Advanced Medical Journal, Vol.11, No.2, P.10-16,2026 https://doi.org/10.56056/amj.2026.452

Effects of Implant Length and Diameter on Implant Primary Stability in Different Bone Types

Heshw Hiwa Ibrahim* Kawan Salahaddin Othman**

Abstract

Background and Objectives: Dental implants have revolutionized oral rehabilitation. Primary implant stability (PIS) of dental implants is influenced by several factors, including bone quality, implant length and diameter. The reason for this research is to assess the correlation between (PIS) and implant dimensions (diameter and length) in relation to various bone types.

Methods: In a cross-sectional observational study, 41 dental implants with different diameters and lengths were inserted into bones with different densities. Implant beds were prepared, and (PIS)was assessed using a novel damping capacity measurement device (AnyCheck) at the time of implant insertion.

Results: Implants with a wider diameter exhibit a mean stability of 69.33 compared to a mean stability of 65 for implants with a narrower diameter. The disparity between these groups was statistically significant, with a p-value of 0.036, and longer implants exhibited greater stability, with a mean value of 70.79, compared to shorter implants, had a mean stability of 64.68. This difference was significant within statistical parameters, with a p-value of 0.018, Regarding bone quality, implants with good bone quality exhibited a mean stability of 69.6 compared to 67.43 for implants with poor bone quality, this observed difference did not reach statistical significance with a p- value of 0.82, with a 95%confidence interval.

Conclusions: The findings indicate that increasing implant length and diameter significantly enhances (PIS), while bone quality did not significantly improved stability, underscoring the critical role of implant dimensions in achieving better treatment outcomes.

Key words: Bone Density, Dental Implants, Implant Geometry, Implant Primary Stability, Osseointigration

*BDS, Restorative Dentistry, Sulaimani Center, Corresponded author: E-mail: heshwbraim@gmail.com
**BDS, MSc, PhD Assistant. Prof., Department of Prosthodontic, College of Dentistry, University of Sulaimani. E-mail: Kawan.othman@univsul.edu.iq

Introduction

The field of clinical dentistry has expanded significantly with the science of dental implantology which became a key solution for restoring oral function in patients with complete or partial tooth loss. For both fixed and removable prostheses, the durability and reliability of dental implants over time have been extensively studied.[1,2] Osseointegration is defined as "the apparent direct attachment or connection of osseous tissue to an inert, alloplastic material without intervening fibrous connective tissue.[3] The absence of bone base movement in the axial, lateral, and rotational planes right after implant placement is known as PIS.[4,5] PIS is one of the factors that influences the long- term survival of implants and the success of osseointegration, or its biometric stability immediately following insertion into the bone.[4,6] The length, diameter, type of implants, amount and bone quality, the surgical procedure; and the size of the osteotomy in relation to the implant's diameter all play a role in implant primary stability.[4,7] Often, dental implants come in a range of lengths from 6 mm to 20 mm. Since they approximately resemble the length of natural roots, 8mm to 15 mm implants are the most widely used sizes in dentistry.[8,9] A normal- length implant is defined as the minimum implant length necessary to achieve consistent success, typically considered to range between 8- and 10-mm.[10] Many research investigations demonstrate that increasing the implant length substantially aids in reducing bone stress and enhancing implant stability in poor bone quality, such as type IV bone.[11] The success rate of dental implant placement can be increased in high-quality bone by providing primary initial stability, promoting effective osseointegration during the healing process, and ensuring a more secure implant foundation.[12] The jawbone structure is composed of two separate layers: an inner layer of porous cancellous bone with trabecular structures and an outer layer of dense cortical bone.[13] Misch2 categorized bones as D1 to D4 based on how resistant they were to drilling. Furthermore, Misch suggested the use of computed tomography (CT) for the objective assessment of bone density measures in Hounsfield units (HU).[14] The objective of this study is to find out the effects of implant length and diameter on PIS and to identify the effect of bone type on primary implant stability.

Patients and method

In this cross-sectional observational study, 41 dental implants of various diameters and lengths were placed different in bone densities. The study duration was 8 months from January 2024, carried out at Shorsh Teaching Dental Center in Sulaimani City. The surgical procedures were performed by a single surgeon, employing consistent surgical techniques and equipment to minimize errors associated with different operators. A total of 30 participants took part in the study, comprising 10 males and 20 females, all aged between 30 and 60 years. The preparation of implant beds followed the specific guidelines provided by the manufacturer. To assess the PIS during their insertion, a novel device known as the Any Check was utilized, which measures PIS. The Implant Stability Quotient (ISQ), which ranges from 0 to 100 and is used to measure implant stability index, reflects greater stability and improved osseointegration with higher values. Preparation protocols varied based on implant size and standard techniques for implant bed preparation, emphasizing proper drilling methods. Precautions were taken to prevent overheating of bone tissue during drilling. Patients were selected as a candidates in our research, included patient criteria are (medical clearance for implant therapy ,sufficient bone volume at intended sites ,maintained oral hygiene standard) while excluded patient criteria are(

https://doi.org/10.56056/amj.2026.452


inadequate oral hygiene, insufficient bone volume minimum requirements:8mm length and 3mm diameter , insertion torque below 25N/cm significant osseous defect, uncontrolled diabetes, immunocompromised status, coagulat ion disorders , history of radiation /chemotherapy, pregnancy). The preoperative analysis comprises a thorough review of the patient's complete medical history, followed by a comprehensive clinical examination. This is supplemented by clinical photographs that document the state of the patient. Subsequently, all participants underwent Cone Beam Computed Tomography (CBCT) to ensure consistency across the study. A designated radiography center, along with a qualified radiologist, was engaged to meticulously interpret and report the radiographic data, specifically focusing on the assessment of bone volume and the bone density classification (D1, D2, D3, D4). 41 implant beds were prepared, with different diameters and lengths in different bone types densities according to the (CBCT) report; each preparation followed the manufacturer's recommended protocol in which the preparations were specifically designed to suit a range of implant lengths and diameters, employing the established d method of implant bed preparation known as the drilling technique. Adherence to the manufacturer's suggested drilling protocol was meticulously observed, with careful measures implemented to prevent overheating the bone throughout the procedure, since high temperatures could potentially harm the bone cells. To prevent the risk of overheating, bone drills were precisely sharpened and operated at controlled speed and force. Continuous saline irrigation was applied at the implant site to further reduce heat generation.[15] The implants were precisely positioned, ensuring the fixture was fully seated in its designated location using the specific screwing instrument from the corresponding implant system. After placing the implant fixture into its designated site by a ratchet, optimum torque was recorded for each implant. After securing the implant abutment to the implant fixture using a torque of 25 N/cm, the AnyCheck® device (Neobiotech Co., Ltd., Seoul, South Korea) was used. PIS is measured by this device as in this, Figure (1).

Figure (1): implant stability meter that measures the stiffness of the alveolar bone and the implant interface

The patient was positioned upright during the measurement procedure in compliance with the manufacturer's instructions. The ISQ value was calculated by taking three separate measurements for each implant, serving as a metric for evaluating the stability index of bone-to-implant integration. A metal rod of the AnyCheck device, was precisely oriented perpendicular to the long axis of the implant abutment, with the start button situated at the top for optimal access. The tip of the tapping rod made gentle contact with the implant abutment, positioned at an angle ranging from 0° to 30°. The average of the three recorded measurements was then noted as PIS. The Kurdistan Higher Council of Medical Specialists ethics approval. (Issue No.: 1563, Date: 8/9/2022). Data analysis was conducted using SPSS Statistics software (version 26, IBM Corp). The Shapiro- Wilk test was used to assess the normality of continuous variables, and results indicated non- normal distribution.

https://doi.org/10.56056/amj.2026.452

Therefore, non-parametric tests were applied. Specifically, the Mann-Whitney U test was used to compare PIS values across different groups based on implant length (short vs. long), implant diameter (narrow vs. standard), and bone quality (good bone quality vs poor bone quality). A p-value < 0.05 was considered statistically significant, and 95% confidence intervals were reported where applicable.

Result

The study involved 41 implants and assessed how the bone quality, implant diameter, and implant length individually affected implant stability. Given that the samples did not follow a regular distribution, we employed nonparametric tests for analysis. As detailed in Table (1), when comparing implant diameters, implants with a wider diameter exhibited a mean stability of 69.33, compared to a mean stability of 65 for implants with a narrower diameter. with a p-value of 0.036, the Mann-Whitney U test indicates statistically significant difference between these groups.

Table (1): Comparing the implant stability between wider-diameter and narrower-diameter implants with their p-value

		Implant stability				
		Mean	Mean rank	Median	p-value	type of test
Implant diameter	Wide implant diameter	69.33	23.66	71	0.036	Mann-Whitney U test
	Narrow implant diameter	65	15.27	67		

Our study additionally assessed the impacts of implant length on stability. We found that longer implants have greater stability, with a mean value of 70.79, compared to shorter implants, which had a mean stability of 64.68. with a p-value of 0.018, According to the Mann-Whitney U Test This difference is statistically significant, Table (2).

Table (2): Comparing the implant stability between long implant length and short implant length with their p-value

		Implant stability				
		Mean	Mean rank	Median	p-value	type of test
Implant length	Long implant length	70.79	25.09	70.5	0.018	Mann-Whitney U test
	Short implant length	64.68	16.26	66		

When it came to the quality of bone, implants placed in high- quality bone showed higher mean stability than those placed in lower-quality bone. However, this observed difference did not reach statistical significance. The reported p-value was 0.82 accompanied by a 95% confidence interval, Table (3) and Figure (2).

Table (3): Comparing the implant stability between wide implant diameter and narrow implant with their p-value

		Implant stability				
		Mean	Mean rank	Median	p-value	type of test
Type of bone	Good bone quality	69.6	21.75	69.5	0.82	Mann-Whitney U test
	Poor bone quality	67.43	20.76	69		

https://doi.org/10.56056/amj.2026.452

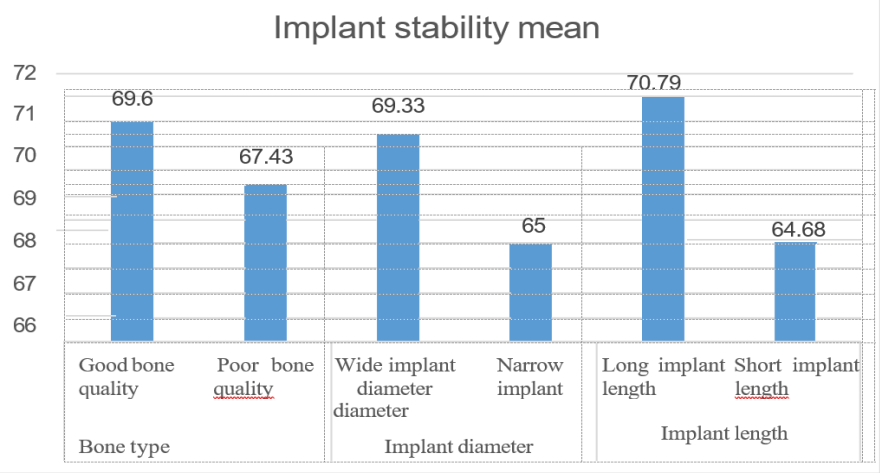

Figure (2): Bar chart demonstrating the mean stability of implants among different type of bones, implant diameters and implant length

Discussion

Achieving primary implant stability is a fundamental objective in the clinical procedure of implant placement. This stability is crucial for determining the optimal timing for implant loading and plays a significant role in enhancing the overall success rate of implants.[7] PIS mostly depends on how the implant and surrounding bone interact. An important factor determining implant overall stability is the contact between the bone and implant structure. The bone quality and the implant, more especially the implant length and diameter, are thought to have an effect on implant stability.[16] The findings of this research indicate that implant length significantly affects PIS longer implants demonstrated higher stability, with a mean value of 70.79, compared to shorter implants, which showed a mean stability of 64.68. With a p-value of 0.018 the difference was statistically significant the reason behind this is longer implant offers a larger surface area for osteointegration and can attach more bone which increase PIS, similar finding was reported by Barikanie et al. concluded that primary stability significantly increased with implant length increase.[14] Regarding implant diameter in this study, implants with a wider diameter exhibited a mean stability of 69.33, compared to a mean stability of 65 for narrower implants. with a p-value of 0.036, this difference was statistically significant the reason behind this result is that the implant diameter is considered the most critical parameter for stress and load distribution and stress is applied to the implant shoulder and According to Ostman et al. since wider implants are more appropriately engaged with the buccal and lingual cortical plates, they exhibit more primary stability. while concerning bone quality, implants inserted in high-quality bone showed higher mean stability compared to those inserted in low-quality bone. However, this difference was not statistically significant, with a p-value of 0.82 the reason behind this result is the lack of statistical significance may be attributed to insufficient data, Since difficulties encountered throughout the clinical data collection process prevented the inclusion of further patients in our research ,However stability seen in high quality bone explained by existence of the cortex of bone

https://doi.org/10.56056/amj.2026.452

Furthermore, a finite element analysis by Winter et al. found a significant relationship between PIS and implant length, especially in cases with poor bone density.[17] Similar findings were reported by Ostman et al. Based on the finding of this study, the high primary stability seen in high- quality bone may be explained by the existence of the cortex of the bone, which is 10-20 times more stiff than cancellous bone, consistent with numerous clinical studies.[18,19,20]

Conclusion

In this vivo study found that implants with greater (PIS) are longer in length and wider implants in dimension, and are placed in high-quality bone. while in our study bone quality did not significantly improved implant primary stability.

Conflict of interest

Regarding the publishing of this study, the authors state that they have no conflicts of interest.

Acknowledgments

Sincere gratitude is extended by the authors to the participating patient for their participation and the public health specialist for her statistical work.

References

1. Adell R, Eriksson B, Lekholm U, et al. Long-term follow-up study of Osseo integrated implants in the treatment of totally edentulous jaws. Int J Oral Maxillofac Implants. 1990; 5: 347–359.
2. Adell R, Lekholm U, Rockler B, et al. A 15-year study of Osseo integrated implants in the treatment of the edentulous jaw. Int J Oral Surg. 1981; 10: 387–416.
3. The Glossary of Prosthodontic Terms 2023: Tenth Edition. J Prosthet Dent. 2023 Oct;130(4 Suppl 1): e1-e3. doi: 10.1016/j.prosdent.2023.03.003. PMID: 37914441.
4. Bataineh AB, Al-Dakes AM. The influence of length of implant on primary stability: an in vitro study using resonance frequency analysis. Journal of clinical and experimental dentistry. 2017 Jan;9(1): e1.
5. Grassi S, Piattelli A, Ferrari DS, Figueiredo LC, Feres M, Iezzi G, et al. Histologic evaluation of human bone integration on machined and sandblasted acid-etched titanium surfaces in type IV bone. J Oral Implantol. 2007; 33:8-12.
6. Quesada-García MP, Prados-Sánchez E, Olmedo-Gaya MV, Muñoz Soto E, González- Rodríguez MP, Vallecillo-Capilla M. Measurement of dental implant stability by resonance frequency analysis: a review of the literature. Med Oral Patol Oral Cir Bucal. 2009;14: e538- 46.
7. Boronat López A, Balaguer Martínez J, Lamas Pelayo J, Carrillo García C, Pe-arrochaDiago
8. M. Resonance frequency analysis of dental implant stability during the healing period. Med Oral Patol Oral Cir Bucal. 2008;13: e244-7.
9. 8. . Georgiopoulos B, Kalioras K, Provatidis C, Manda M, Koidis P. The effects of implant length and diameter prior to and after osseointegra tion: a 2-D finite element analysis. J Oral Implantol. 2007; 33:243-56.
10. Kotsovilis S, Fourmousis I, Karoussis IK, Bamia C. A systematic re view and meta-analysis on the effect of implant length on the survival of rough-surface dental implants. J Periodontol. 2009; 80:1700-18.
11. Griffin TJ, Cheung WS. The use of short, wide implants in pos terior areas with reduced bone height: a retrospective investigation. J Prosthet Dent. 2004; 92:139-44.
12. Kong L, Sun Y, Hu K, Li D, Hou R, Yang J, et al. Bivariate evalua tion of cylinder implant diameter and length: a three-dimensional finite element analysis. J Prosthodont. 2008; 17:286-93.

https://doi.org/10.56056/amj.2026.452

13. Esposito M, Hirsch J-M, Lekholm U, Thomsen P. Biological factors contributing to failures of Osseo integrated oral implants. (II) Etiopathogenesis. Eur J Oral Sci. 1998;106(3):721.
14. Lekholm U. Tissue integrated prosthesis: Patient selection and preparation In: Brånemark PI, Zarb GA, Albrektsson T, eds. 1985. p. 199–209.
15. Barikani H, Rashtak S, Akbari S, Badri S, Daneshparvar N, Rokn A. The effect of implant length and diameter on the primary stability in different bone types. J Dent (Tehran). 2013 Sep;10(5):449-55. Epub 2013 Sep 30. PMID: 24910653; PMCID: PMC4025419.
16. Giro, G., Tovar, N., Marin, C., Bonfante, E. A., Jimbo, R., Suzuki, M., & Coelho, P. G. (2013). The effect of simplifying dental implant drilling sequence on osseointegration: an experimental study in dogs. International journal of biomaterials, 2013(1), 230310.
17. . Bilhan H, Geckili O, Mumcu E, Bozdag E, Sunbuloglu E, Kutay O. Influence of surgical technique, implant shape and diameter on the primary stability in cancellous bone. J Oral Rehabil. 2010 Dec;37(12):900–7.
18. Winter W, Mohrle S, Holst S, Karl M. Parameters of implant stability measurements based on resonance frequency and damping capacity: a comparative finite element analysis. Int J Oral Maxillofac Implants. 2010 May-Jun;25(3):532–9.
19. Ostman PO, Hellman M, Wendelhag I, Sennerby L. Resonance frequency analysis measurements of implants at placement surgery. Int J Prosthodont. 2006 Jan-Feb;19(1):77– 83.
20. Rokn A, Ghahroudi AARR, Mesgarzadeh A, Miremadi A, Yaghoobi S. Evaluation of Stability Changes in Tapered and Parallel Wall Implants: A Human Clinical Trial. J Dent (Tehran) 2011 Fall;8(4):186.

https://doi.org/10.56056/amj.2026.452