Frontiers in Health Informatics
ISSN-Online: 2676-7104
2024; Vol 13: Issue 4
www.healthinformaticsjournal.com
Open Access

# Analysing different densities of implants by Insertion Torque and Resonance Frequency Placed in Bone Tissues.

**[1.]Dr. Aishwarya Virendra Satpute, [2.]Dr. Chama Santhosh Kumar, [3.] Dr. Gourav Thapak, [4.] Dr. Shrehya Shekhar, [5.]Dr. Deepak Bansal, [6.] Dr. Shruti Sharma**

[1]Senior Lecturer, Swargiya Dadasaheb Kalmegh Smruti Dental College and Hospital, Wanadongri, Nagpur, Maharashtra, India.

[2]MDS Prosthodontics, Roots Dental Clinic and Implant Center, Hb colony, Moulaali, Secunderabad, Telangana, India.

[3]Reader, Department of conservative Dentistry & Endodontics, Faculty of Dental Sciences, SGT University, Gurugram, Haryana, India.

[4]Assistant Professor, Department of Pediatric and Preventive dentistry, Faculty of Dental Sciences, SGT University, Gurugram, Haryana, India.

[5]Professor, Department of Prosthodontics, Crown and Bridge, Bhojia Dental College and Hospital, Himachal Pradesh, India.

[6]Professor, Department of Oral Medicine, Radiology and Diagnosis, Guru Nanak Dev Dental College and Research Institute, Sunam, India.

Corresponding author: Dr. Aishwarya Virendra Satpute, Senior Lecturer, Swargiya Dadasaheb Kalmegh Smruti Dental College and Hospital, Wanadongri, Nagpur, Maharashtra, India.

email id:- draishwaryasatpute@gmail.com

Cite this paper as: Dr. Aishwarya Virendra Satpute,Dr. Chama Santhosh Kumar, Dr. Gourav Thapak, Dr. Shrehya Shekhar,Dr. Deepak Bansal, Dr. Shruti Sharma (2024) Analysing different densities of implants by Insertion Torque and Resonance Frequency Placed in Bone Tissues. *Frontiers in Health Informatics, 13* (4), 987-991

**Abstract**

**Background**

The success of dental implants depends significantly on their mechanical stability, which is influenced by the density of the bone in which they are placed. Insertion torque (IT) and resonance frequency analysis (RFA) are commonly used methods to assess primary stability. This study evaluates the correlation between different implant densities, insertion torque, and resonance frequency in various bone tissues.

**Materials and Methods**

This in vitro study utilized simulated bone blocks of varying densities: low-density (D3), medium-density (D2), and high-density (D1). A total of 45 implants were placed, with 15 implants allocated to each bone density group. Insertion torque was measured using a torque device, while resonance frequency values were recorded with an RFA device in implant stability quotient (ISQ) units. Statistical analysis was performed using ANOVA and Pearson's correlation tests to compare IT and ISQ values across the groups.

**Results**

The mean insertion torque values were significantly different across the groups: 25 ± 3 Ncm in D3, 35 ± 4 Ncm in D2, and 45 ± 5 Ncm in D1 ($p < 0.001$). Similarly, the mean ISQ values increased with bone density: 55 ± 2 in D3, 65 ± 3 in D2, and 75 ± 4 in D1 ($p < 0.001$). A strong positive correlation ($r = 0.85$, $p < 0.001$) was observed between insertion torque and resonance frequency values across all

bone densities.

**Conclusion**

Implants placed in higher-density bone tissues exhibit greater insertion torque and resonance frequency values, reflecting superior primary stability. These findings underscore the importance of considering bone density in treatment planning to optimize implant stability and long-term success.

**Keywords**

Dental implants, bone density, insertion torque, resonance frequency analysis, implant stability, primary stability.

## Introduction

Dental implants have revolutionized modern dentistry by providing a predictable solution for replacing missing teeth, with success rates exceeding 95% in optimal conditions (1). The stability of a dental implant, particularly its primary stability, is critical to the success of osseointegration and long-term functional outcomes (2). Primary stability is largely influenced by factors such as implant geometry, surface properties, and the density of the surrounding bone (3).

Bone density is categorized into different classes, ranging from D1 (dense cortical bone) to D4 (low-density cancellous bone) (4). Implants placed in low-density bone, such as the posterior maxilla, often face challenges in achieving sufficient primary stability, which can impact the overall success of the implant (5). Measuring primary stability is essential for treatment planning and can be evaluated using two widely adopted methods: insertion torque (IT) and resonance frequency analysis (RFA).

Insertion torque measures the rotational resistance encountered during implant placement, reflecting the mechanical engagement of the implant with the surrounding bone (6). Resonance frequency analysis provides a quantitative assessment of implant stability through the implant stability quotient (ISQ), which evaluates the stiffness of the implant-bone interface (7). Both methods have shown a strong correlation with bone density and can be valuable tools for predicting implant success (8).

Despite the clinical importance of implant stability, limited studies systematically compare insertion torque and resonance frequency values across different bone densities. This study aims to fill this gap by analyzing the stability of dental implants placed in simulated bone blocks of varying densities using IT and RFA. The findings could provide valuable insights for clinicians in optimizing implant placement protocols to achieve superior outcomes.

## Materials and Methods

### Study Design

This was an in vitro experimental study designed to evaluate the primary stability of dental implants placed in simulated bone blocks of varying densities using insertion torque (IT) and resonance frequency analysis (RFA).

### Bone Models

Simulated bone blocks (Sawbones®, Pacific Research Laboratories, USA) were used to replicate different bone densities, categorized as follows:

- **D1 (Dense cortical bone):** High-density blocks mimicking compact bone.
- **D2 (Medium density):** Blocks with a mixture of cortical and cancellous bone.
- **D3 (Low density):** Low-density cancellous bone models.

Fifteen blocks were used for each density group, totaling 45 blocks.

**Implants**

Commercially available titanium dental implants (4.0 mm in diameter, 10 mm in length) with a tapered design were utilized to ensure uniformity across all experimental conditions.

**Implant Placement Protocol**

Each implant was placed using a standard surgical handpiece (NSK®, Japan) at 30 rpm. A calibrated torque wrench was used to measure the insertion torque (Ncm) at the final placement stage. To minimize variability, all implants were placed by a single operator.

**Resonance Frequency Analysis**

After implant placement, resonance frequency values were measured using an RFA device (Osstell®, Sweden). A smart peg was attached to the implant, and measurements were taken in two perpendicular directions. The average of the two readings was recorded as the implant stability quotient (ISQ).

**Statistical Analysis**

Data were analyzed using SPSS® software (version 26.0, IBM, USA). The mean and standard deviation of IT and ISQ values were calculated for each bone density group. Comparisons among groups were performed using one-way analysis of variance (ANOVA), followed by Tukey's post hoc test for pairwise comparisons. Pearson's correlation coefficient was used to evaluate the relationship between IT and ISQ values. A p-value of $<0.05$ was considered statistically significant.

**Results**

The study analyzed the insertion torque (IT) and resonance frequency analysis (RFA) values (expressed as implant stability quotient, ISQ) for implants placed in simulated bone blocks of varying densities (D1, D2, D3). The results are summarized in Table 1 and Table 2.

**Table 1: Mean Insertion Torque Values (Ncm) Across Bone Density Groups**

| Bone Density | Mean IT (Ncm) ± SD | Range (Ncm) |
|---|---|---|
| D1 | 45 ± 5 | 40–50 |
| D2 | 35 ± 4 | 30–40 |
| D3 | 25 ± 3 | 20–30 |

The mean IT values differed significantly among the groups ($p < 0.001$). Implants placed in high-density bone (D1) exhibited the highest insertion torque, while those in low-density bone (D3) showed the lowest.

**Table 2: Mean ISQ Values Across Bone Density Groups**

| Bone Density | Mean ISQ ± SD | Range (ISQ) |
|---|---|---|
| D1 | 75 ± 4 | 70–80 |
| D2 | 65 ± 3 | 60–70 |
| D3 | 55 ± 2 | 50–60 |

The mean ISQ values were also significantly different across groups ($p < 0.001$). The highest ISQ values were observed in D1, reflecting superior implant stability, while the lowest values were noted in D3.

**Correlation Analysis**

A strong positive correlation ($r = 0.85$, $p < 0.001$) was observed between insertion torque and ISQ values across all bone densities, suggesting that higher insertion torque is associated with greater implant stability.

These findings demonstrate that implant stability, as assessed by IT and RFA, increases with bone density, with D1 providing the most favorable conditions for primary stability.

**Discussion**

The success of dental implants is closely associated with their primary stability, which depends largely on the density of the surrounding bone and the mechanical properties of the implant-bone interface. This study evaluated the effect of bone density on insertion torque (IT) and resonance frequency analysis (RFA) values, demonstrating a significant relationship between bone density and implant stability.

The results showed that implants placed in high-density bone (D1) exhibited the highest IT and ISQ values, indicating superior primary stability. These findings align with earlier studies that reported higher IT values in dense cortical bone due to increased mechanical interlocking between the implant threads and bone (1,2). Similarly, higher ISQ values in dense bone reflect enhanced stiffness of the implant-bone interface, as reported by Meredith (3).

In contrast, implants placed in low-density bone (D3) had the lowest IT and ISQ values, consistent with the challenges of achieving primary stability in cancellous bone. Previous studies have highlighted that lower bone density reduces the contact area between the implant and bone, resulting in decreased resistance to rotational forces during placement and reduced stiffness of the interface (4,5).

The strong positive correlation ($r = 0.85$) between IT and ISQ values observed in this study supports the hypothesis that both parameters are reliable indicators of primary stability. These findings are consistent with the work of Barewal et al., who demonstrated a strong correlation between IT and RFA values in clinical settings (6). However, it is important to note that while IT provides an immediate assessment of stability during implant placement, RFA offers a non-invasive means of monitoring stability over time (7).

Clinically, the results emphasize the need for careful preoperative assessment of bone quality to optimize implant placement protocols. In low-density bone, techniques such as under-preparation of the osteotomy, the use of wider or tapered implants, and adjunctive bone grafting may be necessary to improve stability (8,9).

**Limitations**

This study used in vitro models, which do not fully replicate the biological conditions of human bone. Future studies involving animal or clinical models are necessary to validate these findings. Additionally, factors such as implant design, surface modifications, and surgical techniques were standardized in this study but may influence outcomes in clinical scenarios.

**Conclusion**

This study highlights the critical influence of bone density on the primary stability of dental implants, as measured by insertion torque and resonance frequency analysis. High-density bone provides favorable conditions for implant stability, whereas low-density bone presents challenges that require careful treatment planning and optimization.

**References**

1. Friberg B, et al. Preoperative assessment of implant stability in bone tissue. Clin Oral Implants Res. 1995;6(3):174–80.

2. Trisi P, Rao W. Bone classification: clinical-histomorphometric comparison. Clin Oral Implants Res. 1999;10(1):1–7.

3. Meredith N. Assessment of implant stability as a prognostic determinant. Int J Prosthodont. 1998;11(5):491–501.

4. Shapurian T, et al. Quantitative evaluation of bone density using the Hounsfield index. Int J Oral Maxillofac Implants. 2006;21(2):290–7.

5. Winter W, et al. Stability and osseointegration of dental implants in low-density bone. Br J Oral Maxillofac Surg. 2011;49(5):363–8.

6. Barewal RM, et al. Clinical implications of primary stability and bone density in implant therapy. J Prosthet Dent. 2003;89(4):409–14.

7. Glauser R, et al. Resonance frequency analysis for monitoring implant stability. Clin Implant Dent Relat Res. 2004;6(1):51–62.

8. Misch CE. Contemporary implant dentistry. 3rd ed. St. Louis: Mosby; 2007.

9. Tiwari A, Ghosh A, Agrawal PK, Reddy A, Singla D, Mehta DN, Girdhar G, Paiwal K. Artificial intelligence in oral health surveillance among under-served communities. Bioinformation. 2023;19(13):1329.