https://doi.org/10.48047/AFJBS.6.14.2024.10420-10430

African Journal of Biological Sciences

Journal homepage: http://www.afjbs.com

Research Paper Open Access

Assessment of Osteocalcin in Peri-implant Crevicular Fluid and Radiographic Bone Loss with Crestal and Subcrestal Dental Implants

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Article History

Volume 6, **Issue** 14, 2024

Received: 15 July 2024

Accepted: 31 August 2024

doi: 10.48047/AFJBS.6.14.2024.10420-10430

Abstract:

Background: Dental implants have emerged as the favored option for replacing teeth that are missing. **Aim and objectives**: To compare clinically, radiographically, and biochemically the crestal and subcrestal positioning of dental implants, **Patients and methods**: This randomized controlled clinical investigation has been performed on twenty systemically healthy cases of both sexes (10 men and 10 women) varying in age from twenty to fifty-five years. The cases included in the study have been chosen only from those who visited the outpatient's clinic at the Oral Medicine and Periodontology Department of the Faculty of Dental Medicine at Al-Azhar University, Assiut Branch. All chosen cases with partial edentulous maxillary anterior and premolar areas assessed by clinical and radiographic examination and indicated for delayed dental implant placement, **Results**: There was statistically insignificant variance according to osteocalcin level at (base line), (1w), (1m), and (3m) between (Group one) and (Group two), where (p-value equal 0.173), (p-value equal 0.974), (p-value equal 0.620), and (p-value equal 0.448), respectively. Regarding implant stability, there was a statistically significant variance at (base line) and (6 m) among (Group one) and (Group two), where (p-value equal 0.036) and (p-value less than 0.001), respectively. **Conclusion**: Subcrestal positioning of implants with platform switching enhances stability and minimizes bone loss around delayed dental implants. Osteocalcin levels in peri-implant crevicular fluids show insignificant variance among equicrestal and subcrestal placements. Both crestal and subcrestal positioning affect peri-implant probing depth, soft tissue thickness, and radiographic bone density.

Keywords: Osteocalcin, crestal dental implants, subcrestal dental implants

1. Introduction

Dental implants have emerged as the preferred option for replacing teeth that are absent. Over the previous decade, the success rate of dental implants has risen from 93.5 percent to 97.1 percent, indicating improved outcomes and fewer complications. The demand for implantology is rising as cases seek therapies that provide enhanced aesthetics and comfort. [1]

The usage of dental implants for tooth replacement is based on advancements in the understanding and application of osseointegration principles and technologies. Due to well-documented osseointegration, the use of implant-supported prostheses has shown enhanced functionality, preservation of bone structure, and improved esthetics. [2]

Platform switching (PLS) is a technique utilized to maintain the levels of alveolar bone surrounding dental implants. The approach involves using narrower-diameter restorative abutments on broader-diameter implants instead of using abutments with similar diameters, which is known as platform matching (PLM). Consequently, by raising the width of the epithelial collar surrounding the abutment, a thicker & more tight seal is formed around the abutment, thereby reducing the formation of pockets around it. The primary focus is on promoting the health of the gingival while also increasing the amount of soft tissue & maintaining the crestal bone level.[3]

Preserving the peri-implant bone at the crestal level is critical for the success of the procedure. This is because the stability of the soft tissue, which is important for esthetics & long-term survival, depends on the bone surrounding the implant. [4] Various authors in this field of study emphasize that the placement of the implant in relation to the crestal bone is a crucial determinant in maintaining bone integrity in the long term. [5]

Osteocalcin (OC) is a protein found in the non-collagenous matrix of tissues that undergo calcification. Osteoblasts make it, and it has been identified as the most precise indicator of osteoblast activity.[6] Osteocalcin has been detected in the gingival crevicular fluid of cases with periodontal illness. Elevated levels of osteocalcin in the gingival crevicular fluid are linked to increased rates of bone turnover. The higher concentration of osteocalcin indicates greater bone formation and reduced bone resorption. It was hypothesized that the levels of osteocalcin could potentially indicate the extent of periodontal inflammation. [7]

The purpose of this work was to compare clinically, radiographically, and biochemically the crestal and subcrestal positioning of dental implants.

Patients and methods

This randomized controlled clinical investigation has been carried out on twenty systemically healthy cases of both sexes (10 women & 10 men) varying in age from twenty to fifty-five years. The cases included in the study were chosen exclusively from those who received treatment at the outpatient's clinic of the Oral Medicine & Periodontology Department, Faculty of Dental Medicine at Al-Azhar University, Assiut Branch. All selected patients with partial edentulous maxillary anterior and premolar areas were assessed by clinical and radiographic examination and indicated for delayed dental implant placement.

Case grouping and randomization: Cases have been divided randomly into the following two equal groups: Group I contain 10 cases of platform-switched dental implants with subcrestal

placement by 1.5mm and Group II contains 10 cases of platform-switched dental implants with equicrestal placement.

Ethical approval: The investigation protocol received approval from the ethics committee of the Faculty of Dental Medicine, Al-Azhar University, Assiut Branch, with the reference number AUAREC20220003-10.

Inclusion criteria: adult patients aged over 18 years, all free from systemic diseases, cooperative, motivated, and maintaining good oral hygiene. Cases with missed maxillary anterior and premolar teeth have been advised for delayed dental implant placement. All patients had sufficient vertical inter-arch space for restorative components, were free from parafunctional habits, and had sufficient bone quality and quantity. Preoperative radiographs have been conducted to evaluate the implant site, and opposing teeth were not drifted, malposed, or over-erupted.

Exclusion criteria: Patients with heavy smoking, alcohol or drug abuse, pregnant or lactating women, head and neck cancer patients, chemotherapy patients, those who have received or lost implants, uncontrolled periodontal conditions or oral diseases, sites with acute inflammation or infection, and the inability to achieve primary implant stability may all be affected.

Methods

Pre-surgical preparation: personal data, medical history, dental history, clinical examination, periodontal preparation, radiographic preparation, and clinical photographs

Surgical Procedures:

Before surgery, all patients were rinsed with 20 ml of chlorhexidine-gluconate 0.12% solution (DG-wash) ®1 for 30 seconds as a topical antimicrobial agent. A surgical site was locally anesthetized by Artinibsa® 140 mg/0.01 mg/ml (Articaine hydrochloride + Epinephrine (adrenaline). A fifteen-bladed instrument has been utilized to make an incision at the top of the desired implant location. A flap of tissue was then lifted, going beyond the planned lower limit of the pre-determined implant length. This technique allows for careful assessment of the buccal aspect of the alveolar bone ridge at the implant site. The drilling of the implant was done in a sequential manner. The implant has been eliminated from its vial and inserted about 1.5 mm subcrestally in group one and equicrestally in group two according to the determined length and width according to the analysis of each case done by cone beam computed tomography. It was the insertion of abutments of a lesser diameter than the implant's platform that created the platform modification. A smart peg has been utilized to assess and calculate the initial stability of an implant utilizing the implant stability quotient (ISQ) with the aid of an Ostell®1 device. A healing abutment, which filled the hole created, was implanted immediately following the original implant, which had been inserted prior to the wound being closed. This allowed for clinical and biochemical assessment throughout the investigation's observation durations. The wound has been closed with interrupted 4/0 non-resorbable prolene sutures. The first binding has been applied to accurately situate the coronal margin of the flap in the appropriate location. The sutures have been extracted within a period of ten to fourteen days after the surgery.

Clinical Evaluation: The clinical data that have been measured for all implants were baseline, 3-month, 6-month, and 12-month recordings. The parameters assessed were the modified sulcular bleeding index (mSBI), peri-implant probing depth (PIPD), modified plaque index (mPI), peri-implant soft tissue thickness, and implant stability.

Radiographic evaluation: A radiographic evaluation by cone beam CT was done for all patients to assess marginal bone loss and bone density at the base line, six- and twelve-months following implant placement.

Biochemical evaluation: Osteocalcin level in a peri-implant crevicular fluid (PICF) sample was measured using a human osteocalcin ELISA kit ®[1] at baseline, one week, one month, and three months following implant placement:

Statistical analysis: The mean & SD values have been determined for each group in each test. The data was examined for normality utilizing the Kolmogorov-Smirnov & Shapiro-Wilk tests; however, the results indicated a non-parametric (non-normal) distribution. To comparison among two groups in non-related samples, Mann-Whitney has been implemented. To compare two groups in related samples, Wilcoxon has been implemented. The significance level has been established at $P \leq 0.05$, and Spearman correlation has been utilized to determine the association among various parameters. IBM® SPSS® Statistics Version twenty for Windows has been utilized to conduct the statistical analysis.

RESULTS

Regarding peri-implant probing depth (PIPD), a statistically insignificant variance has been observed at (base line), (3m), (6m) and (1y) among (Group one) and (Group two) where (p-value equal 0.196), (p-value equal 0.058), (p-value equal 0.369) and (p-value equal 1) correspondingly (Table 1).

Table (1): The mean ± standard deviation and p-values of peri-implant probing depth (PIPD) in mm for both groups.

Variables	PIPD								
	Group I				Group II				p-value
	Min	Max	Mean	standard deviation	Min	Max	Mean	standard deviation	
Baseline	0.50	2.00	1.25	0.42	1.00	2.00	1.50	0.41	**0.196ns**
After 3m	1.00	2.00	1.50	0.41	1.00	3.00	2.00	0.67	**0.058ns**
After 6m	1.00	3.00	2.00	0.67	1.50	3.00	2.25	0.54	**0.369ns**
After 1y	2.00	3.00	2.50	0.47	2.00	3.00	2.50	0.41	**1ns**
p-value	**<0.001***				**<0.001***				

*; significant (p<0.05) ns; non-significant (p>0.05)

According to Implant stability, as measured by ISQ, showed a statistically significant distinction among the first group and the second group at baseline and six months after surgery, with p-values of 0.036 and <0.001, correspondingly (Table 2).

Table (2): The mean ± standard deviation & p-values of implant stability in ISQ for both groups.

Variables	Implant stability								
	Group I				Group II				p-value
	Min	Max	Mean	standard deviation	Min	Max	Mean	standard deviation	
Primary	55.00	87.00	70.00	10.30	44.00	75.00	59.00	11.39	**0.036***

Secondary	95.00	98.00	96.70	1.16	75.00	91.00	83.00	5.10	**<0.001***
p-value	**<0.001***				**<0.001***				

Regarding Peri-implant soft tissue thickness, there statistically insignificant distinction has been detected at (base line), (3m), (6m) and (1y) between (Group one) and (Group two) where (p-value =0.773) (p-value equal 0.584) (p-value equal 0.764) (p-value equal 0.470) correspondingly (Table 3).

Table (3): The mean ± standard deviation and p-values of peri-implant soft tissue thickness in mm for both groups.

Variables	Per-implant soft tissue thickness								
	Group I				Group II				p-value
	Min	Max	Mean	standard deviation	Min	Max	Mean	standard deviation	
Baseline	1.00	2.00	1.35	0.47	1.00	1.50	1.30	0.26	**0.773ns**
After 3m	1.00	2.00	1.50	0.41	1.00	2.00	1.40	0.39	**0.584ns**
After 6m	1.00	2.00	1.65	0.34	1.00	2.00	1.60	0.39	**0.764ns**
After 1y	1.50	2.50	1.85	0.34	1.50	2.00	1.75	0.26	**0.470ns**
p-value	**0.029***				**0.010***				

Regarding marginal bone loss, a statistically significant distinction has been observed at (6m) and (1y) between (Group one) and (Group two) where (p-value equal 0.015) (p-value less than 0.001) respectively (Table 4).

Table (4): The mean ± SD and p-values of marginal bone loss in mm for both groups.

Variables	MBL								
	Group I				Group II				p-value
	Min	Max	Mean	standard deviation	Min	Max	Mean	standard deviation	
After 6m	0.26	0.56	0.40	0.10	0.30	0.64	0.52	0.10	**0.015***
After 1y	0.52	0.76	0.62	0.08	0.73	0.96	0.85	0.08	**<0.001***
p-value	**<0.001***				**<0.001***				

Regarding bone density, there was statistically insignificant variation at (base line), (6m) and (1y) among (Group one) and (Group two) where (p-value equal 0.578) (p-value equal 0.910) (p-value =0.658) respectively (Table 5).

Table (5): The mean ± standard deviation and p-values of bone density in Hu for both groups.

Variables	Bone density								
	Group I				Group II				p-value
	Min	Max	Mean	standard deviation	Min	Max	Mean	standard deviation	

Baseline	452.00	617.50	490.09	59.33	383.20	680.50	508.31	82.46	**0.578ns**
After 6m	328.20	580.20	504.11	88.23	464.30	548.20	507.48	30.10	**0.910ns**
After 1y	510.20	688.70	597.90	55.50	517.00	704.50	585.45	67.57	**0.658ns**
p-value	**0.017***				**0.003***				

There was statistically insignificant variance regarding osteocalcin level at (base line), (1w), (1m) and (3m) between (Group one) and (Group two) where (p-value equal 0.173) (p-value equal 0.974) (p-value equal 0.620) (p-value equal 0.448) respectively (Table 6).

Table (6): The mean ± SD and p-values of osteocalcin level in ng/mL for both groups.

Variables	**Osteocalcin level**								
	Group I				**Group II**				**p-value**
	Min	**Max**	**Mean**	**standard deviation**	**Min**	**Max**	**Mean**	**standard deviation**	
Baseline	0.79	1.19	0.98	0.14	0.67	1.09	0.89	0.15	**0.173ns**
After 1w	0.64	1.36	0.98	0.25	0.84	1.26	0.98	0.14	**0.974ns**
After 1m	0.64	1.29	0.85	0.21	0.61	1.03	0.81	0.14	**0.620ns**
After 3m	0.62	1.14	0.84	0.17	0.67	0.95	0.79	0.09	**0.448ns**
p-value	**0.264ns**				**0.002***				

CASE PRESENTATION

Group (I) (sub crestal)

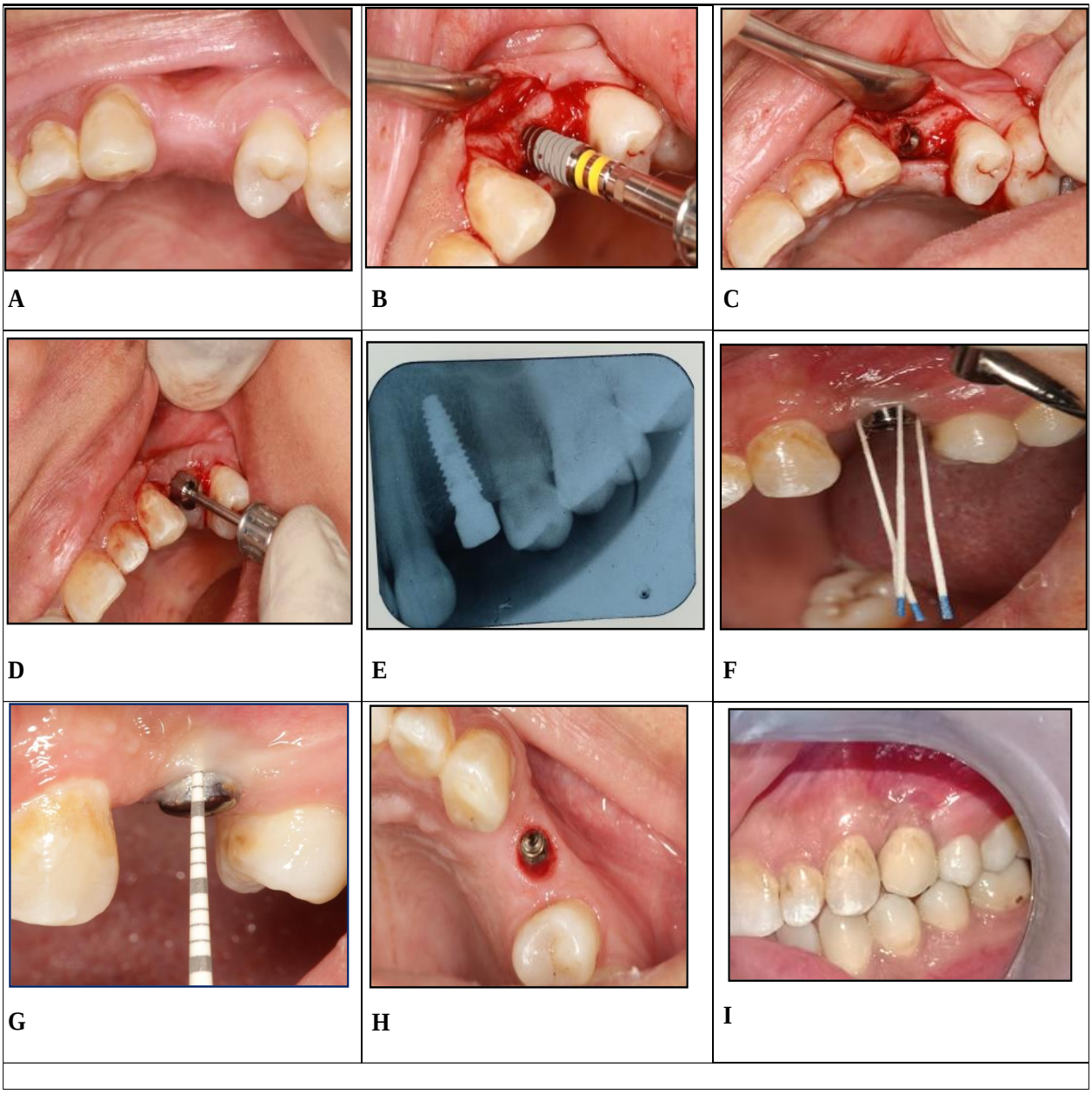

Figure (1): Clinical photographs of 35 years old female patient showing (A) Preoperative clinical photograph (B) Implant placement (C) sub crestal implant position (D) implant with healing abutment (E) Periapical radiograph after surgery (F) peri-implant sulcular fluid sample collection (G) probing depth measurement (H) Soft tissue healing around dental implant (I) Final restoration

Group (II) (crestal)

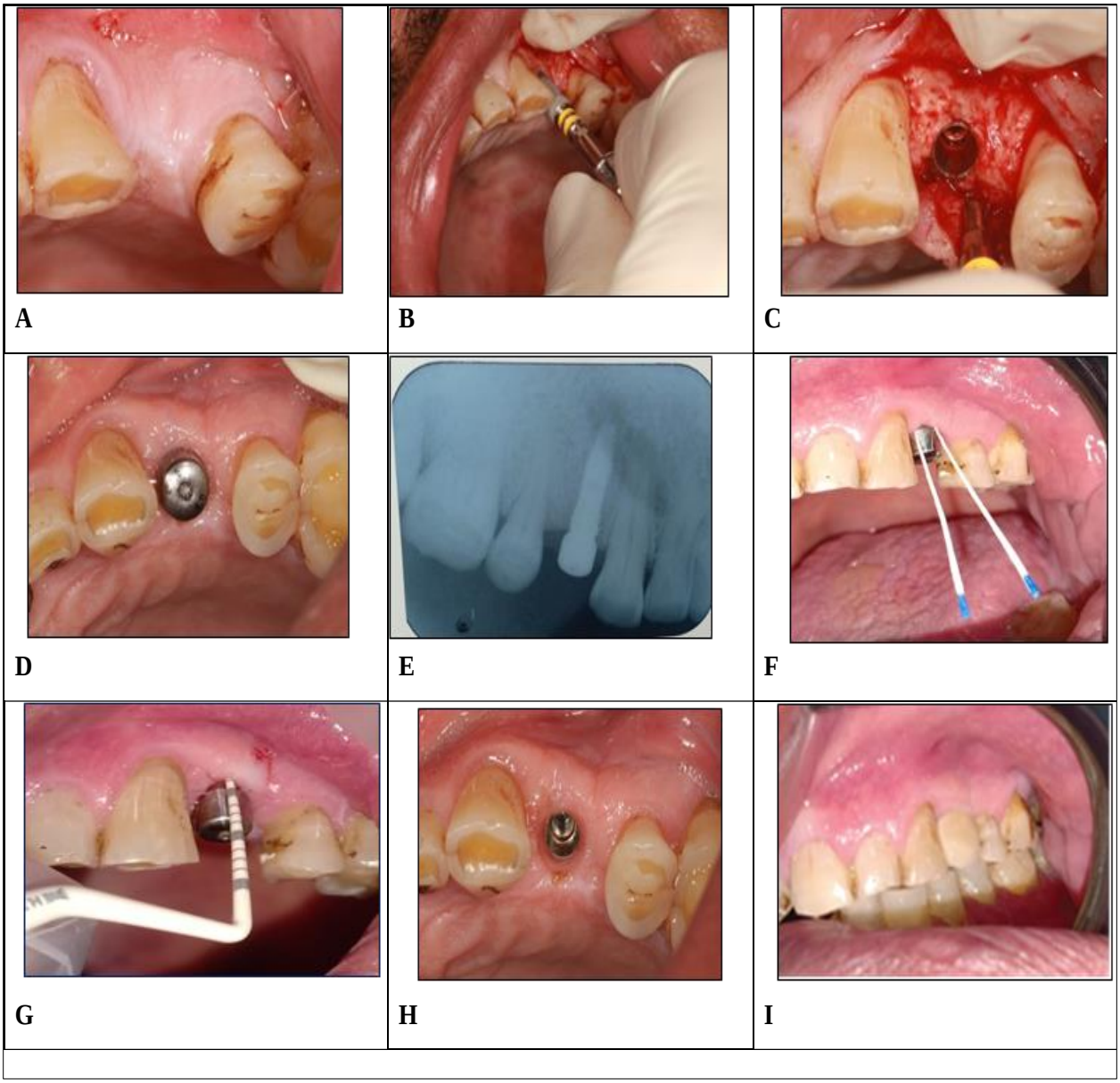

Figure 2: Clinical photographs of 55 years old male patient showing (A) Preoperative clinical photograph (B) Implant placement (C) Equicrestal implant position (D) implant with healing abutment (E) Periapical radiograph after surgery, (F) peri-implant sulcular fluid sample collection (G) probing depth measurement (H) soft tissue healing around dental implant (I) Final restoration

DISCUSSION

There were statistically insignificant variations in probing depth among the first group and the second group at baseline, three months, six months, and one year, with p-values of 0.196, 0.058, 0.369, and 1, correspondingly. The findings of this investigation align with the investigation performed by **Cruz et al.,**[8] which determined that there was statistically insignificant variance in probing depth (measured in millimeters) among crestal as well as subcrestal implant placement (P =.70; mean difference: 0.07 millimeter; ninety-five percent confidence interval: 0.42 to 0.29 millimeter).

In another investigation performed by **Kütan et al., [9]** the peri-implant probing depth was analyzed, and it was revealed that there was statistically insignificant variation among both groups at baseline (T0), sixth month (T2), third month (T1), 12th month (T3), and 36th month (T4) ($p > 0.05$).

The present findings demonstrate the average values of the 1ry and 2ry stability after 6 months as 70.00 ± 10.30 and 96.70± 1.16 for the group I and 59.00± 11.39 and 83.00 ± 5.10 for the group II, respectively, with a statistically significant variance at (base line) and (six month) among (Group one) and (Group two) where (p-value=0.036) ($p<0.001$), respectively, that were within the accepted levels and consistent with studies conducted by **Shiigai [10]; Anitha et al.,[11]** stated that stability of implant with implant stability quotient more than sixty two deemed appropriate.

Peri-implant soft tissue thickness is typically measured among one & two millimeters below the mucosal margin, based on the measurement technique. Evaluating the mid-facial peri-implant mucosa is necessary for assessing the aesthetic results of implant therapy. Studies have shown that a minimum tissue thickness of 1.5 millimeters is necessary to minimize noticeable color changes on abutments. **[12]** The present study recorded mean values of the peri-implant soft tissue thickness at (base line), (3m), (6m) and (1y) 1.35± 0.47, 1.50± 0.41, 1.65± 0.34, 1.85± 0.34 for group I, respectively, and the mean values of the peri-implant soft tissue thickness at (base line), (3m), (6m) and (1y) 1.30± 0.26, 1.40± 0.39, 1.60± 0.39, 1.75 ± 0.26 for group II, respectively. There was a statistically insignificant distinction observed among Group I and the second group at the various time intervals. Also, a statistically significant variation has been observed in marginal bone loss at (6 m) and (1 y) between 1st group and 2nd group, with less bone loss in the subcrestal group. The means of marginal bone loss recorded in Group I and Group II (0.62 ± 0.08 and 0.85 ± 0.08 mm) after 1 year were within the accepted limits, occurring with adequate osseointegration.

The findings of this investigation were agreed with the results of a clinical investigation carried out by **Sun et al.,[13]** which discovered that the marginal bone loss was lower in the subcrestal group compared to the crestal group (0.04 ± 0.08 versus 0.17 ± 0.17 millimeters, p-value = 0.004). Additionally, following one year of functional loading, implants put in a subcrestal position with platform switching exhibited lower marginal bone loss than implants positioned at the crestal level (180).

Although these findings contradicted the results of the research conducted by **Kütan et al.,[9]** the objective of our investigation was to evaluate the extent of marginal bone resorption when platform-switching implants have been placed at or beneath the level of the bone. After one year, bone resorption has been detected around platform-switching implants positioned one millimeter below the bone level. This resorption has been found to be statistically more advanced compared to implants positioned at the bone level ($p < .01$). In addition, after three years, there was evidence of bone loss around platform-switching implants that were positioned one millimeter below the level of the bone. This bone loss was more significant compared to implants sited at the bone level, and the difference was statistically significant ($p < .01$).

Regarding bone density, there were statistically insignificant variations seen at baseline, six months, and one year among the first group and the second group, with p-values of 0.578, 0.910, and 0.658, respectively. A clear correlation exists between bone density and primary stability.

The findings align with a study undertaken by **Farré-Pagès et al.,[14]** which determined that the main stability of the implant, as indicated by ISQ, is influenced by bone density, bone quality, and implant placement. Implants placed in areas with greater bone density exhibit increased stability,

as indicated by higher bone density values (Hu) and greater primary implant stability evaluated in ISQ values. Hounsfield units can serve as a diagnostic indicator to forecast potential implant stability.

Regarding the osteocalcin level, there were no statistically significant differences seen at baseline, one week, one month, and three months between Group I and Group II, with p-values of 0.173, 0.974, 0.620, and 0.448, respectively. The findings of this study indicate a significant decline in osteocalcin levels over time in both Group I and Group II as the healing process around the implant is finished.

Murata et al. [15] determined that elevated levels of osteocalcin in the peri-implant sulcular fluid may suggest increased local bone remodeling in dental implants. Hence, osteocalcin plays a definitive function in increasing osteoblastic activity during the process of bone remodeling.

A separate investigation conducted by **Cakal et al.,[16]** determined that there were no notable disparities in the overall quantities of osteocalcin in peri-implant crevicular fluid among the healthy control group, peri-implant mucositis group, and peri-implantitis group.

CONCLUSION

Subcrestal positioning of implants with platform switching exhibits a significant influence over crestal positioning in terms of improving implant stability and decreasing marginal bone loss around delayed dental implants. Osteocalcin levels in peri-implant crevicular fluids showed no statistically significant variation between subcrestal or equicrestal delayed implant placement. Both crestal and subcrestal positioning of dental implants have comparable effects in terms of peri-implant probing depth, soft tissue thickness, and radiographic bone density around delayed dental implants.

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