflammation which manifests as redness or swelling around the neck of the screws is one of the main causes of miniscrew loosening leading to mobility and anchorage loss.[14] Inflammation of the peri-implant soft tissue has been associated with a 30% increase in failure rate as a result of damage to the bone surrounding the neck of miniscrews.[13] Next, healthy oral mucosa and peri-implant tissues play an important role as a biological barrier to infections,[15] nonetheless, peri-implantitis, a pathological condition of the tissues around dental implants, characterized by inflammation of the peri-implant mucosa,

progressive loss of supporting bone, and even minor infections may occur post miniscrew placement.[16,17] Miniscrew placement can stimulate the surrounding soft tissues and evoke tissue inflammation, small infections, and peri-implantitis, especially when placed through the non-keratinized or mobile gingiva leading to tissue overgrowth which appears as a partial or total covering of the implant head by the surrounding soft tissues.[18]

The success of miniscrews in the oral cavity can be influenced by the site of placement,[19] the placement technique, the amount of load, and hygiene around the implant.[20] Even when the placement procedure is carried out accurately, the stability of the miniscrews should be monitored regularly to avoid peri-implantitis. Central to this monitoring is the guiding and controlling of oral hygiene around miniscrews[21] with periodic clinical assessments advocated for early identification of peri-implantitis and prompt treatment. Although many studies have assessed the percentage of miniscrew failures,[22,23] it is still unclear what the specific influence of oral hygiene practices of the entire oral cavity and specifically the peri-implant regions, has on implant mobility rate. Further, there is a dearth of knowledge on the impact of various oral hygiene practices on the success and failure of orthodontic miniscrews

The objective of this study, therefore, is to examine the impact of three different oral hygiene practices on the degree of inflammation and mobility around the orthodontic miniscrews. We hypothesize that there is a statistically significant difference in the influence of various oral hygiene practices on inflammation and mobility of orthodontic miniscrews

Materials and Methods

Study Design and Area:

This prospective study trial was designed to assess the effectiveness of three oral hygiene practices on orthodontic miniscrews in adult patients undergoing

fixed orthodontic appliance therapy in the Department of Preventive Dentistry, University of Benin Teaching Hospital, Benin City, Edo State, Nigeria.

Selection Criteria

Adult fixed orthodontic patients aged 18 years and above who require 2- or 4-unit extraction and anterior segment retraction as part of their treatment who are free from systemic disease, known bone pathology, active periodontal disease, as well as those who use tobacco or consume excessive alcohol were excluded from the study.

Randomization

This is a single-stage randomized clinical trial. The randomization was to allocate oral hygiene practice to each of the study participants. The randomization was accomplished by using the permuted random block size of 3 with the random generation function in Excel (Microsoft, Redmond, Wash). Subsequently, the random sequences were concealed in opaque envelopes and shuffled before the intervention to increase the unpredictability of the random allocation sequence. Each patient was asked to pick a sealed envelope to assign an oral hygiene practice Allocation concealment was done to prevent selection bias and protect the assignment sequence until allocation.

Blinding

This was ensured only at the data analysis stage as blinding participants and clinicians was not feasible

Sample Size Estimation

Using power analysis with G* Power software version 3.1.9.7[24] and with the following parameters

Number of groups = 3

$\alpha = 0.05$

Power $(1 - \beta) = 0.8$

Cohen's Effect size, f = 0.4

Number of measurements = 4

Correlation among repeated measures = 0.5

The minimum sample size required for an F-test family comprising three groups with four repeated measurements is 42. Accounting for 15% attrition, the minimum sample size will be 48 per sample i.e 16 samples per group. Sixty (60) miniscrews with 18 participants were eventually recruited into the study

Statement of Ethics:

Approval was sought from the Health Research Ethics Committee of the University of Benin Teaching Hospital, Benin City with approval number **ADME/E22/A/VOL.VII/183011210033.** Study participants who met the inclusion criteria were required to sign a written informed consent after a thorough explanation of the study to them.

Study Groups

Depending on the type of oral hygiene practice they will carry out, eighteen (18) participants boring 60 miniscrews were randomly assigned into groups A, B and C. Group A participants were required to brush twice daily throughout the study, while those in group B were required to brush twice daily and also, gaggle with a solution of warm saline mouth rinse, (constituted as a levelled teaspoon of salt dissolved in 75ml of warm water) three times daily throughout the study and group C participants were required to brush twice daily and also, gaggle with 0.12% of Chorhexidene (Cosordyl®) twice daily for two weeks, alternating with two weeks of no gaggle until end of the study. Each participant had either two or four miniscrews inserted and assessed depending on whether en-masse anterior retraction of the anterior segments was done on one or both arches.

Miniscrew Insertion Process

At the time of miniscrew placement, all study participants were required to have had adequate oral hygiene as evidenced by a low plaque index and an absence of gingivitis and/or periodontitis in the area where miniscrews were placed. Oral hygiene guidelines were given.

Self-drilling miniscrews by GDT® measuring 1.8x8mm were used by inserting each buccally between the second premolar and first molar where they served as an absolute anchorage for en-masse retraction of anterior segments in adult patients. Clinical assessment of the miniscrew chosen site for placement, which was 5mm apical to the gingival margin between the first permanent molars and the second premolars[19] was done, the topical anaesthetic was applied at the placement site, local anaesthesia infiltration was done around the gingival margin, miniscrew was then placed using a miniscrew driver. Stability/mobility was assessed using gentle finger pressure.

Outcomes of Interest

Evaluations of the three oral hygiene practices were done at 7 days, 4 weeks, 8 weeks and 12 weeks post-miniscrew insertion. Parameters assessed were peri-implant gingival inflammation using the Gingival index and mobility of miniscrew. Miniscrew mobility was assessed using a scoring system prescribed by Vicioni-Marques et al.[21]

Orthodontic miniscrews were considered successful when they proved a perfect skeletal anchorage with no peri-implantitis during the entire 12 weeks of this study.

Statistical Analysis

The data collected were screened for completeness and entered into IBM Statistical Package for the Social Sciences (SPSS) version 23. The results of the analysis were presented in tables and charts as appropriate. A Chi-square test for independence of association was conducted to determine the association between oral hygiene practices and per-implant gingivitis, and the association between the oral health practices and TAD mobility. The level of statistical significance was set at $P < 0.05$, while the 95% confidence level was used to construct confidence intervals around estimates.

RESULT

Eighteen subjects were recruited with a total of 60 miniscrews inserted. As shown in Table 1, the subjects' ages ranged from 18-33 years with a mean age of 24.9 ± 4.5 years and consisted of 12 females and 6 males. Twelve (had 4 unit extraction) subjects got miniscrew in all quadrants and 6 (had 2 unit extractions only, either in the upper or lower arch) subjects in just 2 quadrants. A total of 60 quadrants in 17 upper arches and 13 lower arches s were included in this study with miniscrew loss/anchorage loss observed in just one quadrant (1.67%).

Table 1: Sociodemographic of Study Participants

Characteristic	Overall, N = 18[1]	B + CHL, N = 6[1]	B + WS, N = 6[1]	BO, N = 6[1]	p-value[2]
Age	24.9 ± 4.5	24.8 ± 3.1	27.0 ± 4.6	23.0 ± 5.3	0.320
Gender					0.085
Female	12 (66.7%)	4 (66.7%)	2 (33.3%)	6 (100.0%)	
Male	6 (33.3%)	2 (33.3%)	4 (66.7%)	0 (0.0%)	

[1]Mean ± SD; n (%)

[2]One-way ANOVA; Fisher's exact test

Table 2 below shows the relationship between oral hygiene practices and gingival inflammation at different time intervals post miniscrew insertion. On Day 7, all teeth in group B + CHL (Group C) and group B + WS (Group B) had normal gingiva while 77.3% and 22.7% of those in group BO (Group A) had normal gingiva and mild gingival inflammation, respectively. The development of gingivitis was associated with the oral hygiene practices (p = 0.010).

At week 4, the gingiva of all teeth in group B + CHL remained normal while 28.6% of those in group B + WS and 63.6% of group BO had mild gingivitis. Also, 9.1% of group BO had moderate gingivitis. At this period also, the development of gingivitis was associated with oral hygiene practices (p = 0.010).

At week 8, 35.3% of group B + CHL had mild gingivitis, 42.9% of group B + WS and 45.5% of group BO also had mild gingivitis. A few of group BO (4.5%) had moderate gingivitis. There was no association between gingivitis and oral health practices at week 8 (p = 0.840).

At week 12, 52.9% of group B + CHL had mild gingivitis while 76.2% of group B + WS and 22.7% of group BO had mild gingivitis. Moderate gingivitis was 5.9% in group B + CHL, 4.8% in B + WS and 18.2% in group BO. There was an association between gingivitis and oral health practices (p = 0.011).

Table 2: Relationship between Gingivitis and Oral Health Practices at the Different Post-Miniscrew Time Periods

Characteristic	**Overall**, N = 60[1]	**B + CHL**, N = 17[1]	**B + WS**, N = 21[1]	**BO**, N = 22[1]	**p-value**[2]
GI (day 7)					0.010
Normal	55 (91.7%)	17 (100.0%)	21 (100.0%)	17 (77.3%)	
Mild gingivitis	5 (8.3%)	0 (0.0%)	0 (0.0%)	5 (22.7%)	
Moderate gingivitis	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Severe gingivitis	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
GI (week 4)					0.000
Normal	38 (63.3%)	17 (100.0%)	15 (71.4%)	6 (27.3%)	
Mild gingivitis	20 (33.3%)	0 (0.0%)	6 (28.6%)	14 (63.6%)	
Moderate gingivitis	2 (3.3%)	0 (0.0%)	0 (0.0%)	2 (9.1%)	
Severe gingivitis	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	

Characteristic	**Overall**, N = 60[1]	**B + CHL**, N = 17[1]	**B + WS**, N = 21[1]	**BO**, N = 22[1]	**p-value**[2]
GI (week 8)					0.840
Normal	34 (56.7%)	11 (64.7%)	12 (57.1%)	11 (50.0%)	
Mild gingivitis	25 (41.7%)	6 (35.3%)	9 (42.9%)	10 (45.5%)	
Moderate gingivitis	1 (1.7%)	0 (0.0%)	0 (0.0%)	1 (4.5%)	
Severe gingivitis	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
GI (week 12)					0.011
Normal	23 (39.0%)	7 (41.2%)	4.0 (19.0%)	13 (59.1%)	
Mild gingivitis	30 (50.8%)	9 (52.9%)	16 (76.2%)	5 (22.7%)	
Moderate gingivitis	6 (10.2%)	1 (5.9%)	1 (4.8%)	4 (18.2%)	
Severe gingivitis	0.0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	

[1]n (%)

[2]Fisher's exact test

Table 3 below shows the relationship between oral hygiene practices and TAD mobility at different periods post miniscrew insertion. On Day 7, there was no TAD mobility in each group. There was no association between tad mobility and oral hygiene practices (p = 1.000).

At week 4, there was also no tad mobility in group B + CHL and B + WS while 4.5% of group BO had mobile but still functional miniscrew. There was no association between TAD mobility and oral hygiene practices (p = 1.000).

At week 8, none of group B + CHL had TAD mobility, 4.8% of group B + WS and 4.5% of group BO were mobile but still functional. While 4.5% of group BO miniscrew was lost or in the soft tissue. There was no statistically significant association between TAD mobility and oral health practices at week 8 (p = 1.000).

At week 12 also, none of group B + CHL had mobility while 14.3% of group B + WS and 9.1% of group BO miniscrews were mobile but still functional. There was yet no significant association between TAD mobility and oral health practices at week 12 (p = 0.361).

Table 3: Relationship between TAD Mobility and Oral Health Practices at the Different Post Miniscrew Time Periods

Characteristic	**Overall**, N = 60[1]	**B + CHL**, N = 17[1]	**B + WS**, N = 21[1]	**BO**, N = 22[1]	**p-value**[2]
MOB (day 7)					1.000
No mobility	60 (100.0%)	17 (100.0%)	21 (100.0%)	22 (100.0%)	
Mobile but functional	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Lost or in soft tissue	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
MOB (week 4)					1.000
No mobility	59.0 (98.3%)	17 (100.0%)	21 (100.0%)	21 (95.5%)	
Mobile but functional	1.0 (1.7%)	0 (0.0%)	0 (0.0%)	1 (4.5%)	
Lost or in soft tissue	0.0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
MOB (week 8)					1.000
No mobility	57 (95.0%)	17 (100.0%)	20 (95.2%)	20 (90.9%)	
Mobile but functional	2 (3.3%)	0 (0.0%)	1 (4.8%)	1 (4.5%)	
Lost or in soft tissue	1 (1.7%)	0 (0.0%)	0 (0.0%)	1 (4.5%)	
MOB (week 12)					0.361
No mobility	54 (91.5%)	17 (100.0%)	18 (85.7%)	20 (90.9%)	
Mobile but functional	5 (8.5%)	0 (0.0%)	3 (14.3%)	2 (9.1%)	
Lost or in soft tissue	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	

[1]n (%)

[2]Fisher's exact test

DISCUSSION

Plaque control has been judged the best periodontal health maintenance protocol during the use of orthodontic miniscrew.[25,26] The paucity of studies on human subjects on the effect of various oral hygiene practices on the periodontal health of patients on orthodontic miniscrews has led researchers to ask for studies in this direction.[27]

Healthy peri-implant tissue is a necessary biological barrier to microbes.[15] Tissue inflammation and infection following orthodontic miniscrew placement can lead to peri-implantitis, which has been associated with a 30% increase in miniscrew failure rate. Tissue inflammation, minor infection, and peri-implantitis can occur after miniscrew placement.[13,16]

The present study showed relationships between three different oral hygiene practices and gingivitis around the miniscrew (peri-implantitis). The use of chlorhexidine mouth rinse or warm saline solution alongside the routine brushing twice daily practice showed no superior results in preventing the development of peri-implantitis. These cheap adjuncts although they can downplay inflammation and hence prevent epithelialization around miniscrew head,[28] mechanical plaque removal and antibacterial effects from toothpaste were also effective in preventing peri-implant inflammation. This finding is also contrary to a previous study, with similar recruitment protocol, which showed superior oral hygiene maintenance with chlorhexidine and failure with routine brushing in the maintenance of peri-implant tissue health.[29] The study also recommended the use of other antiseptic mouth rinses like 7.5% povidone-iodine and essential oils as effective mouth rinse

for patients undergoing treatment with miniscrew. However, this study is similar to another study finding by Mohamed et al in 2023 which showed no additional advantage with the use of chlorhexidine mouth rinse.[27] It is essential to remark that the alternate fortnightly discontinuance and resumption of chlorhexidine use by the 3rd group was to avoid potential tooth and tongue staining and altered taste sensation which has been recorded to be the most common adverse effect of prolonged chlorhexidine mouth rinses.[30]

Some other studies emphasized that the high level of motivation of patients to follow home care routines such as the use of electric toothbrushes and flossing is being most important. The use of chitosan-based mouth rinse and professional interventions like diode lasers as adjunctive interventions in the prevention of inflammation around peri-implant tissues for high-risk patients.[29]

There was no significant difference in miniscrew mobility in all groups. This could have been because miniscrews could still be functional in the presence of mild to moderate gingival inflammation. It is properly documented that the success of miniscrews can be influenced by several screw-related factors such as screw thread shape, diameter, length, and primary stability; patient-related factors such as age, cortical bone thickness, age, placement site (ie maxillary or mandibular), vertical skeletal pattern (Frankfort-Mandibular plane angle);[31,32] as well as certain treatment-related factors such as pin type, the magnitude of orthodontic force and mechanics.[33] However, just a failure in the peri-implant health can lead to mobility of miniscrew and overall failure.[34] Premium emphasis was placed on routine morning and night brushing in all study groups which was enough to maintain miniscrew success for the 12 weeks of this study duration.

The study will not be able to address the long-term influence of these oral hygiene measures on mini screws because the design was just for a 12-week duration and miniscrews may be in function for longer durations. Despite limitations, the present study forms a locus for further quantitative and longitudinal studies.

Good oral hygiene practices have been established to have a great influence on the success of orthodontic miniscrew. Findings from this study suggest that routine twice-daily brushing of the mouth (morning and night), produced no significant difference in the overall implant success in peri-implant tissue health and implant stability when compared with adjunctive use of warm saline mouth rinse or chlorhexidine mouth rinse. However, adjunctive use of chlorhexidine and warm-saline mouth rinses can aid in oral hygiene optimization.

Therefore, a strict routine of twice-daily brushing post-insertion of miniscrews is enough to maintain oral hygiene and achieve implant success for a well-motivated orthodontic patient who receives orthodontic miniscrews**.**

REFERENCES

1. Reynders R, Ronchi L, Bipat S. Miniscrews in orthodontics: a systematic review of the literature. Am J Orthod Dentofacial Orthop 2009; 135:564.e1–564.e19.
2. Crismani AG, Bertl MH, Celar AG, Bantleon HP, Burstone CJ. Miniscrews in orthodontic treatment: review and analysis of published clinical trials. Am J Orthod Dentofacial Orthop 2010; 137:108-113.
3. Lee J, Miyazawa K, Tabuchi M, Sato T, Kawaguchi M, Goto S, et al. Effectiveness of en-masse retraction using midpalatal miniscrews and a modified transpalatal arch: Treatment duration and dentoskeletal changes. Korean J Orthod 2014; 44:88-95.
4. Arai C, Choi JW, Nakaoka K, Hamada Y, Nakamura Y. Management of open

bite that developed during treatment for internal derangement and osteoarthritis of the temporomandibular joint. Korean J Orthod 2015; 45:136-45.

5. Kim TW, Kim H, Lee SJ. Correction of deep overbite and gummy smile by using a mini-implant with a segmented wire in a growing class II division 2 patient. Am J Orthod Dentofacial Orthop 2006; 130:676-85.
6. Kocsis A, Seres L. Orthodontic screws to extrude impacted maxillary canines. J Orofac Orthop 2012; 73:19-27.
7. Gurdán Z, Szalma J. Evaluation of the success and complication rates of self-drilling orthodontic mini-implants. Niger J Clin Pract 2018; 21:546-552.
8. Inchingolo AD, Ferrara I, Viapiano F, Netti A, Campanelli M, Buongiorno S, et al. Rapid Maxillary Expansion on the Adolescent Patient: Systematic Review and Case Report. Children 2022; 9(7):1046.
9. Umemori M, Sugawara J, Mitani H, et al. Application of caps with brackets to titanium screws for stationary anchorage in edgewise treatment. Orthodontic waves : J Jap Ortho Soc. 1999; 60:409–413.
10. Crismani AG, Bertl MH, Čelar AG, et al. Miniscrews in orthodontic treatment: review and analysis of published clinical trials. Am J Orthod Dentofacial Orthop 2010; 137:108–113.
11. Sarul M, Lis J, Park HS, et al. Evidence-based selection of orthodontic miniscrews, increasing their success rate in the mandibular buccal shelf. A randomized, prospective clinical trial. BMC Oral Health 2022; 22:414.
12. Stanford N. Mini-screws success rates sufficient for orthodontic treatment. Evid Based Dent 2011; 12:19.
13. Miyawaki S, Koyama I, Inoue M, et al. Factors associated with the stability of titanium screws placed in the posterior region for orthodontic anchorage. Am J Ortho Dentofacial Orthop. 2003; 124:373–378.

14. Antoszewska J, Papadopoulos MA, Park HS, Ludwig B. Five-year experience with orthodontic miniscrew implants: a retrospective investigation of factors influencing success rates. Am J Orthod Dentofacial Orthop 2009; 136:158-160.
15. Sanchez-Garces MA, Gay-Escoda C. Peri-implantitis. Med Oral Patol Oral Cir Bucal 2004;9(1):63-9.
16. Costa A, Pasta G, Bergamaschi G. Intraoral hard and soft tissue depths for temporary anchorage devices. Semin Orthod 2005; 11:10-15.
17. Sanz M, Chapple IL, Working Group 4 of the VEWoP. Clinical research on peri-implant diseases: consensus report of Working Group 4. J Clin Periodontol. 2012; 39(12):202–206.
18. Lo Giudice A, Rustico L, Longo M, Oteri G, Papadopoulos MA, Nucera R. Complications reported with the use of orthodontic miniscrews: A systematic review. Korean J Orthod. 2021; 51:199-216.
19. Heidemann W, Terheyden H, Gerlach KL. Analysis of the osseous/metal interface of drill free screws and self-tapping screws. *J Craniomaxillofac Surg.* 2001;29(2):69–74.
20. Nosouhian S, Rismanchian M, Sabzian R, Shadmehr E, Badrian H, Davoudi A. A Mini-review on the Effect of Mini-implants on Contemporary Orthodontic Science. J Int Oral Health. 2015; 7(1):83-7.
21. Vicioni-Marques F, Diego Jesus Brandariz Pimentel, Mírian Aiko Nakane Matsumoto, Maria Bernadete Sasso Stuani, Fábio Lourenço Romano∗, Orthodontic mini-implants: clinical and peri-implant evaluation, J World Fed Orthod. 2021; 21(42):1-7.
22. Pan CY, Liu PH, Tseng YC, Chou ST, Wu CY, Chang HP. Effects of cortical bone thickness and trabecular bone density on primary stability of orthodontic mini-implants. J Dent Sci 2019; 14:383–388.

23. Baumgaertel S, Palomo JM, Zaverdinos M, Elshebiny T. Ten years of miniscrew use in a U.S. orthodontic residency program. Am J Orthod Dentofacial Orthop 2020; 158:834–839.
24. Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A.. G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behave Res Method. 2007; 39:175-191.
25. Dersot, J. M. Le contrôle de plaque, un élément essentiel du succès du traitement orthodontique. Orthod F. 2010; 81:33–39
26. Nassar, P. O. , Bombardelli, C. G. , Walker, C. S. , Neves, K. V. , Tonet, K. , Nishi, R. N., et al. A. Periodontal evaluation of different toothbrushing techniques in patients with fixed orthodontic appliances. *Dental Press J Orthod*. 2013;18:76–80
27. Mohamed, A. , Wafaie, K. , Mohammed, H. , Mohamed, A. M. A. , Xinrui, W. , Vandevska-Radunovic, V., et al. Effect of chlorhexidine mouthwash on gingival health around orthodontic miniscrew implants: A pilot placebo-controlled randomized trial. *Ortho Crainof Res*, 2023: 26(2):163–170.
28. Favero M, Araujo M, da Silva D, de Almeida R. Maintaining hygiene in orthodontic miniscrews: patient management and protocols—a literature review. Dent J. 2024, *12*, 227.
29. Akbulut Y. The effects of different antiseptic mouthwash on microbiota around orthodontic mini-screw. Niger J Clin Pract 2020; 23:1507–1513
30. Deus M, Santos L, Lima A, Vieira A. Chlorhexidine in dentistry: pharmacology, uses, and adverse effects. Int Dent J. 2022; 72(3):269–177.
31. 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. Clin Oral Implants Res 2007;18:768–775 .

32. 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; 19:100-106.
33. Jing Z, Wu Y, Jiang W, Zhao L, Jing D, Zhang N, et al. Factors affecting the clinical success rate of miniscrew implants for orthodontic treatment. Int J Oral Maxillofac Implants. 2016; 31(4):835–841.
34. Pithon MM , Santos MJ , Ribeiro MC , et al. Patients' perception of installation, use and results of orthodontic mini-implants. Acta Odontol Latinoam 2015; 28:108–112.