

Influence of Polymeric Materials on Osseointegration and Stability of Dental Implants: An in-Vivo Resonance Frequency Analysis

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Abstract

Osseointegration, the successful integration of dental implants with surrounding bone tissue, is crucial for long-term implant stability. Resonance frequency analysis (RFA) provides a valuable tool for assessing implant stability. This in-vivo study investigates the potential role of polymeric materials used in dental implants, such as surface coatings or membranes, in influencing osseointegration and RFA-measured stability. By analysing the impact of these polymers on factors like cell adhesion, proliferation, and differentiation at the implant-bone interface, the study aims to shed light on how polymeric components can contribute to improved implant stability. Further, this in-vivo study aimed to conduct a comparative resonance frequency analysis of dental implants placed using conventional drilling protocols versus Osseo densification surgical drilling protocols. The study involved the placement of dental implants in patients using both techniques, followed by resonance frequency analysis to assess implant stability. Results indicated significant differences in resonance frequency values between the two drilling protocols, suggesting variations in implant stability. This investigation provides valuable insights into the comparative effectiveness of conventional and Osseo densification drilling techniques in promoting implant stability, thus informing clinical decision-making in dental implantology.

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INTRODUCTION

The aim of contemporary dentistry is to restore missing natural teeth to their normal contour, function, aesthetics, speech, and health. Implant dentistry has emerged as an essential aspect of prosthodontics for patients with partial or complete tooth loss. Dental implant restorations have the highest survival rate compared to any other form of prosthesis for tooth replacement. They have become the preferred choice for enhancing oral function and health in patients. Dental implants demonstrate a high success rate in replacing missing teeth, establishing them as an essential element of modern dental treatment plans.

The concept of osseointegration, initially delineated by Branemark and Schroeder, marked the genesis of implant dentistry. Over the last 15

years, implant dentistry has undergone significant evolution and now serves as a vital component of dental rehabilitation. While originally devised to restore fully edentulous patients, the treatment emphasis has progressively shifted towards partially edentulous patients. Currently, single-tooth replacement stands as the primary indication for implant therapy. Implant dentistry has also experienced substantial advancements in associated treatment protocols. [1,2].

Atrophic edentulous jaws pose a questionable outcome to the use of endosseous implants. The vertical and horizontal ridge resorption occurs at differential rates that vary among different individuals and at different sites in the same individuals. However, there is substantial extent of horizontal resorption that would make the implant positioning a difficult task. Several implants driven treatment techniques have been proposed for horizontal defects such as monocortical block bone grafting, guided bone argumentation, ridge expansion techniques, and alveolar augmentation through distraction osteogenesis [2]. With the advancement of bone augmentation techniques, clinicians can effectively manage alveolar bone deficiencies. Guided bone regeneration, alongside sinus floor elevation and the application of barrier membranes, has become an essential aspect of treatment to rectify bone defects in different regions of the oral cavity. These advancements make implant therapy increasingly essential and desirable to patients. [1].

The stability of implants is pivotal in attaining successful osseointegration, characterized by a direct functional and structural integration between the interface between the bone and the load-bearing insertion (Bränemark et al., 1977; Sennerby & Roos, 1998). Assessing insertion stability is a crucial method for gauging the efficacy of an insertion. Insertion stability is evaluated during two phases: primary and secondary. Primary fixation arises from mechanical engagement with cortical bone and is affected by variables including bone volume and density, surgical approach, implant dimensions (length, diameter), and configuration (Meredith, 1998). The subsequent stability of the implant hinges on the primary stability established during the initial implantation.[3].

Insufficient primary fixation of a dental implant is critical for its clinical success, and numerous factors contribute to enhancing primary implant stability. These factors encompass bone quality and quantity, surgical technique, clinician proficiency, and insert design, particularly surface morphology, and topography. Ensuring optimal primary fixation of implants is imperative for successful osseointegration and, consequently, for their sustained long-term clinical efficacy [4]. Measuring primary implant stability offers several positive outcomes. These include making more precise determinations regarding the timing of loading or unloading, selecting the most suitable loading protocol for implants, and fostering confidence between the patient and clinician [5].

An ample supply of high-quality bone, coupled with adequate primary stability during implant insertion, are pivotal factors for success in immediate loading scenarios. Throughout osseous healing, implant stability diminishes until a secondary biological stability is attained.[6] Soft bone is ideally suited for trabecular compaction. Through the Osseo densification technique, the quality of Type IV bone can be transformed into Type III or II, and Type III can be compacted to Type II.

The objective of this study was to evaluate and contrast the stability of dental implants inserted using conventional drilling protocol and osseodensification surgical drilling protocol. To achieve this, implant stability quotient (ISQ) values were evaluated for both protocols. The results indicate that implants placed using conventional drilling demonstrated higher ISQ values compared to those placed using osseodensification. This suggests that conventional drilling protocol may offer greater primary implant stability than osseodensification protocol. Overall, the study provides valuable insights into the comparative effectiveness of these two surgical drilling protocols in ensuring stable dental implant placement.

REVIEW LITERATURE

Mu-Seung Kwak et.al (2013) [7]. The objective of this investigation was to evaluate the impact of insertion contact ratio and the stiffness of inserted-surrounding materials on RFA values. The study

revealed that the impact of RIC amount on RFA values was negligible, except for RIC disparities exceeding 85%. RFA values were notably affected by the stiffness of the ecosystem materials. Lakshmi Kanth et al (2014)[8]: The aim of the current investigation was to investigate implant stability during the initial healing phase utilizing Osstell Mentor® resonance frequency analysis (RFA) across various bone densities, and to investigate the incorporation of RFA into standard clinical assessment for assessing implant stability. David Lipton et.al. (2015) [9]. The objective of this case series report was to investigate the degree of ridge expansion achieved through osseodensification, quantified directly in millimeters. Twenty-eight implants were installed in 21 patients, with alveolar ridge widths stratified into three groups. The mean insertion torque was 61N/cm, and the ISQ value was 77. In general, greater bone expansion was observed at the coronal position compared to the apical position.

Hema Kanathila¹, Ashwin Pangi (2018) [10]. Bone Condensing Technique (BCT) is a contemporary surgical method that has attracted significant attention in recent years for its capacity to augment bone density around dental implants and enhance primary stability. Various investigations have explored the effectiveness of this pioneering approach. The aim of this review article is to offer a thorough examination of the BCT procedure. BCT entails the formation of an autograft layer of compacted bone at the periphery of the implant site. This is accomplished utilizing densah burs, which rotate in both clockwise and counterclockwise directions. By compacting bone during osteotomy preparation, OD enhances implant stability and promotes successful osseointegration. This technique is particularly advantageous for patients with poor bone quality, as it facilitates the attainment of reliable primary implant stability.

Dr.Chlorokostas Georges et al., (2017)[11]. uses different methodologies for evaluating inserted stability and recent advancements in this area. Resonance Frequency Analysis (RFA) emerges as a clinically practical approach for assessing implant stability, providing a reasonable level of predictability. While the theoretical foundations of RFA are robust, certain ambiguities remain, such as identifying the critical threshold that can consistently signify the success or failure of a particular implant system. Bradley Lahens et.al. (2017):[12] The aim of this investigation was to evaluate the qualitative and quantitative effects of the osseodensification surgical technique over time and in conjunction with implant surface treatment. The sheep hip model was selected as an appropriate testing platform due to its low-density environment. Twelve sheep participated in the study, with each receiving six implants bilaterally into the ilium, totalling 36 acid-etched and 36 as-machined implants. Umesh Y. Pai et.al. (2017) [13]: - This study introduces a pioneering method for osteotomy referred to as osseodensification (OD), which has emerged as a forefront innovation in surgical site preparation within implantology. This relatively recent technique, enabled by universally compatible drills, seeks to improve osteotomy preparation, bone densification, and streamline indirect sinus lift procedures. Additionally, it facilitates bone expansion in regions with diverse bone densities.

Materials and Methods

The current investigation was conducted in the Department of Prosthodontics and Crown & Bridge at the School of Dental Sciences, Krishna Institute of Medical Sciences "Deemed to be" University (KIMSDU), Karad, following the requisite approval from the institutional protocol committee.

Inclusion Criteria

1. Patient willing for the study.
2. Absent dentition in the posterior maxillary/mandibular region
3. Sufficient vertical and horizontal bone dimensions with ideal bone density
4. Study group consist of
 - a. Either male/female
 - b. Age range – Above 20 years and below 60yrs
5. Dental implant requiring conventional implant placement in patient.
6. Patients requiring at least 2 implants in each arch.

Exclusion Criteria

1. Factors impeding the fulfilment of study participation
2. Persistent regular intake of antibiotics or extended steroid consumption
3. Medical background encompassing leukocyte dysfunction, coagulopathies, cancer necessitating radiation or chemotherapy, metabolic bone ailments, unregulated endocrine conditions, and HIV infection
4. Recent utilization of experimental medications or apparatus within 30 days prior to the study timeframe
5. Alcohol dependency, substance misuse, or excessive smoking (more than 10 cigarettes daily)
6. Simultaneous involvement in additional research endeavours
7. Pregnancy

A total of 36 individuals were selected for the research which is fulfilling the criteria.

All individuals were apprised about the nature of the investigation. Detailed explanation of the procedure, complications and follow-up period involved in the study was given to all the participants. Those patients willing to undergo the procedure and the follow-up visits were enrolled in the study and a written apprised consent was procured. All individuals were subjected to the same standardized surgical protocol by the same surgeon.

Materials

1. Tapered implant design
2. Surgical Armamentarium

Other Instruments

- i. Mouth mirror.
- ii. William's periodontal probe
- iii. Cheek retractor
- iv. Lip retractors.
- v. Surgical suction cannula

General Instruments

- i. Anesthesia syringe/needle
- ii. Dental tweezers (regular)
- iii. Periodontal probe
- iv. Dental probe

Instruments For Flap Elevation

- i. Surgical scalpels (No. 12 and 15 blades; Microblade)
- ii. Periosteal elevator

Additional Instruments

- i. Clamp
- ii. Sterile gauzes
- iii. Irrigation syringe

Instruments And Suture Material for Wound Closure

- i. Suture material.
- ii. Needle holder.
- iii. Scissors
3. Penguin RFA unit
4. Universal Densah Bur Kit (OD DRILLS).
5. Standard Implant Physio-dispenser.
6. Standard Implant surgical kit. (Genesis Tapered Kit)
7. Conventional Drills.

Method

This investigation conducted jointly by the Department of Prosthodontics and Crown & Bridge and Implantology, along with the Department of Oral and Maxillofacial Surgery, at the School of Dental Sciences, KIMS (DU), Karad

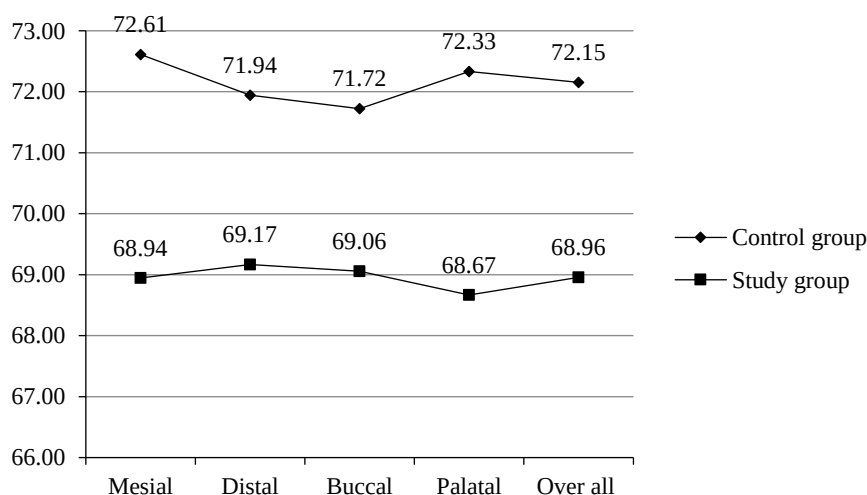
In this In-Vivo study, Same patient was selected for implant placement on either side of maxillary or mandibular Posterior and anterior Region of jaw by two different protocols i.e. conventional drilling protocol or control group and osseodensification surgical drilling protocol or test group. Prior to the surgery informed consent has been taken from the patient. The investigation cohort of this controlled randomized trial comprises 36 patients receiving implants either male/female with an age range from 20-60 years and 36 implant sites and in which 18 implant sites were prepared with conventional surgical drilling protocol and 18 implant sites were prepared with osseodensification surgical drilling protocol.

One implant placement was done by conventional surgical drilling protocol on either side [right or left] of maxillary or mandibular region of the jaw and other implant was placed by osseodensification surgical drilling protocol on contra-lateral or adjacent to the implant placed by control group. All surgical treatments were conducted under local anaesthesia. The investigation was performed on the same patient. The purpose is to maintain the standardization of the study. All patients were studied following our clinical implantology protocol for prosthetic rehabilitation. The systemic health conditions of all participants were documented. Comprehensive descriptions of all procedures were verbally conveyed and furnished in written format to the patients, and informed consent documents for the implant placement procedure were endorsed by all patients. Additionally, OPG X-ray images were taken preoperatively and postoperatively on the same day as the placement or insertion to assess the bone and neighbouring anatomical structures.

Initial treatment planning was conducted, and a prosthetic stent was fabricated for precise surgical placement. Diagnostic intraoral photographs, panoramic radiographs, and CBCT scans were obtained to evaluate morphology and skeletal relationships. Assessments of available bone height, width, and length were conducted. Before commencing the procedure, all patients provided their consent after being fully informed. All implants were positioned in conformity with a standardized surgical protocol adhering to the manufacturer's guidelines.

Results

Data collected and statistically assessed and compared amongst primary implant stability with conventional surgical drilling protocol and osseodensification surgical drilling protocol. Obtained values were recorded, by using unpaired t-test. Statistical analysis done by using SPSS 25 software and the results were compared.



Graph 1. ISQ value difference between groups

Table 1. Overall comparison ISQ value of Group A (Control/Conventional Drilling Group) and Group B (Test/ Osseodensification Drilling Group) respectively.

	N	Average	SD	SE	T - value	P - value
Control category	18	72.1528	4.10983	0.96870	2.533	0.016*
Study category	18	68.9583	3.42595	0.80750		

SD – Standard Deviation SE- Standard Error Intergroup comparison of mean differences of two groups was done where the Average of control group and study group were 72.1528 and 68.9583 respectively as indicated in table 1. Unpaired T-test was utilized to analyse the average values among the two groups. According to the Unpaired T-test it was confirmed that the mean primary stability for Group A and Group B was significant with the t value being 2.533 and the significance being $p < 0.016^$.*

For Group A, the basic data for evaluating the primary stability, the mean value for each of the samples in the group and the mean for Group A was calculated. The mean primary stability obtained for Group A was 72.1528 ISQ with a SD of 4.10983 and a SE of 0.96870. The topmost values are 78.00 and bottommost values are 65.50 as indicated in graph 1.

The Primary stability Based on ISQ value of Group B (Test/Osseodensification Drilling Group): For Group B, the basic data for evaluating the primary stability, the mean value for each of the samples in the group and the mean for Group were calculated. The mean primary stability obtained for Group B was 68.9583 ISQ with a SD of 3.42595 and a SE of 0.80750. The topmost value is 74.75 and bottommost values are 61.50.

CONCLUSION

In an In-Vivo study, the same patient underwent implant placement on opposing sides of the maxillary or mandibular posterior region using two different protocols: conventional drilling (control group) and Osseo densification surgical drilling (test group), employing a split-mouth technique. A combined total of 36 dental implants were inserted, with 18 employing traditional drilling techniques and the remaining 18 utilizing Osseo densification. Both groups underwent assessment for primary stability using Penguin RFA. The primary implant stability ISQ for the Group A was measured at 72.1528 ISQ, while for the Osseo densification group (Group B), it was 68.9583 ISQ. This suggests that the conventional drilling approach exhibited superior primary implant stability in comparison to Osseo densification, as indicated by resonance frequency analysis.

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