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A clinico-relationship between Vitamin D and early implant failure

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ABSTRACT

Background: Due to the fact that osseointegration is contingent on bone metabolism, low vitamin D levels in the blood may have an unfavourable impact on bone development around dental implants. Only a few researches have looked into the probable link between vitamin D levels in the blood and early dental implant failure (EDIF), which happens within three months of placement well before the prosthetic abutment is engaged. The goal of this study was to see if there is a association between low vitamin D levels in the blood and EDIF.

Materials and Methods: This prospective study was conducted among the total of 100 patients within the age group 18-55 years who fulfilled the inclusion & exclusion criteria of the study. These subjects were selected from the patients who visited the outpatient department of Himachal Dental College, Sundernagar. Clinical parameters were assessed at 3^{rd} month post-operatively and implant failures were assessed and correlated with the levels of serum vitamin D.

Results: In our study, 6, 71 and 23 subjects were <10 ng/ml, 10-30 ng/ml and >30 ng/ml vitamin D serum levels respectively. One (1) incidence of failure was reported in patients with high serum levels of vitamin D (>30 ng/mL) (4.3%). Failed implants were revealed maximum among subjects with vitamin D level <10 ng/ml (16.67%), followed by 10-30 ng/ml (7.04%).

Conclusion: The relation between serum Vitamin D levels and early dental implant failure is statistically insignificant. More clinical trials with a prospective design and appropriate statistical analysis are needed, to confirm whether or not a relation between low serum levels of vitamin D and an increased rate of early dental implant failure exists.

1. Introduction

The goal of modern dentistry is to provide a healthy and beautiful smile that is accompanied by a functional and comfortable dentition. Despite all the advances in modern dentistry, tooth loss is still a major public issue worldwide. Tooth loss is usually accompanied by bone loss and affects both the maxilla and mandible. Long-standing edentulism leads to a significant effect on residual bone level leading to a reduction in alveolar bone height and size of denture bearing area; thereby, affecting the esthetic appearance by reducing the facial height. A number of prosthetic techniques are available over time for the rehabilitation of partial or complete loss of tooth/teeth. These methods are, however associated with limitations for many people, and such devices can cause eating difficulties, psychological problems and problems related to aesthetics, retention and stability of prosthesis and a greater amount of risk of the sacrifice of the adjacent healthy tooth structures. In order to overcome the problems associated

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with conventional prosthetic treatment, the dental implants came into existence.

Dental implants are contemplated as a successful treatment for reestablishing the function and esthetics.[1] They have been proven to have a predictable treatment outcome for the replacement of missing teeth with a removable and fixed prosthesis with long term survival rates.[2] The success of dental implants depends upon osseointegration i.e. formation of direct contact between bone and implant. This integration of the implant with bone is necessary during initial healing after insertion of the implant which results in asymptomatic fixation of the implant with the underlying bone and this integration has to be maintained for the long term.[3,4]

Osseointegration is a complex phenomenon which relies upon various variable such as surgical technique, type of prosthesis, quality of underlying bone, implant-related factors[5] (i.e. materials, design,etc). Lately the research has focused on implant related factors more than other elements.[6] Thus, several implant systems have been invented to improve integration and to decrease failure.

Regardless of the way that every one of these upgrades has added to the expansion in the stability of the implant, and widened the utilization of surgical and prosthetic techniques that were earlier viewed as risky, for example, the immediate placement of the implant in a fresh extraction socket; immediate loading protocols. There is still some percentage of implant failures which seems to be difficult to resolve.[7]

Based on the time of failure, implant failures may be classified as early implant failure, late implant failure. Both of them have different underlying etiologies. Early implant failure manifest when there is no osseointegration with the underlying bone. This may be due to poor quality and quantity of bone or impaired healing after implant placement. Late implant failures usually occur after prosthetic loading.[8] They mainly occur to peri-implantitis or occlusal overloading. Early implant failure has also been found to occur when there are sufficient quality and quantity of bone, following the surgical protocol and even after using the optimal material implants making these failures more worrisome for the clinician. These failures are a little difficult to resolve and seem to be related to the patient's systemic health. Recognition of these systemic factors may decrease this failure and improve the credibility of the implantologist. Various minerals, hormones, and vitamins play an important role in bone metabolism and bone remodeling, and bone turnover rate. Some factors (Vitamin D deficiency) particularly play a very significant role but have been ignored in the literature.[9]

Vitamin D is a fat soluble secosteroid (steroid with broken rings) which was first discovered in 1919–1924 as an antirachitic agent. It enters the body through diet or synthesized in skin 7-dehydrocholestrol, by the means of ultraviolet (UV) light of the sun.[10] Cholesterol molecules are first hydroxylated into 25(OH) D in the liver, then 25(OH) D undergoes hydroxylation again in the kidney into the biologically active 1, $25(OH)_2D$. Vitamin D works as a hormone and is vital for all systems of body and is a very important component of bone metabolism. It promotes calcium absorption and regulates calcium and phosphorus metabolism. It increases the osteoclastic activity and the production of extracellular matrix by osteoblasts.[11] T1/2 of 1, 25(OH)2D is only 4 hours, however, t1/2 of 25(OH)D is long i.e. about 3 weeks. Therefore for assessing vitamin D levels in the body, levels of 25(OH)D is assessed. Normally vitamin D levels fluctuate between 25 to 138nmol/L. however, there is no clear agreement on the ideal levels of 25(OH)D. According to European society, clinical practice guidelines vitamin D deficiency is defined as plasma 25(OH)D level <50nmol/L. Values of less than 37.5 nmol/L show vitamin D deficiency and concentrations higher than 200 nmol/L show hypervitaminosis.[12] Vitamin D deficiency is prevalent worldwide. In the north of Italy, upto 80% population can be deficient especially in winters due to less sun exposure.[12]

As osseointegration of implants depends upon bone metabolism, this can be contemplated that low levels of vitamin D may influence bone metabolism which may alter the stability of implants.[13] Only a few studies have yet been done investigating the levels of vitamin D and early implant failures. The purpose of this study was therefore to investigate any possible correlation between blood levels of vitamin D and early implant failure (failure occurring in the three months prior to giving prosthesis, because of a lack of osseointegration or because of infection).

2. Materials and Methods

A total number of 100 patients with edentulous sites, willing to have a dental implant with the age group of 18 to 55 years, comprising both male and female patients visiting the Out-patient Department of Himachal Dental College, Sundernagar, Himachal Pradesh were randomly selected, for the present study. Each patient was explained the details about the risk and benefits of participation in this study. Those who agreed voluntarily were required to sign a consent form prior to their inclusion in the study. The approval for this study was taken from the institutional ethical committee.

Only those patients were included in the study that satisfied the following inclusion and exclusion criteria.

2.1. Inclusion criteria

1. Patients within the age group of 18 to 55 years.
2. Willing to comply with all the study requirements.
3. Absence of any relevant systemic disease.

2.2. Exclusion criteria

1. Poor oral hygiene with no possibility of improvement.
2. Poor compliance.
3. Drug or alcohol abuse.
4. Pathologic changes at the recipient site (cysts, tumors and osteomyelitis).
5. Irradiation in the implant area.
6. Pregnant women and lactating mothers.
7. Patients taking Vitamin supplements.

2.3. Study design

2.3.1. Presurgical procedure

After inclusion of the patients in this study each individual underwent a full diagnostic work- up which included:

1. All the patients included in the study were subjected to detailed medical and dental history.
2. Radio-Visual Graphs (RVG); Orthopantogram (OPG) and Intra Oral Peri Apical Radiographs (IOPAR).
3. Clinical photographs, Diagnostic casts.
4. Routine Blood Investigations- Bleeding time, Clotting time, Total Leucocyte Count, Differential Leucocyte Count, Haemoglobin, Blood Glucose Level, Enzyme linked Immunosorbent Assay (ELISA) test for HIV, HbsAg for Hepatitis-B.
5. **Assessment of serum Vitamin D Status:** Venous blood samples of all the selected patients were taken from median cubital vein present in antecubital fossa of the forearm in a standardized fashion.

   On the basis of serum concentration of vitamin D patients were classified as:

   (a) Severely deficient patients (serum vitamin D <10 ng/mL),
   (b) Patients with low levels (serum vitamin D 10–30 ng/mL), and
   (c) Patients with optimal levels of vitamin D (serum vitamin D >30 ng/mL).

6. The length and diameter of the implant were calculated for each patient based on an intraoral examination, RVG, IOPAR, and OPG radiographic evaluation.
7. Complete oral prophylaxis was done and oral hygiene instructions were given to the patients who were instructed to take antibiotics and analgesic 1 hour before surgery.
8. The patient was recalled for implant placement after one week.

2.3.2. Surgical procedure

Following procedure was performed for all patients by the same surgeon according to the same precise methodology. Bioline implant system i.e. implant kit (Figure 1) Bioline implants (Figures 2 and 3) were used.

1. The patient was scheduled for implant surgery after phase I therapy. After achieving profound anesthesia the mucoperiosteal flap was elevated.
2. After marking the site, a pilot drill (D-1.9mm) was put to use for creating the osteotomy site of approximate depth for implant placement. It was indexed with various markings (6mm,8mm,10mm,11.50mm,13mm,16mm) cor to the desired implant lengths.
3. When approximate depth was reached with the pilot drill; the implant probe was used for tactile perception of intact bony plates and for perforations and the confirmation of the desired osteotomy depth.
4. Once the desired depth was confirmed, paralleling pins were placed to check the proper alignment of the implant with adjacent teeth & opposing occlusion.
5. The implant site was generously irrigated with sterile saline to remove any residual bone chip/another residue following preparation.
6. The depth of implant osteotomy site was ascertained with implant depth probe. The implant was removed from the sterile vial using insertion tool and delivered into the osteotomy site.
7. The implants were then placed into the prepared site with manual pressure aided by the insertion mount and insertion tools attached to the implant head.
8. Following which the insertion mount was removed and hex driver was placed into the implant internal hex and ratcheted with torque-controlled implant ratchet. Care was taken not to allow excessive force application while insertion. Implant was checked for stability by applying gentle pressure to determine if it could be depressed or rotated. Primary stability was also assessed with the torque controlled ratchet.
9. All implants were placed within the alveoli confines and were clinically stable at the time of insertion. Torque and reverse torque was checked at the time of implant insertion.
10. Then the primary closure of the wound was achieved by stabilization of the flap using simple interrupted sutures with monofilament 4-0 reverse cutting.

All the patients were recalled after 7 days for the suture removal. Patients were recalled at 3 months for checking the stability of the implant and further for giving prosthesis.

2.4. Clinical parameters were assessed 3rd month post-operatively.

2.4.1. • Stability of implant

Stability of implants was assessed with following methods:

Insertion torque is the rotational force recorded during the surgical insertion of a dental implant into the prepared

Fig. 1:

Fig. 2:

site, and it is expressed in Newton centimeters. In this present study we checked the insertion torque for each patient and observed insertion torque ≥ 30 Ncm for both groups indicating a good primary stability.

The Percussion test involves the tapping of a mirror handle or other instrument against the implant carrier and judging stability by the sound. This test is based upon vibrational acoustic science and impact response theory. A clinical judgment on osseointegration is made based on the sound heard upon percussion with a metallic instrument. A clearly ringing "crystal" sound indicates successful

Fig. 3:

osseointegration, whereas a "dull" sound may indicate no osseointegration

Reverse torque test is the application of a reverse or unscrewing torque to the implant at the time of abutment connection. It was proposed in 1984 by Roberts et al. and was developed later by Johansson and Albrektsson in 1987.[14]Then presence or absence of dental implant movement was recorded as well as any incidence of pain or clinical signs were recorded. This test has a special advantage as this can be used before stage 2 surgery and the stability of implant can be assessed. Torque is commonly expressed as Newton Centimeter (Ncm).[15,16] Advantages of reverse torque test:

1. Non invasive
2. Easy to apply
3. Cheap
4. Objective diagnostic tool

2.5. Reverse torque < 30N cm – implant mobility Reverse torque > 30N cm – implant stability

Radiographic Assessment:

2.5.1. • Peri-implant radiolucency:

Standardized intraoral peri-apical radiograph was obtained for each implant site at 3rd month after placement of the implant. The X-ray unit with long cone paralleling device was used to assess the peri implant radiolucency.

On the basis of clinical and radiographic parameters at 3^{rd} month the subjects were divided into two group's i.e.

1. Implant Survival Group.
2. Early Implant Failure Group.

The data thus collected was subjected to statistical analysis.

2.6. Statistical analysis

Data so collected was tabulated in an excel sheet and was analysed using SPSS version 24.00 for windows (SPSS inc, Chicago, USA). The statistical analysis for the present study was done by applying the Chi-square test: Difference between two groups (Stable Implants and Failed Implants) was determined and the level of significance was set at $p \leq 0.05$.

3. Results

This study was conducted among the total of 100 patients within the age group 18-55 years who fulfilled the inclusion & exclusion criteria. Serum vitamin D status was measured in Dr. Lal Pathlabs by ECLIA method situated in Sundernagar, Himachal Pradesh, in the period between November 2018 and September 2020, for the present study. Failed implant was reported among the seven subjects.(Table 1).

Clinical parameters were assessed 3rd month post-operatively. The stability of dental implants was evaluated at 3rd month from the day of implant placement during 2nd stage surgery. Patients were randomly selected.

Further, both the groups were divided on the basis of vitamin D levels per patient and the relationship was investigated whether there was correlation between early dental implant failure and levels of vitamin D. The results are tabulated and are as follows:

In our study, there were 52 males and 48 females. EDIF were found among 4 (7.69%) males and 3 (6.25%) females with statistically insignificant difference (Table 2).

In our study, 21, 53 and 26 subjects belonged to age group of <30 years, 30-50 years and >50 years respectively. Failed Implants were revealed maximum among >50 years subject's (11.54%) followed by 30-50 years and <30 years. When implant stability was compared statistically according to different age groups, it was found to be statistically insignificant (Table 3).

In our study 6, 71 and 23 subjects were < 10 ng/ml, 10-30 ng/ml and > 30 ng/ml vitamin D serum levels respectively. Failed Implants were revealed maximum among subjects with vitamin D level < 10 ng/ml (16.67%), followed by 10-30 ng/ml (7.04%). One (1) failure was reported among subjects having vitamin D serum levels > 30ng/ml (4.3%). When implant stability was compared statistically according to vitamin D serum level, it was found to be statistically insignificant as $p < 0.05$ (Table 4).

4. Discussion

Dental implants are generally considered a safe and highly predictable surgical procedure performed by many clinicians with the aim of replacing missing teeth. Yet, to this day, a number of implants placed in adequate bone volume are lost each year within a 2- to 8-week period following implant placement for unexplained reasons. Most commonly used are titanium intraosseous implants whose biocompatible surface permits a persistent connection between the living bone tissue and the implant. The implant placement procedure results in the formation of a post-operative wound within the soft and hard tissues. The relationship between the implant and the surrounding tissue is a continuous and dynamic process also called as "osseointegration". The process of osseointegration is a constant and dynamic relationship between the implant and the surrounding tissue. "Osseointegration," according to Bosshardt et al.,[17] is the establishment of an unmediated bone-implant interface. Dental implants should be thoroughly homogenized in the bone throughout the early healing period, with the end result being a clinically asymptomatic fixation under functional stress. The surgical and prosthetic protocol, the surgeon's experience and authority, the time of prosthetic loading, the surface and material of the implant, and other patient-related criteria such as bone quality and quantity all influence osseointegration.[18]

In recent years, research has mostly concentrated on surgical and prosthetic techniques, as well as implant features, in order to lower implant failure rates even more. As a result, different implant designs and threads have been tested in an effort to improve implant stability and minimize failure rates. Failures can be classed as "early dental implant failures" (EDIFs) or "late dental implant failures" (LDIFs) based on chronological criteria (LDIFs). EDIFs are caused by failed osseointegration, indicating poor bone healing, whereas LDIFs are caused by osseointegration failure. Inappropriate surgical and prosthetic procedures, surgical difficulties, insufficient bone volume or quality at the recipient site, or habits (smoking and parafunctions) that, in combination with systemic diseases, can threaten osseointegration are regarded to be the most common causes of EDIF.[19,20] The identification of systemic risk factors may help to minimize dental implant failure rates and improve predictability. Some factors, such as vitamin D insufficiency in the blood, may play a role in the development of EDIFs, but the dental literature has mostly overlooked this possibility. Alvim-Pereira et al.[21] conducted a clinical study in 2008 to look into the link between vitamin D receptor gene variation and dental implant loss, but found no link.[21]

Bryce et al.[22] investigated the link between vitamin D deficiency and the placement of dental implants in 2014. The patient was found to be severely vitamin D deficient in this case study, which may have contributed to the implant

Table 1: Distribution of overall patients and implant stability.

Parameter	Value
Overall	100
Stable Implants	93
Failed Implants	7

Table 2: Comparison of overall patients and implant stability according to gender.

Gender	N	Stable Implants	Failed Implants	Failed Implants %	p value
Male	52	48	4	7.69	0.82
Female	48	45	3	6.25	

Table 3: Comparison of overall patients and implant stability according to age at surgery.

Age at Surgery	N	Stable Implants	Failed Implants	Failed Implants %	p value
<30 Years	21	20	1	4.76	
30-50 Years	53	50	3	5.66	0.09
>50 Years	26	23	3	11.54	

Table 4: Comparison of overall patients and implant stability according to vitamin D serum levels

Vitamin D serum levels	N	Stable Implants	Failed Implants	Failed Implants %	p value
<10 ng/ml	6	5	1	16.67	
10-30 ng/ml	71	66	5	7.04	0.28
>30 ng/ml	23	22	1	4.3	

failure. Schulze-Spate et al.[23] evaluated the relationship between vitamin D supplementation and local bone development following maxillary sinus augmentation in a randomized, double-blind, controlled clinical experiment two years later. Six to eight months following surgery, they compared bone samples from a group of patients who received vitamin D3 (5,000 IU) and calcium (600 mg) to a group of patients who received only calcium. Nonetheless, there was no substantial distinction at the histology level.

Both implant survival and implant failure groups were divided on the basis of vitamin D levels per patient and the relationship was investigated whether there was correlation between early dental implant failure and levels of vitamin D. According to vitamin D classification three groups were made:

Group-1 Deficient (<10 NG/ML)

Group -2 Insufficient (10-30 NG/ML)

Group-3 Optimal (>30 NG/ML)

In our study, 6, 71 and 23 subjects were <10 ng/ml, 10-30 ng/ml and >30 ng/ml vitamin D serum levels respectively. One (1) incidence of failure was reported in patients with high serum levels of vitamin D (>30 ng/mL) (4.3%). Unstable implants were revealed maximum among subjects with vitamin D level <10 ng/ml (16.67%), followed by 10-30 ng/ml (7.04%) as seen in Table 4. When implant stability was compared according to vitamin D serum level, it was found to be statistically insignificant. The study showed a tendency for EDIFs to increase in patients with vitamin D–deficient states in the blood,although is statistically insignificant in accordance with the studies done by F.G Mangano,[24] Bryce[22] & Alvim-Pereira.[21] In fact, the incidence of early implant failure was rather low (4.3%) in patients with normalized levels of vitamin D in the blood (>30 ng/mL), rose to almost double (7.04%) in patients within sufficient serum levels (10–30 ng/mL), and were rather high (16.67%) in patients characterized by severe deficiency states. Despite the fact that patients with deficient states had a higher risk of early failure, the differences between the three groups of patients were not statistically significant in our analysis.

However, there has been very little clinical research on the effects of vitamin D insufficiency on osseointegration and bone regeneration in dentistry. This is likely due to the fact that there are numerous factors that can influence the success or failure of dental implants; clinicians have been concentrating their efforts on developing surgical and prosthetic protocols as well as identifying new materials and implant surfaces to improve osseointegration rather than analyzing patient-related risk factors.

The current study's strengths is its prospective design, and it is one of the few in India. The study's sample size is, nonetheless, a limitation. As a result, randomized, controlled clinical trials are required to demonstrate the existence of a link between low vitamin D serum levels and an increased risk of early implant failure. It would be prudent to investigate whether vitamin D supplementation in the weeks leading up to the procedure could reduce early failures, whether due to osseointegration issues or implant

infection. In order to fully study this issue, additional scientific studies with an adequate design and a more powerful empirical analysis would be required.

5. Conclusion

Only a few investigations, mostly in animals, have looked at the link between vitamin D levels in the blood and dental implant osseointegration. According to these research, appropriate vitamin D levels in the blood can help peri-implant bone tissue repair faster. Within the limitation of study, following conclusions were drawn from the present study:

1. The relation between serum Vitamin D levels and early dental implant failure is statistically insignificant.
2. More clinical trials with a prospective design and appropriate statistical analysis are needed, to confirm whether or not a relation between low serum levels of vitamin D and an increased rate of Early Dental Implant Failure exists.

Vitamin D deficiency is one of the most common vitamin deficiencies world has ever known, and studies have shown a clear link between bone tissue homeostasis and remodeling. Vitamin D has an impact on the osseointegration of intraosseous implants at various stages. Given the high prevalence of vitamin D deficiency among patients, it is reasonable to measure 25(OH)D levels in the blood prior to implantation and consider supplementing. The fact that the majority of the population has low vitamin D levels leads to the conclusion that a severe deficiency is not a direct cause of osseointegration failures. Its synergistic effect with other risk factors, on the other hand, appears to be extensively documented. To summarize, our findings suggest that more long-term research with a large sample size is needed to evaluate the relationship between osseointegration of implants and serum Vitamin D concentration levels, as well as to develop a procedure for treatment when a deficiency is discovered.

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7. Conflict of interest

The authors state that they have no competing interests in the release or authorship of this work.

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None.

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