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# Evaluation of Bioactive material as a Bone Substitute aroundTitanium Implants

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**ABSTRACT**

**Aims:**This experimental study was conducted to evaluate the effect of Bioactive material as a bone graft substitute on the bone response around titanium implants.

**Materials and Methods:**Forty titanium implants were employed. Twenty New–Zealand rabbits were included in the experiment and a bed was made for implantation in each head of the left femur. Each animal received a titanium implant in the mesial femoral head and this group of implants was considered as a control group. Then the bioactive bone graft material was placed in the implant bed at the distal femoral head followed by fixation of an implant, and this group was considered as an experimental group. The twenty rabbits were randomly allocated into four groups, to represent the study periods i.e., 3 days, 7days, 14 days, and 28 days. Bone response was assessed around each of the forty implants by measuring the bone mineral density using densitometric analysis of the digital periapical radiological image which was taken after the euthanization of the animals according to study intervals.

**Results:**The results showed a statistically significant difference between the control group (titanium implants) and the experimental group (titanium implants with bioactive bone graft) in bone mineral density.

**Conclusions:**The use of bioactive bone material as an artificial bone graft around titanium implant is beneficial for increasing bone formation around the implant as it increases bone density.

**Keywords:** titanium implant,Densitometric analysis, bioactive bone material graft, bone response.

## I. INTRODUCTION

Titanium alloys are frequently utilized as load-bearing implants due to their excellent mechanical qualities and proven biocompatibility. A stress shielding effect is created by the mechanical mismatch between solid titanium and surrounding natural bone tissues, resulting in bone resorption and implant micromotion [1].

Since Brnemark demonstrated the integration of titanium with bone tissue in the 1960s, which is the basis of the idea of osseointegration, titanium has been widely used in dental and orthopedic disciplines[2].

Because of their high biocompatibility, mechanical strength, and osseointegration qualities, titanium-based materials are employed as dental implants. In recent years, nanotechnology has brought new and exciting uses in dentistry. The presence of nanoparticles on the implant surface can alter the topography as well as the surface chemistry, resulting in unique implant specifications [3].

Because of their biocompatibility and capacity to achieve osseointegration, titanium implant screws are still the gold standard for oral implant applications [4].

Because of their corrosion resistance, biocompatibility, and mechanical qualities, titanium alloys are the gold standard for endo-osseus dental implant manufacturing. The surface properties of titanium implants are especially important during the early stages of osseointegration [5].

The physiological underpinning of successful endosseous implantation is osseointegration, which is a direct structural and functional connection between living bone and the surface of implants [6].

Primary stability is replaced by secondary stability during osseointegration, which is a dynamic process"Osseointegration is a foreign body reaction in which interfacial bone is generated as a defense reaction to shield the implant from the tissues," according to a new definition. To test this hypothesis, a densitometric evaluation of the bone density around all implants at four time–intervals was statistically analyzed [7][8].

## II. MATERIALS AND METHODS

The study was approved by Research Ethics Committee board (University of Mosul, College of Dentistry, REC reference UoM.Dent/ A.L.11/ 21).
Twenty New–Zealand male rabbits with an age range of about 6 months and weighing about 1.5 Kg ± 200grams were subjected to the experiment. Before being admitted for surgeries, all the animals were vaccinated with ivermectin (200mg/kg) subcutaneously and put into quarantine for clinical observation. They were kept in an animal house in a standard environment and all received the same nutrition.

**Study design**

A total of forty titanium implants were used, divided into two sets of twenty implants each.

- Group of (titanium): consisted of 20 titanium implants, each was implanted in the mesial head of the femoral bone.
- Group of (titanium+bioactive bone graft): consisted of 20 titanium implants, each was implanted in the distal head of the femoral after the application of Bioactive Bone Graft(Unigraft)in the implant's bed.

Animals were placed into four groups based on a three-day, seven-day, fourteen-day, and 28-day time interval, with each group containing five animals.

**Implants design and manufacturing**

The titanium implant used in this study is a Speed Dental (Global Standard Service of Medical) Korea Item No.160-GS4-08 taper type screw with a diameter of 1.6 and a length of 8 mm.Figure (1).

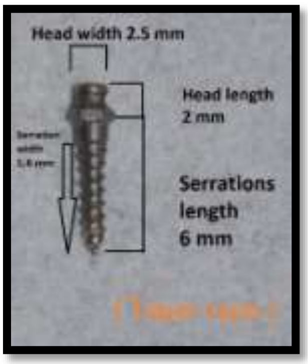


**Figure (1):** The Dimensions of the Titanium Implant**.**

**The Bioactive bone graft substitute**

Unigraft (bioactive bone graft) is made entirely of fused calcium, phosphorus, silicon, and sodium oxide crystals.

**The surgical procedure**

The surgery was performed in an aseptic environment, and the animals were given intramuscular injections of ketamine hydrochloride 5mg/kg and Xylazine hydrochloride 50mg/kg to anesthetize them [9]. A surgical skin incision of roughly 2cm with a periosteal flap was produced with a No.15 surgical blade, then the flap reflected to reveal the femoral bone. Using an implant screw drive with an implant handpiece engine (1500 rpm) and ample cooled distilled water irrigation, two cavities were bored through the bone around 1cm distant from each femur's head. A titanium implant was placed in the mesial cavity, whereas the distal cavity received a conventional amount of 0.5 gram of unigraft powder mixed with 0.5 gram of unigraft powder.Figure (2).

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**Figure (2):** TitaniumImplants in the Mesial and Distal Implant's Beds.

**Post–operative Care**

Oxytetracycline was given as a single intramuscular injection for 5 days at a dose of 15 mg/kg/day. To avoid the harmful effects of anti-inflammatory medications on bone healing, no anti-inflammatory medications were administered following the surgery [10][11]. The veterinarian performed a periodic clinical examination to assess wound healing and look for any surgical complications.

**The Densitometric Evaluation**

Digital radiographic imaging was undertaken for each implant site at Al Rasheed center in Mosul city using MICROFOCUS DENTAL X-RAY UNIT with CARESTREAM RVG 5200 digital imaging sensor to be evaluated by densitometric analysis of the CS imaging software 7.0.3. For standardization, a source-objects distance of 20cm, a milliampere of 10 mA, a voltage of 60 kV, and a time of exposure of 0.20 sec. were set. The measurements were taken along the serrations of the implant's screw by drawing a line between every two serrations peaks, the serration/s in the cortical bone were discarded, then a mean was calculated for the measured average value of all the lines. Figure (3).

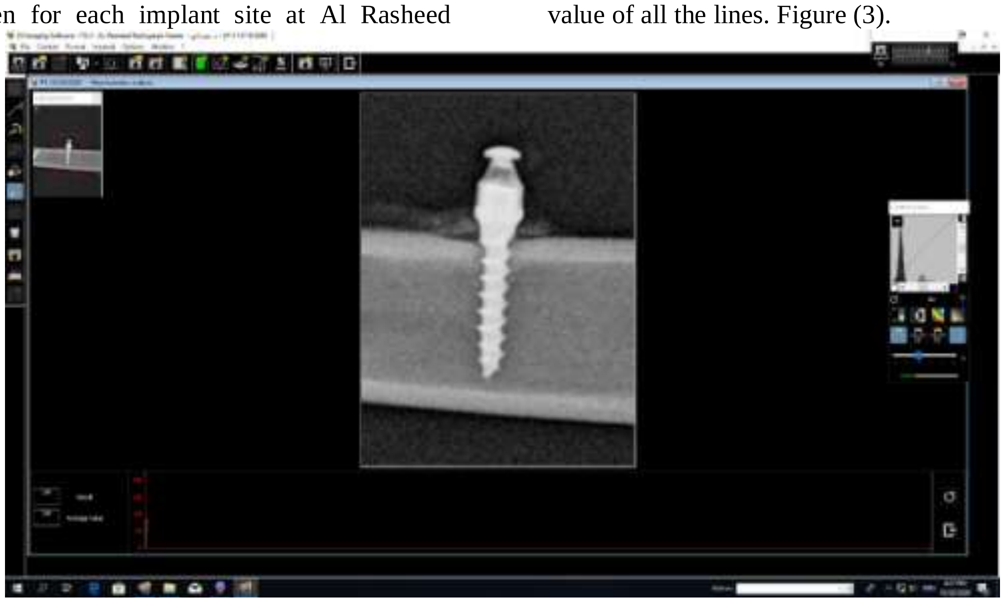

**Figure (3):** The Window of the Program with an Illustration of the Method Used For the Densitometric Analysis**.**

**Statistical analysis**

The statistical analysis was performed using IBM SPSS Statistic 19 software. The differences between groups were statistically analyzed using paired–samples T–test and considered to be statistically significant at a $P \leq 0.05$ and highly significant at a $P \leq 0.01$.

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## III. RESULTS

No implant was lost in this experiment, all the animals used for the study tolerated well to the implantation and recovered after the surgery with no significant complications or interference. The results showed a statistically significant difference at p≤0.05 in bonedensity around the titanium implant between the group of (titanium) and the group of (titanium+unigraft) at all time.The results of the changes that occurred in bone density at each of the four periods of time and between the control (Titanium Implant) and experimental (Titanium Implant + Unigraft) groups are shown in Table (1) Figure (4).

**Table (1):** Comparison in the Changes of Bone Density Median Around Titanium Implant in Both Comparison groups

| Group | Three Days | Seven Days | Fourteen Days | 28 Days |
|---|---|---|---|---|
| **Titanium Implant** | 100.8 | 109.4 | 107.6 | 111.6 |
| **Titanium Implant+Unigraft** | 110.0 | 119.8 | 107.6 | 113.4 |

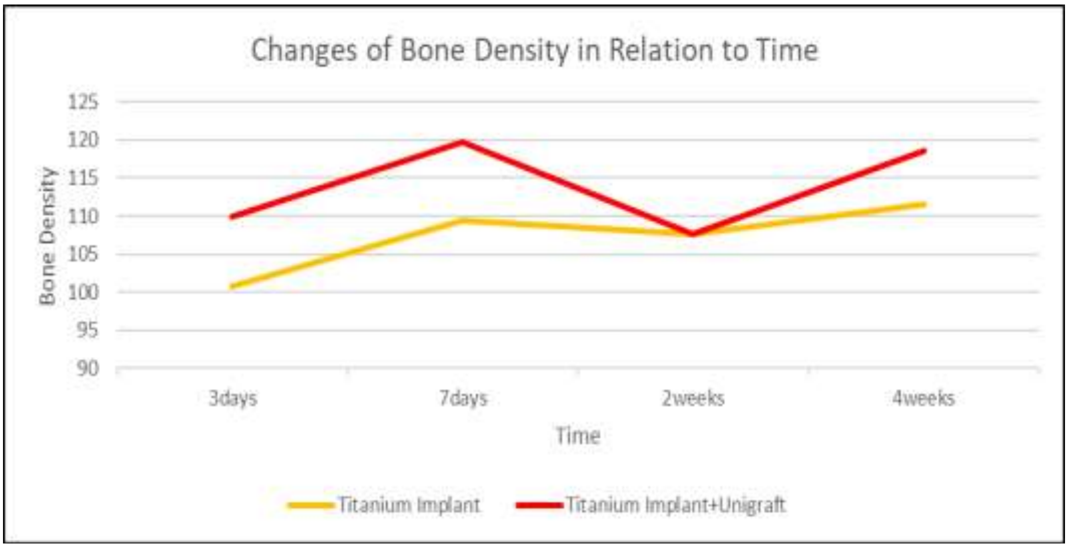


**Figure (4):** The changes of Bone Density During the Four Periods of Time.

The statistical analysis done using (Mann-Whitney Test)and the results are shown in Table (2)

**Table (2):** Statistical Analysis using Mann-Whitney Test Comparing the Bone Density Results During All Four Periods

| **Titanium Implant / Titanium Implant+Unigraft** | **Sig.** |
|---|---|
| **Day 3** | .026* |
| **Day 7** | .008** |
| **Day 14** | .008** |
| **Day 28** | .249 |

* Significantly different at p≤0.05, ** Significantly different at p≤0.01

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The radio-logical images for an implant in each time interval for both groups are displayed in Figure (5).

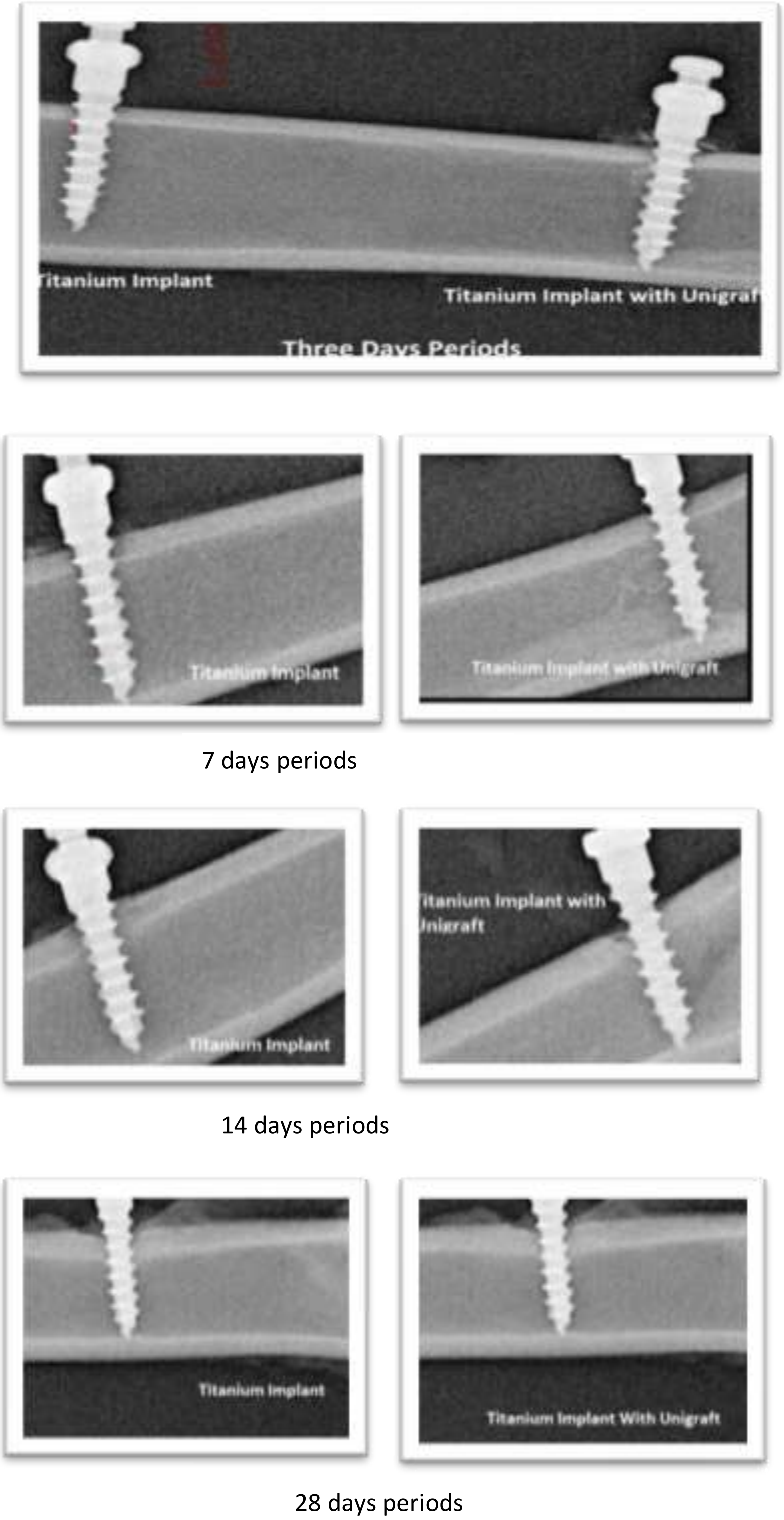


**Figure (6):** The Radio-Logical Images for an Implant in Each Time Intervals for Both Groups

## IV. DISCUSSION

The goal of this study was to examine the response of bone tissue around titanium implants that were fixed alone versus those that were fixed after a bioactive bone graft was applied to the implant's bed in rabbit. Three-seven, fourteen days, and four-weeks healing periods were chosen to examine the bone formation process, with a particular focus on the response of bone tissue at the surface of implant, using radiological measurements of the density of bone.

**After 3 days from implantation,**

The measured bone density around the serrations of the implant showed an early increase, with a highly significant difference between the groups of Titanium implants with Bioactive Bone Graft material (Titanium Implant + Unigraft) and the group of Titanium implants without Bioactive Bone Graft material (Titanium Implant).This study comes in agreement with the study of (Zafar and Khurshid 2020)[12] which indicates that Bioactive silicate glasses increase angiogenesis, which is of a great significance when restoring large bone defects to allow a sufficient origination and nutrient and as a passageway for stem cells.

**After 7 days from implantation,**

The measured bone density around the serrations of the titanium implants increased, indicating bone formation, as confirmed by the study of(Marques, Padovan et al. 2013)[13] who found medullary bone, consisting of thin and slender newly formed bone trabeculae in the impressions of the implant threads, as well as a highly vascularized fibrous tissue permeating these regions.

According to (Lin, Fuh et al. 2020) [14], the Titanium surface promoted cellular spreading and boosted the rate of Osteoprogenitor cell migration considerably. A statical comparison of bone density between the two groups revealed that the (Titanium Implant + Unigraft) group had more bone development than the (Titanium Implant) group. While density of bone dropped in this period for group (Titanium Implant + Unigraft) compared to the prior period, this can be described by calcium phosphate absorption in the tissues due to its rapid biodegradation capability (Houschyar, Tapking et al. 2019) [15].

**After 14 days from implantation,**

Despite the (Unigraft) continuing to degrade in the tissues, densitometric analysis reveals a significant difference in bone density around the implants' serrations between the two groups at this time, with the highest value for the group of (Titanium Implant + Unigraft), indicating more bone formation in the group of (Titanium Implant + Unigraft). This is due to enhanced calcium phosphate solubility, which leads to greater bone formation; this is in line with previous research (Tan, Zhang et al. 2019) [16].At the two-week time point, the remnants of the silicate-based cement were granulated and sparsely distributed within the interior and at the margins of the defects filled by acellularized and vascularized connective tissue from the periphery, indicating that most of the silicate-based cement had been absorbed, according to (Lin, Chen et al. 2020) [14]. There was also appositional growth on the top and bottom surfaces of the surviving bone plate for bone formation, as well as development from the defect's borders.

**After 28 days from implantation,**

The bone density around the Titanium implant showed no significant difference between group of (Titanium implant) and the group of (Titanium implant + Unigraft) at 28 days period.

A significant rise in observed bone density for (Titanium Implant + Unigraft) in this period compared to the previous period could imply that most of the silicate-based cement has been dissolved in tissue and replaced by new bone. This is consistent with the in vitro findings of (Zhu, Ren et al. 2017) [17] on the breakdown profile of silicate-based cement after water immersion (simulated body fluid). The silicate-based cement was shown to deteriorate rapidly in simulated bodily fluid.

## V. CONCLUSIONS

Within the limitations of the present study, it can be concluded that the bioactive bone graft material stimulates more bone formation around the titanium implant. It also accelerates the rate of bone formation at the early stage of bone healing. The titanium implant enhanced by unigraft seems to be a promising implant material

## REFERENCES

[1]. Zhang, Y., Y. Chen, H. Kou, P. Yang, Y. Wang and T. Lu (2018). "Enhanced bone healing in porous Ti implanted rabbit combining bioactive modification and mechanical stimulation." J Mech Behav Biomed Mater 86: 336-344.

[2]. Lopes, H. B., G. P. Freitas, D. M. C. Fantacini, V. Picanço-Castro, D. T. Covas, A. L. Rosa and M. M. Beloti (2019). "Titanium with nanotopography induces osteoblast differentiation through regulation of integrin αV." J Cell Biochem 120(10): 16723-16732.

[3]. Yazdani, J., E. Ahmadian, S. Sharifi, S. Shahi and S. Maleki Dizaj (2018). "A short view on nanohydroxyapatite as coating of dental implants." Biomed Pharmacother 105: 553-557.
[4]. Rupp, F., L. Liang, J. Geis-Gerstorfer, L. Scheideler and F. Hüttig (2018). "Surface characteristics of dental implants: A review." Dent Mater 34(1): 40-57.
[5]. Ottria, L., D. Lauritano, M. Andreasi Bassi, A. Palmieri, V. Candotto, A. Tagliabue and L. Tettamanti (2018). "Mechanical, chemical and biological aspects of titanium and titanium alloys in implant dentistry." J Biol Regul Homeost Agents 32(2 Suppl. 1): 81-90.
[6]. Yu, Y. J., W. Q. Zhu, L. N. Xu, P. P. Ming, S. Y. Shao and J. Qiu (2019). "Osseointegration of titanium dental implant under fluoride exposure in rabbits: Micro-CT and histomorphometry study." Clin Oral Implants Res 30(10): 1038-1048.
[7]. Bosshardt, D. D., V. Chappuis and D. Buser (2017). "Osseointegration of titanium, titanium alloy and zirconia dental implants: current knowledge and open questions." Periodontol 2000 73(1): 22-40.
[8]. Albrektsson, T. and A. Wennerberg (2019). "On osseointegration in relation to implant surfaces." Clin Implant Dent Relat Res 21 Suppl 1: 4-7.
[9]. Satheshkumar S. Ketamine - Xylazine anaesthesia in rabbits. The Indian veterinary journal. 2005; 82(4): 388-389.
[10]. Cottrell J, O'Connor J. Effect of Non-Steroidal Anti-Inflammatory Drugs on Bone Healing. Pharmaceuticals. 2010; 3(5): 1668-1693.
[11]. [11]. Wheatley BM, Nappo KE, Christensen DL, Holman AM, Brooks DI, Potter BK. Effect of NSAIDs on Bone Healing Rates: A Meta-analysis. Journal of the American Academy of Orthopaedic Surgeons. 2019; 27(7): e330-e336.
[12]. Zafar, M. S. and Z. Khurshid (2020). Dental Implants: Materials, Coatings, Surface Modifications and Interfaces with Oral Tissues, Woodhead Publishing.
[13]. Marques, G., L. E. M. Padovan, M. A. Matsumoto, P. D. R. Júnior, E. M. Sartori and M. J. R. R. S.-B. d. O. Claudino (2013). "Bone healing in titanium and zirconia implants surface: a pilot study on the rabbit tibia." 10(2): 110-115.
[14]. Lin, M. C., C. C. Chen, I. T. Wu and S. J. Ding (2020). "Enhanced antibacterial activity of calcium silicate-based hybrid cements for bone repair." Mater Sci Eng C Mater Biol Appl 110: 110727.
[15]. Houschyar, K. S., C. Tapking, M. R. Borrelli, D. Popp, D. Duscher, Z. N. Maan, M. P. Chelliah, J. Li, K. Harati, C. J. F. i. c. Wallner and d. biology (2019). "Wnt pathway in bone repair and regeneration–what do we know so far." 6: 170.
[16]. Tan, J., M. Zhang, Z. Hai, C. Wu, J. Lin, W. Kuang, H. Tang, Y. Huang, X. Chen and G. Liang (2019). "Sustained Release of Two Bioactive Factors from Supramolecular Hydrogel Promotes Periodontal Bone Regeneration." ACS Nano 13(5): 5616-5622.
[17]. Zhu, T., H. Ren, A. Li, B. Liu, C. Cui, Y. Dong, Y. Tian and D. Qiu (2017). "Novel bioactive glass based injectable bone cement with improved osteoinductivity and its in vivo evaluation." Sci Rep 7(1): 3622.