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ORIGINAL ARTICLE

IMPACT OF VITAMIN D3 SUPPLEMENTATION ON DENTAL IMPLANT STABILITY

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Summary

Objectives: The goal of this study was to see how systemic vitamin D3 supplementation affected the durability of dental implants as assessed by radiofrequency analysis.

Methods: This split-mouth clinical trial included a total of twelve patients seeking dental implant therapy, ranging in age from 25 to 50 years. The patients were divided into control group and treatment group. Each patient in both groups received dental implants in posterior maxillary extraction sites. The radiofrequency analysis (RFA) was conducted using Osstell Mentor device to evaluate the stability of dental implant at various time points.

Results: During the three months of the trial, substantial differences between the treatment and control groups were detected according to osstell meter device at the time of insertion (primary stability) and 3 months later (secondary stability).

Conclusion: Vitamin D supplementation has a positive effect on dental implant stability.

Key words: Vitamin D3; Dental implant; Stability; Osseointegration; Radiofrequency analysis; Bone

Introduction

Osseointegration of a dental implant is required for long-term survival; that is, a direct link between the bone and the implant surface must be created with no need for fibrous tissues. Once formed, this tight link must be preserved over long time to provide clinically symptomless implant attachment under functional strain. Osseointegration is a complex process influenced by a number of factors, some of which are linked to the implant (implant surface, material used, and macroscopic design), others to the surgical-prosthetic procedures (time, surgical technique, and loading conditions), and yet others to the patient's condition (host response, quantity/quality of bone at the receiving site) (1).

Systemic circumstances, in addition to local variables, are thought to expedite the qualitative and quantitative loss of alveolar bone (2). Immune response governs wound/tissue healing and regenerative pathways, according to evidence. The findings support the theory that the same mechanisms that activate osseointegration during the early stages of peri-implant tissue healing also trigger osseointegration (3). In the past, vitamin D was thought to be

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a permissive component in calcium metabolism. It's more of a hormone than a vitamin, and it's involved in calcium homeostasis. It also improves bone resorption while lowering calcium and phosphate excretion. Vitamin D receptors are found in osteoblasts and have a direct influence on cells through controlling gene expression as well as other bone-forming proteins such as osteocalcin. Vitamin D is essential for bone health (4). During osseointegration, the effect of calcitriol on calcium and phosphate metabolism, as well as the stimulation and division processes of osteoblasts and osteoclasts, is crucial. For example, it was shown that osteoclasts (osteoclast cells), which lack vitamin D receptors, are formed by the union of 5 to 10 vitamin D-influenced progenitor cells. That receptor is found in osteoblasts (osteogenic cells) (5). Meredith submitted the RFA device in 1996 based on animal research. It is now the most practical, non-invasive, clinical, quantitative tool for evaluating the stability of dental implants at various time periods utilizing vibration. Osstell® ''Osstell AB, Göteborg, Sweden'', which comprises of a wired titanium or stainless steel transducer and cantilever with piezoceramic components, was initially launched, and later Osstell® Mentor and Osstell® ISQ were manufactured with minor modifications (6). The goal of this study was to see how primary and secondary dental implant stability differed in individuals who had dental implants with or without Vitamin D3 supplementation.

Materials and Methods

Study Design: This study involved a total of twelve individuals, with each receiving one implant in the posterior maxillary region(molar/premolar region) who met the following research requirements: they must be adults, aged 25 to 50 years, with vitamin D deficiency (below 30 IU), no history of diseases, non-pregnant and non- lactating females, no history of vitamin D allergy, did not take any drug or supplement for the previous three months, non-smoking, and non-alcoholic and filled out and signed a permission form to participate in this study. The deficiency was researched before the implant surgery for about a week extending to 3 months after surgery when the implant fixture was loaded. Main cause of vitamin D deficiency among those patients was lack of exposure to sunlight to synthesize vitamin D. Any patient who did not meet any of the aforementioned criteria was ruled out. Blood tests were done before the research to obtain the patients vitamin D levels. Patients seeking dental implant therapy ranged in age from 25 to 50 years old. Each patient received a verbal and written permission form (appendix) outlining the operation and its results. All surgical operations were conducted by the same oral surgeon utilizing a uniform surgical method and equipment to eliminate operator-mediated mistakes. Two groups of patients were formed: a control group and a treatment group; each patient in both groups received one dental implant in the posterior maxillary extraction sites. In the treatment group, each patient was to receive a supplementation dose of vitamin D (1000 I/U per day) (7, 8), while the control group was kept without vitamin D supplement. Before administrating local anesthesia, each patient was told to rinse his mouth for one minute with a half cup of 0.2 percent chlorhexidine mouth wash (Kin/Spain). Infiltration of anesthesia into buccal and palatal mucosa was used. Two cartilages were administered, each containing 4 percent Articaine hydrochloride solution and 1:100.000 epinephrine "Colombia". A crestal incision along the surgical site (created somewhat palatally) was made by using a scalpel blade number15, and a three-sided mucoperiosteal flap was softly lifted and reflected using a mucoperiosteal elevator following the deposition of surgical local anesthetic as determined by deep probing (Figure 1A). Under profuse chilled 0.9 percent saline solution, the crestal ridge was cleaned and a typical surgical osteotomy for installation of a dental implant (as given from the manufacturer (Dentium / South Korea, (sandblasted with large grit and acid etched (S.L.A) surface, 10mm in length and a diameter of 3.6mm) was made using an angled surgical handpiece (Figure 1B). The implant fixture was then carefully screwed into the osteotomy bed (Figure 1C).

Before putting the smart peg above the implant fixture to test primary implant stability, the location was cleansed with saline solution, isolated, and dried using cotton rollers (Figure 1D). OsstellTM was used to determine the principal implant stabilities for both the control and treatment groups. ISQ values were recorded in five directions: occlusal, buccal, lingual, mesial, and buccal. The main stability was calculated using the average of the five ISQ readings. The device tip was placed at a distance of 2 mm from the smart peg tip, following a stringent measurement technique. A healing screw was inserted when the readings were completed. The surgical site was evaluated and irrigated with chlorhexidine solution, then flap was replaced to its original area and closed by using a non-absorbable 3-0 black silk suture (Figure 1E).

The surgical region was covered with sterile gauze soaked in 0.2 percent chlorhexidine gluconate, and the patient was encouraged to gently bite on it for 30 minutes. It was necessary to follow the proper post-operative guidelines.

Pain killers (paracetamol tabs) 500 mg daily every 8 hours were provided with amoxicillin tab 500 mg three times daily for five days. Every patient was told to use regular saline mouthwash twice a day until the sutures were removed (after ten days). For densometric analysis, a baseline CBCT radiograph was acquired at the operation site. After three months; The lid screw was removed with a screw driver from the Dentium kit at this interval, and the same process was followed as during the 3-month recall appointment (See Figure 1F), A primary dental implant stability measurement and a secondary dental implant stability measurement were taken.

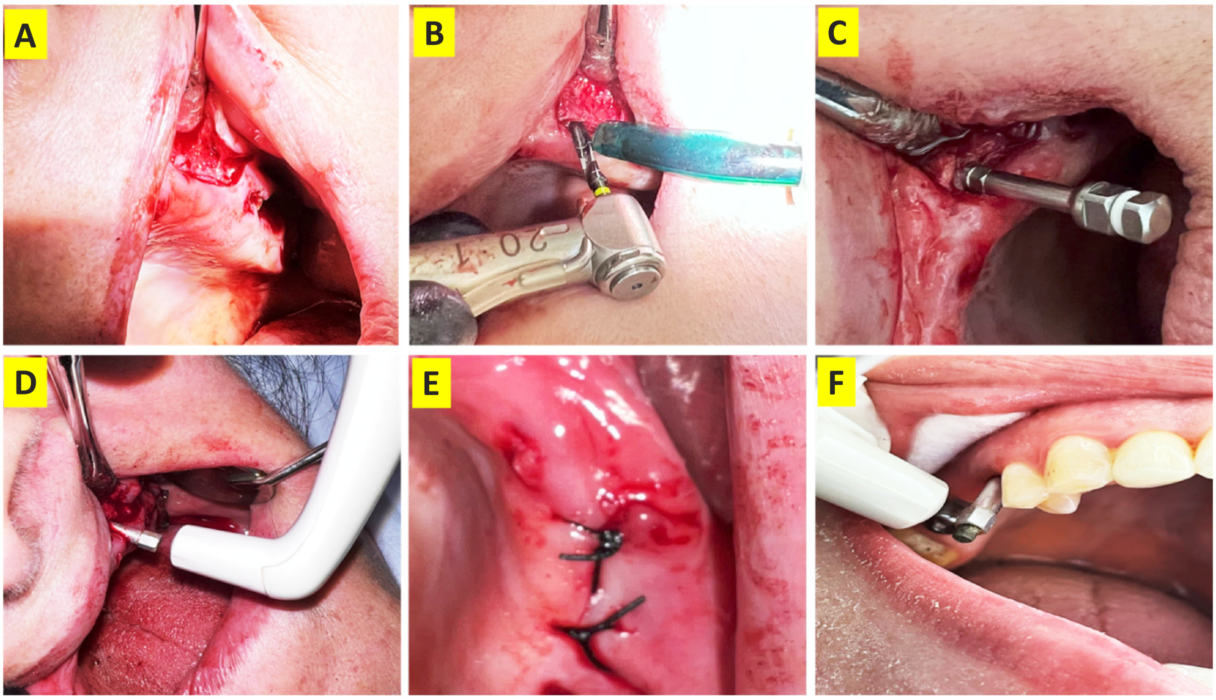

Figure 1. A representative images for the conducted implant surgery from the start to the end.

Statistical Analysis

The information was converted into a digital database structure. The study was carried out with the use of commercially accessible statistical tools (SPSS Version 23.0). The following tests were employed to assess the non-parametric nature of all variables: T–test to evaluate significance between control and treatment groups at time intervals. Descriptive; means and Standard Deviation (SD). Statistical significance was set at (at $P \leq 0.05$).

Results

There were 12 patients in the trial (6 males, 6 females). Patients in the research ranged in age from 25 to 50 years old, with an average age of 40. The total number of dental implants implanted was 20, with half of them going to the control group and half going to the research group. All instances had an uncomplicated post-operative healing phase, with a 100 percent survival rate until the time of prosthetic part implantation. In all instances, bone quality around implants at the operation site was classified as type D3 in treatment patients and type D3 in control patients, according to the Lekholm and Zarb classification. After 3 months, substantial differences were identified between the treatment and control groups, with a considerable increase in dental implant stability in the treatment group, indicating a positive response to vitamin D3 supplementation and significant improvement in implant stability. Table 1 shows standard descriptive data of RFA for both the control and treatment groups (table 1). As demonstrated in Table 2, the results of the Paired Samples Test revealed significant variations in primary and secondary dental implant stability within each group (table 2).

Table 1. Descriptive Statistics of RFA for control and treatment groups during study period.

Group		Minimum	Maximum	Mean
Control (n=24)	Day of surgery	51.00	73.00	63.5±5.6
	After three months	60.00	81.00	68.9±6.6
Treatment (n=24)	Day of surgery	50.00	73.00	63.7±7.1
	After three months	60.00	89.30	77.6±9.2

Table 2. The Comparison between before after RFA measurements within each group.

		Mean ± SD	*P* - value
Control	Day of surgery and after three months	5.02083 ± 5.01190	0.000**
Treatment	Day of surgery and after three months	13.84167 ± 2.85427	0.000**

** Highly Significant at $P \leq 0.01$.

When comparing between RFA measurements in both groups regarding primary stability, the results disclosed a non-significant difference between both control and treatment groups. On the other hand, in secondary dental stability measurement after three months, a highly significant increase of RFA was observed in treatment group (77.5667 ± 9.20258) compared to control group (68.9208 ± 6.57419) [as shown in Table 3 and Figure 2]

Table 3. The Comparison between before and after RFA measurements between groups.

		Mean ± SD	*P* - value
Day of Surgery	Control	63.4833 ± 5.58925	0.896
	Treatment	63.7250 ± 7.11595	
After three months	Control	68.9208 ± 6.57419	0.001**
	Treatment	77.5667 ± 9.20258	

** Highly Significant at $P \leq 0.01$.

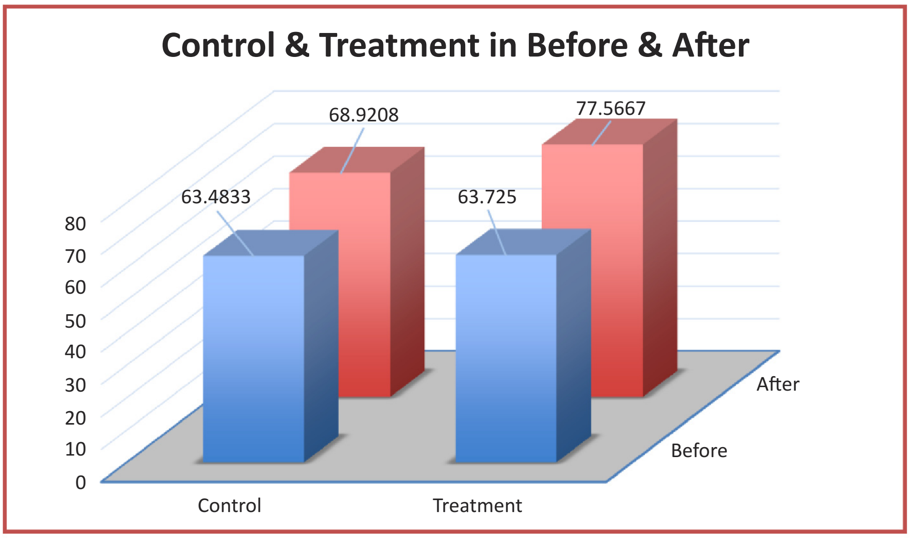

Figure 2. The Comparisons between RFA measurements of both groups at two timetables (day of surgery and following three months).

Discussion

Dental implants are increasingly the treatment of choice for restoring function and aesthetics in dental patients, with excellent results (9, 10). In reality, an expected treatment plan with outstanding survival percentage stands out in the decision-making process for the replacement of missing teeth with a removable or fixed prosthesis (11, 12).

During the early healing stage, homogenization of dental implants in the bone is necessary, as a result of which the attachment is clinically asymptomatic under functional stress (13). The surgical and prosthetic procedure, the surgeon's authority and expertise, the duration of prosthetic loading, the implant surface and material, and, of course, other factors related to patient status such as bone quantity and quality, as well as systemic variables, all have an impact on osseointegration (14, 15). Vitamin D has long been recognized to influence the bones, which is one of the "traditional" tissue targets. Vitamin D is essential for bone metabolism. It maintains the equilibrium of calcium and phosphate in tissues and is required for bone and tooth mineralization (7, 8).

In this study, patients who took Vitamin D3 supplements had higher dental implant durability, indicating excellent osseointegration. This might be because patients who took Vitamin D supplements had reduced bone loss. In this context, it can be explained by Vitamin D's role in the production of anti-inflammatory cytokines and a decrease in pro-inflammatory cytokines, decreasing the body's response to surgical intervention. Calcitriol is an immunomodulator that activates both acquired and innate immune responses (18). The second explanation is Vitamin D's function in calcium metabolism. Vitamin D supplementation may enhance calcium supply, allowing for quicker mineralization of new bone (19). Vitamin D is also known to increase the formation of osteocalcin and alkaline phosphatase in osteoblasts, This may compensate for the effect of lower turnover (20). The findings of this study are consistent with those of Javed *et al*., who found that Vitamin D supplementation may hasten bone formation and hence increase contact of the titanium implant surface with bone (21, 22).

Zhou *et al*. found an increase in osseointegration in osteoporotic rats given Vitamin D supplements (23), while Wu *et al*. found an increase in the percentage of interaction of bone with implant in diabetic rats given Vitamin D supplements (23). According to the findings of this study, vitamin D stimulates osteoblasts and promotes the synthesis of extracellular matrix proteins by osteoblasts (24).

Hong *et al.* examined the positive effects of calcium and vitamin D supplements on bone healing in a canine model by closely monitoring the postoperative recovery of surgically produced alveolar sockets. Few animal studies have looked at the absorption of dental implants into the bones, as well as the link between vitamin D levels and bone health (16, 17, 18, 19, 20). The quantity of 25-hydroxycholecalciferol given on the day of surgery, as well as vitamin D deficient treatment, have a big impact on the osseointegration process' radiologically measured rise in bone level at the implant site (25). bone-to-implant interaction and implant stability have been examined nearly exclusively as a result of vitamin D (22). Vitamin D affects bone metabolism in a variety of ways, including: It promotes extracellular matrix protein creation by osteoblasts and stimulates osteoclast activity by upregulating the gene expression of osteocalcin, osteopontin, and 24-hydroxylase in osteoblasts (26). Vitamin D3's dual function in promoting bone remodeling has been widely researched (25). Vitamin D supplementation is an excellent way to boost your vitamin D levels (27). Because osseointegration of dental implants is dependent on bone metabolism, low vitamin D levels in the blood may have an adverse effect on healing and new bone formation on the implant surface (27). Vitamin D deficiency may also impair bone remodeling around dental implants, likely lengthening the time it takes for osseointegration to take place (24). As a consequence of the current study's findings, it's possible that the creation of osseointegration during the early stages of development may necessitate Vitamin D-dependent regulatory systems. As a consequence of the findings of this study, vitamin D supplementation appears to be a good way to enhance the osseointegration of dental implants (24).

Conclusion

Within the limitations of the current study including the sample size and the short follow-up period. The results showed an important role for vitamin D supplementation in enhancing the healing of dental implant and improvement in its stability.

Acknowledgment

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Conflict of interest

The authors declare no conflict of interest concerned in the present study.

Adherence to Ethical Standards

The study were approved by the Research Ethical Committee and Scientific Committee in the Department of Dental Basic Science of College of Dentistry / University of Mosul (UoM.Dent/H.L4/22). The location of the study was in a private dental clinic in the Province of Zakho / Kurdistan Region / Iraq.

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