Journal of Research in Medical and Dental Science
2023, Volume 11, Issue 9, Page No: 25-34

Available Online at: www.jrmds.in
eISSN No. 2347-2367: pISSN No. 2347-2545

Orthodontic Implant Stability and Its Dependency on Screw Diameter and Insertion Depth: A Comprehensive Study

Waleed Shallal*, Aseel Niema Hafith, Bakir Ghanem Murrad

Department of Dentistry, Kut University College, Kut, Wasit, Iraq

ABSTRACT

Objective: This study delves into the stability of orthodontic implants with a specific focus on how screw diameter and insertion depth impact the insertion torque, oral vitality, and pain perception.

Material and Methods: A cohort of 64 patients participated in this comprehensive investigation. Orthodontic implants were meticulously positioned at varying depths after predrilling holes of differing diameters. The insertion torque was meticulously measured to rigorously assess implant stability. A subset of these implants served as indicators for quantifying the necessary adjustments to accommodate local variations in bone quality.

Results: The findings of this study uncovered a profound correlation between insertion torque and stability scores, as well as their implications for oral vitality and pain perception (p<0.001). Notably, both insertion depth and the diameter of the predrilled holes demonstrated distinct influences on the measured insertion torque.

Conclusion: Heightened insertion depths yielded increased insertion torque, thereby enhancing implant stability. Conversely, larger predrilled whole diameters led to a reduced requirement for insertion torque. This equilibrium between these variables proved instrumental in preserving oral vitality and maintaining consistent levels of patient comfort

Key words: Orthodontics, Implant stability, Insertion depth, Pain perception, Oral vitality

HOW TO CITE THIS ARTICLE: Waleed Shallal, Aseel Niema Hafith, Bakir Ghanem Murrad, Orthodontic Implant Stability and Its Dependency on Screw Diameter and Insertion Depth: A Comprehensive Study, J Res Med Dent Sci, 2023, 11(9):25-34.

Corresponding author: Waleed Shallal
e-mail✉: dr.waleedkut@gmail.com
Received: 28–August–2023, Manuscript No. jrmds-23-114517;
Editor assigned: 31–August-2023, PreQC No. jrmds-23-114517(PQ);
Reviewed: 14–September-2023, QC No. jrmds-23-114517(Q);
Revised: 18–September-2023, Manuscript No. jrmds-23-114517(R);
Published: 25–September-2023

INTRODUCTION

Orthodontics has witnessed a transformative evolution with the growing adoption of small dental implants, opening new horizons for previously unattainable tooth corrections. This innovative approach shows great promise, yet its overall clinical success remains complex and challenging. Mini-implants have reported success rates ranging from an impressive 97% to a remarkable 100%, underscoring their potential in orthodontics. However, temporary anchoring devices, including mini-implants, exhibit success rates within a broad range of 75% to 91%, reflecting the multifaceted nature of the challenge at hand [1-3]. It is essential to recognize that numerous factors impact the performance of orthodontic implants, with insertion torque emerging as a crucial determinant. High-impact clinical investigations, boasting success rates between 95% and 99%, have highlighted the centrality of torque in this regard. Notably, these clinical studies are intricately linked with factors such as bone quality, cortical bone thickness, implant design, and the critical preparatory step known as predrilling. Predrilling is indispensable for implant threads that do not self-prepare drill holes. The nuanced interplay between these influential factors and the primary stability of orthodontic implants directly affects clinical success and the survival of orthodontic treatments [4-6].

In the realm of dental implantology, primary stability, which refers to an implant's stability immediately post-insertion, is a critical consideration. It is noteworthy that the length and predrilling depth in spongy bone do not exert a direct influence on insertion torques. However, studies suggest that applying an insertion force within the range of 5 to 10 Ncm to 1.6-millimeter mini-implants may mitigate the risk of failure. Exceeding these values could increase the risk of failure, potentially due to site compression with micro damages or the fracture of a mini-implant. This complex interplay, influenced by unique bone compression effects, underscores the importance of understanding the factors that directly affect primary stability and insertion torque. Therefore, adapting clinical procedures to optimize insertion torque becomes a paramount consideration [7-9]. The link between primary stability and insertion torque is unequivocal, yet the precise influence of mini-implant insertion depth on insertion torque remains an intriguing and uncharted territory, adding a new layer of complexity to the existing body of knowledge [10,11]. Selecting the right anatomical locations for anchorage is of paramount importance for the success of orthodontic interventions. Given that one of the fundamental definitions of anchoring pertains to the prevention of tooth displacement, it is evident that the effectiveness of this role significantly impacts the orthodontic process [12].

In conventional orthodontic therapy, external appliances are frequently employed for anchorage. However, these approaches necessitate active patient involvement, are prone to anchor loss, potentially affect esthetic considerations, and may lead to undesirable tooth wear. In contrast, mini-screws have emerged as a popular and efficient alternative for temporary anchoring. These screws are characterized by dimensions ranging from 6 to 12 mm in length and 1.4 to 2.5 mm in diameter. Their utilization offers swift and straightforward implantation and removal procedures, particularly in cases of osseointegration failure. It is worth noting that self-tapping mini-screws necessitate predrilling before insertion, whereas self-drilling mini-screws obviate this requirement [13].

These versatile mini-screws hold a range of benefits, making them valuable across various therapeutic contexts. Their utility extends to addressing challenges such as mass molar retraction, intrusion, open and deep bite correction, and the treatment of deep bites. Notably, they have been instrumental in expediting treatment timelines when managing impacted canine teeth using skeletal anchoring, significantly reducing challenges and treatment duration. However, despite the many advantages and ease of use associated with mini-screws, they are not immune to occasional failures. Potential complications encompass injuries to the tooth roots surrounding the screw, as well as screw loosening or breakage, with the added concern of inflammation in the surrounding area [14].

This study endeavors to provide insights into the success rate of mini-screws within a clinical orthodontic practice by employing a retrospective research approach. The primary focus of this research is to unravel the intricate relationships between screw diameter, insertion depth, and insertion torque, illuminating the pivotal determinants of orthodontic implant stability and, ultimately, the success of orthodontic treatments [15].

MATERIALS AND METHODS

Study Participants

A cohort of 64 orthodontic patients (33 males and 31 females) was recruited from specialized dental clinics in Baghdad City under the supervision of the Department of Dentistry at Alkut College University. These patients had undergone orthodontic treatment involving orthodontic appliances and mini-implants between November 2017 and November 2018.

Predrilling Procedure

Predrilling was conducted using drills of 0.5 mm, 1 mm, and 1.5 mm diameters sourced from the Dual Top system. The predrilling depths were consistently set at 3 millimeters. The chosen mini-implant for this study was the Dual Top Screw, measuring 1.5-8 mm. The insertion depth was adjusted manually until the gap between the bone and mini-implant collar reached 0.7 mm, 1.5 mm, or 2.5 mm, as required. This combination of insertion depth and predrilling diameter was replicated 24 times. To evaluate the compatibility of bone segments, five Dual Top Screws measuring 1.5 mm by 8 mm were inserted into each bone segment. A final 0.3 mm of screwing was applied to reach the predetermined insertion depth.

Ethical Considerations

An assessment of patient experiences related to orthodontic mini-implant insertion was conducted using a questionnaire administered before and after the procedure. The study protocol and informed consent forms were approved by the Ethical Committee of the Department of Dentistry at Alkut College University. Patients and their parents provided informed consent after receiving comprehensive information about the study.

Inclusion Criteria

Eligible participants required orthodontic treatment involving fixed appliances and orthodontic mini-implants for anchoring reinforcement. Additionally, patients needed to have achieved permanent occlusion. Exclusions encompassed individuals with craniofacial anomalies, those unable to complete the questionnaire, and those who had completed orthodontic treatment.

Stability Assessment

The stability of mini-implants and any instances of failure were documented during patient visits. Inflammatory criteria were assessed using the gingival index, a scale ranging from 0 (absence of inflammation) to 3 (severe inflammation) based on observations of redness, swelling, and bleeding.

Pain and Discomfort Evaluation

Patients used a Visual Analog Scale (VAS) to self-report their pain levels. The VAS consisted of an 11-point numeric scale for precise pain assessment.

Statistical Analysis

Data analysis involved the use of Graph Pad Prism version 7 and SPSS version 24. Descriptive statistics were computed and presented, with statistical significance set at a p-value of less than 0.05.

RESULTS

Demographic Profile of the Study Participants

The study's outcomes highlighted distinct age distributions between male and female participants, with ages ranging from 20 to 47 years old (Table 1). Further demographic stratification by gender revealed that the study encompassed a total of (31 ± 1.37) females and (33 ± 1.62) males.

Correlated of Gender with Pain Degree.

The statistical analysis of our study revealed that there is no statistically significant association between the intensity of pain and an individual's gender (p-value = 0.98). We observed that the majority of male participants were assigned to degree 1, while most female participants fell within degree 2, as indicated in (Table 2, Figure 1, and Table 3).

Degree.

Correlation of Pain Degree and Oral health Scores in this Research

The oral health scores were categorized into four levels (1, 2, 3, and 4), with the highest score representing the best oral health (4), and the lowest score indicating poor oral health (1). Similarly, the pain degrees were classified into four categories (1, 2, 3, 4), with the highest degree corresponding to the mildest pain (4), and the lowest degree representing severe pain (1).

Correlations between these two variables were assessed for each patient in the study. The statistical analysis revealed that a score of 4 was most frequently associated with pain degree 1, and less common in pain degrees 2, 3, and 4,

Table 1: distribution of samples according to gender and age.

		Age													Total
		20	21	23	24	27	28	29	34	35	36	37	46	47	
Gender	F	1	2	3	1	0	2	2	7	5	2	2	1	3	31
	M	3	2	1	3	4	2	2	1	3	2	2	7	1	33
Total		4	4	4	4	4	4	4	8	8	4	4	8	4	64

Table 2: Correlated of gender with pain degree.

		Gender		Total
		F	**M**	
Pain degree	1	14	8	22
	2	9	13	22
	3	5	9	14
	4	3	3	6
Total		31	33	64

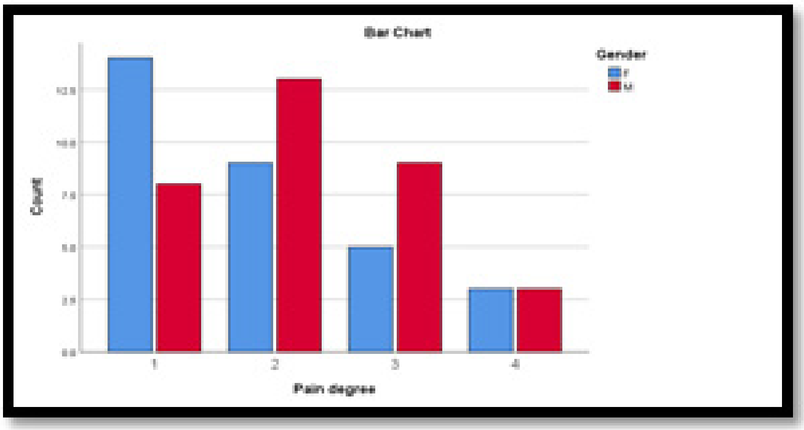

Figure 1: Correlated of Gender with Pain Degree.

Table 3: Statistics of Samples according to Gender and Age.

	Gender			Statistic	Std. Error
	F	Mean		32.74	1.373
		95% Confidence Interval for Mean	Lower Bound	29.94	
			Upper Bound	35.54	
		5% Trimmed Mean		32.64	
		Median		34	
		Variance		58.398	
		Std. Deviation		7.642	
		Minimum		20	
		Maximum		47	
		Range		27	
		Interquartile Range		8	
		Skewness		0.18	0.421
Age		Kurtosis		-0.286	0.821
	M	Mean		32.52	1.628
		95% Confidence Interval for Mean	Lower Bound	29.2	
			Upper Bound	35.83	
		5% Trimmed Mean		32.43	
		Median		29	
		Variance		87.445	
		Std. Deviation		9.351	
		Minimum		20	
		Maximum		47	
		Range		27	
		Interquartile Range		18	
		Skewness		0.323	0.409
		Kurtosis		-1.261	0.798

with a highly significant p-value of < 0.0001, as presented in Table 4 and Figures 2, 3.

Correlation of pain degree and stability in this research

The stability scores were categorized into five levels (1, 2, 3, 4, 5), with the highest score representing the best stability (5), and the lowest score indicating poor stability (1). Similarly, the pain degrees were classified into four categories (1, 2, 3, 4), with the highest degree corresponding to the mildest pain (4), and the lowest degree representing severe pain (1).

The correlation between these two variables was assessed for each patient in this study. The statistical analysis revealed that scores 4 and 5 were most frequently associated with pain degrees 1 and 2, and less common in pain degrees 4, 3, and 2, with a highly significant p-value of < 0.001, as presented in (Table 5 and Figures 4, 5).

Predrilling Orthodontic Mini-Implants

From the Dual Top system, drills with diameters of 0.5 mm and 1 mm, in addition to a drill with a diameter of 1.5 mm. The predrilling depths

Table 4: Correlation of pain degree and Oral health scores.

		Oral Health				Total
		1	2	3	4	
Pain degree	1	11	3	5	3	22
	2	7	8	3	4	22
	3	2	4	4	4	14
	4	1	2	2	1	6
Total		21	17	14	12	64

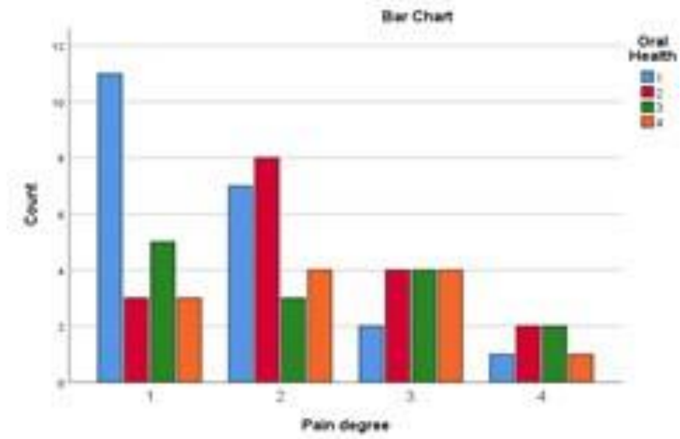

Figure 2: Correlation of pain degree and Oral health scores.

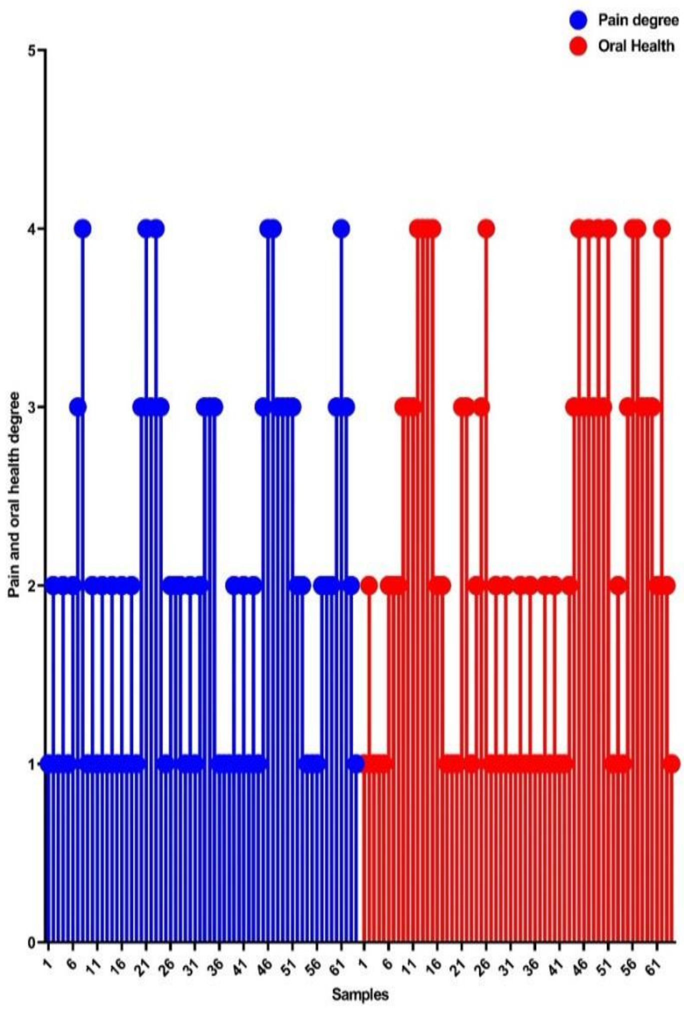

Figure 3: Map in the Correlation of pain degree and Oral health scores.

Table 5: Correlation of pain degree and stability in this research.

		Stability					Total
		1	2	3	4	5	
Pain degree	1	1	3	5	7	6	22
	2	0	4	8	4	6	22
	3	1	2	3	6	2	14
	4	1	0	1	3	1	6
Total		3	9	17	20	15	64

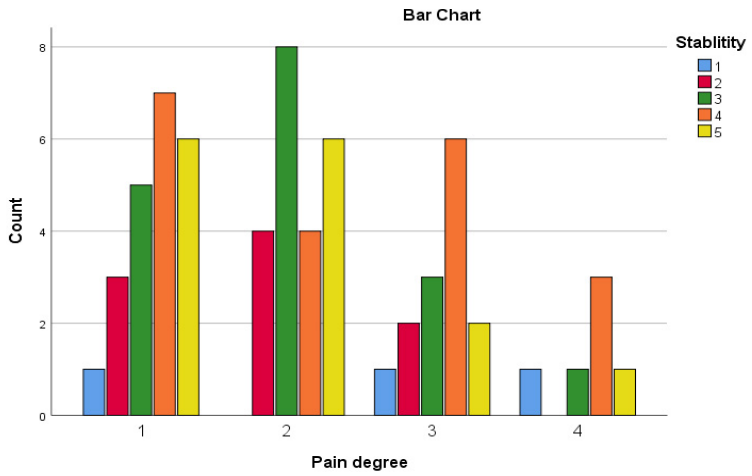

Figure 4: Correlation of pain degree and stability in this research.

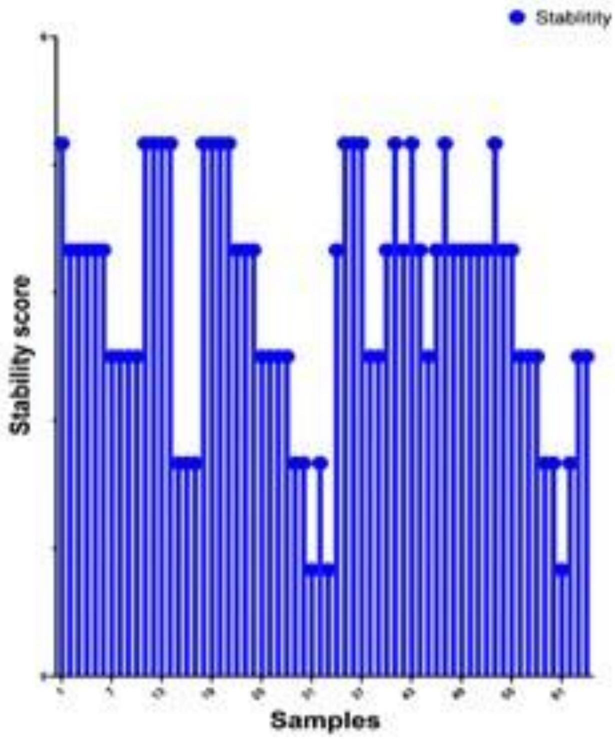

Figure 5: Map in the Correlation of pain degree and stability in this research.

were adjusted to a value of three millimeters throughout the process (Figure 6).

The Dual Top Screw, which ranges in size from 1.5-8 mm, was decided to be the best option for the mini-implant role. Before taking the measurement, the implants were placed manually using a portable screwdriver until the distance between the upper and the mini-implant collar reached either 0.7 mm, 1.5 mm, or 2.5 mm, depending on the value that was wanted. A total of twenty-four separate

Figure 6: Drilling Orthodontic Mini-Implants (Screws with dimensions of 0.7 millimeters) for patient no 20.

Figure 7: Predrilling orthodontic mini-implants (Screws with dimensions of 1.5 millimeters) for patient no. 6.

Figure 8: Drilling Orthodontic Mini-Implants (Screws with dimensions of 2 millimeters) for patient no. 7.

Figure 9: Drilling Orthodontic Mini-Implants (Screws with dimensions of 2.5 millimeters) for patient no. 20.

tests were performed, one for each conceivable combination of insertion depth and predrilling diameter. Five Dual Top Screws with dimensions of 1.5 millimeters by 8 millimeters were inserted into each mandible segment so that a point of reference could be established for establishing whether or not two bone segments are compatible with one another. After that, continue tightening the screws by another 0.3 mm all the way up to the designated insertion depth (Figures 7-11).

Figure 10: Drilling Orthodontic Mini-Implants (Screws with dimensions of 2.5 millimeters) for patient no. 20.

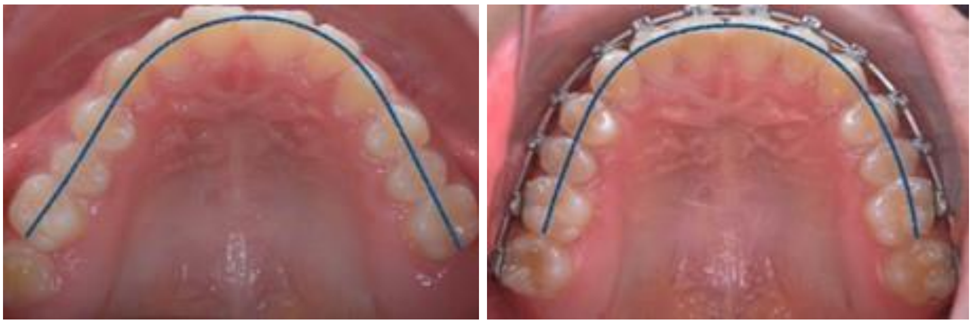

Figure 11: A) Oral health appearance and stability before treatment. B) Oral health appearance and stability after treatment.

DISCUSSION

Clinical success in orthodontic mini-implants relies on various factors, including implant location, type, and implantation procedure. This study aimed to assess the wide spectrum of reported success rates and their determinants.

Mini-implants have proven instrumental in anchoring orthodontic treatments, which is corroborated by their survival and efficacy rates. To ensure positive outcomes, it is crucial to consider several variables, such as the insertion site. Research indicates that more screws tend to dislodge when placed in non-keratinized mucosa. Additionally, screws located in the buccal surface of the alveolar process have been associated with inflammation, mirroring our own findings. This inflammation is often linked to muscular forces, with labial components being particularly susceptible due to exposure and varied gingiva attachment. However, in cases with tight palate mucosa, smaller screws can function effectively.

Our study revealed that approximately 5% of orthodontic mini-implants experienced dislodgement. It's worth noting that 14% of buccal anchoring screws exhibited loosening. Clinical studies by Lee et al. underscored the importance of keratinized soft tissue and thin bone, allowing for smoother insertion and improved patient comfort. The thickness of the cortical bone plays a pivotal role in overall stability, with mini-screws having lower success rates when anchored in thinner cortical bone. Utilizing Computed Tomography (CT) for precise diagnosis can aid in determining ideal placement and assessing bone thickness.

In our study, we observed that the likelihood of screw loss was higher in the narrower buccal fold, whereas palate cortical thickness typically provided optimal stability with comparable inflammation rates in both areas. Further research conducted by Motoyoshi and colleagues involved mini-screws subjected to orthodontic force. The timing of force application appeared to significantly impact treatment outcomes, with adolescents experiencing suboptimal results if subjected to force load within two months. In contrast, the treatment improved markedly after three months.

Screws used for similar therapy, loaded immediately, exhibited a 77% success rate. However, these anchoring instruments had to be retrieved in nearly 20% of cases when a distalization occurred due to screw dislodgement [16]. Recent advancements have led to the development of similar mini-screws for intrusions, with buccal and palatal placements resulting in greater screw movement during intrusions than extrusions.

The healing period before loading an implant remains a subject of debate, with research showing an 88% success rate for small titanium screws used as orthodontic anchors for canines after four weeks [17, 18]. Torsion fractures may occur if titanium implants are placed too closely together. Mini-screws can withstand quick loads without issues, but the choice of power can affect their stability [19]. It is evident that pre-drilling mini-screws enhances stability [20].

Temperature plays a crucial role, with intraosseous temperatures decreasing to 7.6°C when mini-screws are chilled to 1°C [21]. Mechanical stability, rather than diameter or length, is a key factor in mini-screw stability. While some advocate for longer mini-screws to improve system stability, caution should be exercised to prevent root damage [22]. In this study, mini-screws ranging from 0.7 to 2.5 mm proved effective [23].

Pan et al. conducted research on 2.5-mm screws, with oscillation monitoring screw resonance post-insertion. Despite data suggesting that 10-12 mm titanium screws have a diameter of 2.26 mm, deeper insertion consistently improves stability by reducing stress and tilting strains [24]. In our study, the Screw System Dual Top from Jeil, Korea, demonstrated greater sturdiness compared to Tomas Pin (1.5 mm, 8–10 mm) [25-29]. The intranasal cylinder also contributed to improved Twin Top screw performance. Additionally, employing drill sizes smaller by 0.5 mm than the implants helps minimize screw fractures and bone tension [30].

In summary, this discussion has delved into the multifaceted considerations associated with mini-implants in orthodontic treatments. Location, type, and implantation technique are pivotal in achieving clinical success. As highlighted by various studies and our own findings, the choice of insertion site, the quality of soft and hard tissues, and factors like insertion depth and temperature can profoundly influence stability. These insights provide valuable guidance for clinicians and researchers in optimizing orthodontic mini-implant treatments [31].

CONCLUSION

Our study offers valuable insights into the critical factors influencing the success of orthodontic implants. The positive correlation between insertion depth and torque highlights the importance of achieving optimal primary stability, which is pivotal for successful outcomes. Furthermore, the inverse relationship between predrilling hole diameter and insertion torque underscores the need for careful consideration of these parameters during implantation procedures. This equilibrium in stability not only preserves oral vitality but also ensures a consistent pain experience for patients. These findings have significant implications for orthodontic practice, emphasizing the need for precise planning and execution to enhance clinical success rates. Further research in this area will contribute to a deeper understanding of orthodontic implant stability and its impact on patient outcomes.

REFERENCES

1. Motro M, Will LA. Success with TADs: Evidence and Experience. TAD 2020; 747-55.
2. Baumgaertel S. Drei Top-Indikationen für den Einsatz kieferorthopädischer Minischrauben. Inf Ortho Kie 2020; 52:197-202.
3. Tang Z, Gao Y, Chen Y, et al. Development of a Systematic Course On Orthodontic Temporary Anchorage Devices (TADs) for Orthodontic Residency Program. 2021.
4. Camci H. Vakaya Uygun Mini Vida Seçimi. Turk Klin J 2017; 23.
5. Alanli İA. Mandibular ark distalizasyonunda kullanılan ortodontik minivida ve ramal plak ankrajının dental etkilerinin sonlu elemanlar analizi ile değerlendirilmesi.
6. Jaradat M, Al Omari S. Orthodontic Mini Implants, an Update. EC Dent Sci 2021; 20:107-16.
7. Giudice AL, Rustico L, Longo M, et al. Complications reported with the use of orthodontic miniscrews: A systematic review. Korean J Orthod 2021; 51:199-216.
8. Romero-Delmastro AA, Kadioglu O, Currier GF. Considerations for the Placement of TADs. TAD 2020; 83-9.
9. Lee JS, Kim JK, Park YC, et al. Orthodontic Mini-Implants. 2007.
10. Van Sant LA. Survey Of Canadian Orthodontists Regarding Orthodontic Miniscrew Usage.
11. Nandini K. Evaluation of Factors Influencing the Placement of Mini Implants in Infrazygomatic Crest Region. 2020.
12. Varghese KG, Sreela LS, Peter E, et al. Journal of Clinical Dentistry. J Clin Dent 2010; 1.
13. Paolo A, Luca B, Alessandro M, et al. Smiling to rheumatoid arthritis: how an appropriate diagnostic iter can allow to treat orthodontic and gnathologic problems. J Osseointegration 2017; 9:112-138.

14. Ghorbanyjavadpour F, Kazemi P, Moradinezhad M, et al. Distribution and amount of stresses caused by insertion or removal of orthodontic miniscrews into the maxillary bone: A finite element analysis. Int Orthod 2019; 17:758-68.

15. Kunihiro T, Oba T. Endoscopic sinus surgery for otolaryngological complications associated with dental and oral surgical treatment: A report of three illustrative cases. 2013; 6:205-213.

16. Craig JR, Tataryn RW, Sibley HC, et al. Expected costs of primary dental treatments and endoscopic sinus surgery for odontogenic sinusitis. Laryngoscope 2022; 132:1346-55.

17. Abusamaan M, Giannobile WV, Jhawar P, et al. Swallowed and aspirated dental prostheses and instruments in clinical dental practice: A report of five cases and a proposed management algorithm. J Am Dent Assoc 2014; 145:459-63.

18. Kitamura A. Removal of a migrated dental implant from a maxillary sinus by transnasal endoscopy. Br J Oral Maxillofac Surg 2007; 45:410-1.

19. Hajiioannou J, Koudounarakis E, Alexopoulos K, et al. Maxillary sinusitis of dental origin due to oroantral fistula, treated by endoscopic sinus surgery and primary fistula closure. J Laryngol Otol 2010; 124:986-9.

20. Gâta A, Toader C, Valean D, et al. Role of endoscopic sinus surgery and dental treatment in the management of odontogenic sinusitis due to endodontic disease and oroantral fistula. J Clin Med 2021; 10:2712.

21. Costa F, Emanuelli E, Robiony M, et al. Endoscopic surgical treatment of chronic maxillary sinusitis of dental origin. J Oral Maxillofac Surg 2007; 65:223-8.

22. Ramotar H, Jaberoo MC, Ng NK, et al. Image-guided, endoscopic removal of migrated titanium dental implants from maxillary sinus: Two cases. J Laryngol Otol 2010; 124:433-6.

23. Little RE, Long CM, Loehrl TA, et al. Odontogenic sinusitis: A review of the current literature. Laryngoscope Investig Otolaryngol 2018; 3:110-4.

24. Mattos JL, Ferguson BJ, Lee S. Predictive factors in patients undergoing endoscopic sinus surgery for odontogenic sinusitis. Int Forum Allergy Rhinol 2016; 6:697-700.

25. Akiyama K, Nakai Y, Samukawa Y, et al. Assessment of simultaneous surgery for odontogenic sinusitis: endoscopic sinus surgery with endoscopic apicoectomy. J Craniofac Surg 2019; 30:239-43.

26. Hernandez-Divers SJ. Clinical technique: Dental endoscopy of rabbits and rodents. J Exot Pet Med 2008; 17:87-92.

27. Li Z, Yao S, Xu J, et al. Endoscopic near-infrared dental imaging with indocyanine green: A pilot study. Ann N Y Acad Sci 2018; 1421:88-96.

28. Li ZS, Sun ZX, Zou DW, et al. Endoscopic management of foreign bodies in the upper-GI tract: experience with 1088 cases in China. Gastrointest Endosc 2006; 64:485-92.

29. Pagella F, Emanuelli E, Castelnuovo P. Endoscopic extraction of a metal foreign body from the maxillary sinus. Laryngoscope 1999; 109:339-42.

30. Fusetti S, Emanuelli E, Ghirotto C, et al. Chronic oroantral fistula: Combined endoscopic and intraoral approach under local anesthesia. Am J Otolaryngol 2013; 34:323-6.

31. Osborn JB, Lenton PA, Lunos SA, et al. Endoscopic *vs.* tactile evaluation of subgingival calculus. ADHA 2014; 88:229-36.