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THE EFFECT OF TWO DIFFERENT IMPLANT SYSTEMS ON BONY CHANGES IN MANDIBULAR IMPLANT SUPPORTED OVERDENTURE

Eatemad T. Rekaby*; Fardos N. Rizk** and Azza F. Metwaly***

ABSTRACT

Objective: This study was conducted to evaluate the bone changes that may occur around Legacy I implants and NanoTite Tapered implants supporting mandibular overdentures utilizing cone beam computed tomography (CBCT).

Materials and Methods: Fourteen completely edentulous male patients were randomly divided into two equal groups. Group I: Each patient received two Legacy I implants. Group II: Each patient received two NanoTite Tapered Implants. All implants were inserted bilaterally in the mandibular canine region. For all patients conventional complete dentures were constructed before implants placement. After complete osseointegration of implants, dome shaped healing collars were screwed to the implants upon which mandibular overdentures were fitted. Once patients were comfortable to the prosthesis, they were placed on a zero, six, and twelve months follow-up periods. Radiographic evaluation of peri-implant bony changes was made using CBCT. Measurements were taken for bone density and crestal bone height surrounding the implants.

Results: Both groups showed reduction in the crestal bone height however, Legacy I implants showed more bone resorption than NanoTite tapered implants. While bone density measurements showed statistically non-significant difference between the two groups.

Conclusion: NanoTite Tapered Implant System is more compatible with crestal bone height however, regarding bone density there is no difference between using NanoTite Tapered Implant System and Legacy I Implant System in cases of implant-retained mandibular overdenture.

Keywords : Legacy I Implant System, NanoTite Tapered implant System, overdenture, CBCT

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INTRODUCTION

Oral rehabilitation by means of two implants retained mandibular overdenture is a well known treatment modality to improve the oral functions, biting force, masticatory efficiency, patient satisfaction and quality of life. [1,2] It also plays an important role in long term preservation of the remaining alveolar and basal bone, moreover it improves the prognosis of mandibular edentulism. [3-7]

Osseointegration is widely accepted in implant dentistry as the base for dental implant success. Clinical efforts to improve implant success rate have been focused on increasing the amount of bone formation at the endosseous implant surface. The amount of bone contact, the rapidity of its formation as well as the mechanical nature of bone-implant connection is influenced by the nature of the implant surface itself.[8-13]

The significance of micro-scale topography was highlighted in a report by Buser and Colleagues [14] who observed that micro–scale rough surface prepared by grit blasting and subsequent acid etching was capable of rapid and increased bone formation. Also titanium oxide grit blasted surface supported more rapid and increased bone formation at titanium implants. [15]

Several investigators have further described the specific effect of surface topography on titanium-adherent osteoblastic cell behavior and have shown that increased surface topography effectively enhances extracellular matrix synthesis of adherent cells and provides a faster and more reliable osseointegration response.[16-32]

A current approach is surface impregnation or coating with different kinds of crystals, particularly hydroxyapatite or calcium phosphate with various thickness resulted in significant positive bone reaction in both in vitro and in vivo studies . [21, 33-41]

The Dual Acid–Etched (DAE) implant surface has been shown to develop more adherent bone than the machined-surface implant during the loading bone condition and can be placed in function immediately after implant placement, without sacrificing implant integration performance. [42-46]

Recently, with the development of nanotechnology it was found that the nanoscale topographic surface has an interesting feature of selective cell adhesion. Several investigations have demonstrated the relative increase in the osteoblastic cell adhesion compared to the fibroblastic cell adhesion whenever nano and micro structured surfaces were evaluated.[47, 48] Bacterial adhesion and proliferation are also diminished on the nano phase material. [49]

In 2007, the NanoTite surface was introduced ,featuring a nanotopography created by Discrete Crystalline Deposition (DCD) of calcium phosphate(CaP) nanoparticles added to the DAE Osseotite surface. The actual deposits of discrete crystals occupy approximately 50% of the Osseotite surface within its peaks and valleys. The DCD process increases the micro surface area by 200% over the Osseotite Surface, providing greater micro complexity. This nanometer-scale surface enhancement shows increase in early bone formation and early fixation outcomes compared with the (DCD) surface controls in several animals' models as well as histomorphometric outcomes in human studies. [50-54]

Cone beam computed tomography or CBCT is well suited for imaging the craniofacial area. It provides clear images of highly contrasted structures and is extremely useful for evaluating bone. [55,56] Cone beam CT scanning, when compared to traditional medical CT scanning, utilizes less than 2% of the radiation, provides more accuracy in the area of interest, and is safer for the patient.[57] CBCT accurately pinpoints vital structures and allows the surgeon to create a surgical guide, which allows the surgeon to accurately angle the implant into the ideal space thus the chances of complications are dramatically reduced with increasing success rates and decreasing post-operative healing.[58, 59]

This study was conducted to evaluate the bone changes that may occur around Legacy I implants and NanoTite Tapered implants supporting mandibular overdentures utilizing CBCT.

MATERIALS AND METHODS

Study Design

This prospective clinical study was conducted to provide outcomes of fourteen Legacy I implants versus fourteen NanoTite Tapered implants in implant supported mandibular overdenture cases after twelve months follow-up period. Specific treatment plans were based on the need of each patient to incorporate implants for supporting an overdenture.

Patients Selection

Patients eligible for the study were male patients completely edentulous for at least one year and for no more than three years with age ranging between 53 to 65 years and for whom a decision had already been made to incorporate dental implants for the treatment of complete edentulism. The exclusion criteria was limited to: insufficient bone volume, severe maxillomandibular skeletal discrepancy, tempromandibular joint disorders, drug abuse, smoking, local radiotherapy to the head and neck region for malignancies, chemotherapy, chronic renal or liver disease, diabetes, stroke, immune compromised status, bleeding disorders , mucosal disease such as lichen planus, acute infection of the implant site, signs of chronic bone disease, bruxism and general contraindications for surgical procedures. [60-63] The inclusion criteria included: Patients with good health, firm healthy mucosa, adequate bone quality (D2) and quantity (Type A, B) of the alveolar ridge and freedom of any pathological signs, bony undercuts, or neoplasia. [64] Fourteen qualified Patients were enrolled and motivated to the treatment. They signed an informed consent form to cooperate and follow the recommendations and instructions.

Prosthetic Procedures

Complete dentures were fabricated for all patients prior to implant installation to assure ideal implant placement in harmony with osseous anatomy, denture esthetics and abutment connection. Primary impression was taken using alginate impression (Alginmax, Major Prodotti. Dentari SPA. Moncalieri. Italy)in stock tray. Secondary impression was taken using medium body rubber base (Swiss TEC, Coltene, Whaledent, Altstatten, Switzerland) in a specially constructed special trays. Occlusion blocks were fabricated and maxillomandibular relationships were obtained using the conventional wax wafer technique. Casts were mounted on semi-adjustable articulator (Dentatus type ARH, AB Dentatus, Stockholm, Sweden). Setting up of teeth was done following esthetic tooth evaluation and modified lingualized occlusion scheme using modified cusped teeth (Vita-pan acrylic teeth, Vita Bad Sackingen-Germany).[65] After approval of the try-in stage the waxed up denture was flasked and processed into high impact heat cure acrylic resin (Lucitone 199, Dentsply, York, PA-USA). Laboratory remounting was done before finishing the denture and occlusal discrepancies were adjusted.

Any necessary adjustments were carried out to eliminate occlusal interference and the denture was delivered to the patient. It was checked after twenty four and seventy two hours for any needed adjustment and to ensure that the patient was satisfied with esthetics, stability and retention of the denture. Following denture placement and patient adaptation, the mandibular denture was duplicated in clear acrylic resin and used as a surgical template. This assured that implants were installed beneath the planned position which was determined by ideal denture contour and esthetics.

Study Implants

1- Legacy I Implant System (Implant Direct LLC, USA, Canada) the next generation of Zimmer's tapered screw vent implants. Implants' dimensions are 3.7x13mm, with 3.5mm diameter platform and internal connections. Its surface treatment is Soluble Blast Media (SBM) textured surface created by blasting with a blast media of biocompatible tri-calcium phosphate particles that are soluble and easily removed therefore eliminating subsequent acid-etching procedures needed to remove imbedded blast particles.

2- NanoTite Tapered Implant System (BIOMET 3i, Palm Beach Gardens, FL, USA with dimensions 3.25x13 mm. Its shape is closely approximating the shape of natural tooth root with osseotite surface and nanaoscale scale crystals to the base of the implant collar. NanoTite Implant surface technology is the proven Dual Acid Etched (DAE) Osseotite Surface and the unique process of Discrete Crystalline Deposition (DCD), which is the application of calcium phosphate nano particles to all areas of the implant surface that had already received the Osseotite Dual Acid Etch (DAE) conditioning.

Surgical Procedures

Before the surgery the selected patients were randomly divided into two equal groups according to the type of implant they received.

*Group I***:** Included **s**even patients each received two Legacy I implants with the previously mentioned criteria.

Group II: Included **s**even patients each received two NanoTite Tapered implants with the previously mentioned criteria.

Aided by the surgical guide, implants were installed in the canine region at equal distance from the mid line, parallel to each other and perpendicular to the occlusal plane.

All implants were placed by the same oral surgeon according to the two stage surgical protocol. The insertion torque values were set at 35 Ncm and the covering screws were then threaded into the implants. The patient was recalled after seven days to remove the sutures. During the initial healing period (two weeks after surgery) no prosthesis was used over the implants so that early healing can occur without functional loading. After the two weeks period the tissue surface of the existing denture was relieved in the area overlying the installed implants. Resilient relining material (Permsoft Myerson Chicago IL. USA) was placed into the relieved areas to assure intimate tissue contact.

All implants were allowed to integrate for three to four months.Osseointegration of the implants was verified by digital panoramic radiographs. After that, surgical uncovering of the submerged implants was carried out. Dome shaped healing collars were screwed to the implants (Fig. 1).

Fig. 1: Healing collars

The dome shaped healing collars were threaded and unthreaded three to four times to ensure perfect adaptation of the screw in the internal hex of the implants.[66] These collars were utilized as over denture abutments. The mandibular denture base was relieved to accommodate the newly inserted healing collars. The complete over denture was then checked intra orally for complete seating.

Self -cured acrylic resin (Lucitone 199; Dentsply) was injected in the relief areas made opposite to the abutments positions. The complete overdenture was inserted in the patient's mouth and close-mouth technique was carried to ensure intimate adaptation. After hardening of the acrylic resin, the denture was finished and polished.

Lingualized balanced occlusal scheme was verified clinically to ensure equal distribution of posterior occlusal contacts and no anterior contacts. The dentures were inserted, and pressure indicating paste (Mizzy Inc, Cherry Hill, NJ) was utilized to identify pressure areas and to ensure point contact with dome-shaped healing collars.

Patients were instructed to follow strict oral hygiene measures. They were recalled for follow-up visits one week after denture insertion, six and twelve months later on. At these intervals, patients returned for assessment of implant, prosthesis' function and standardized evaluation of their oral health. CBCT was used to identify peri-implant radiolucencies, crestal bone levels and bone density.

Radiographic evaluation using Cone Beam Computed Tomography (CBCT)

Images were acquired using the Scanora 3D Imaging system (Scanora 3D, Sorredex-Finland) (voxel size 133um-350 um) which allows the recording of linear bone height and density measurements of images. The personal computer utilized was an Intel Core Duo- 2.13 Mhz-3.25 Gbites-21 inches flat screen 9 Hewlett-Packard Pavilion Elite m9200t series (Hewlett-Packard Pavilion Elite m9200t series USA).

Image Analysis

Linear measurements for evaluation of crestal bone height

Mesial and distal crestal bone levels were calculated from the reconstructed corrected sagittal views by drawing a line parallel to the implant serration extending from the crestal bone to the apical end of the implant. Similarly, buccal and lingual bone levels were calculated by using cross-sectional views (Fig.2). Average readings of the four sides at each interval were calculated and tabulated for statistical analysis.

The density measurements were performed by calculating the CT numbers 1 mm away from the surface of each implant at all buccal (B) and lingual (L) sides (cross sectional views) and mesial (M) and distal (D) sides (corrected sagital views). Therefore each implant had four CT numbers (B, L, M, D) indicating the quality (density) of bone engaged with the threads of the implant (Fig 3). Average readings of the four sides at each interval were calculated and tabulated for statistical analysis.

Statistical analysis

The statistical analysis of data was done by using excel program and SPSS program (statistical package for social science) version 16 on windows xp

The description of data as done is

1- Frequency and proportion for qualitative data

2- Mean ± SD for normally distributed quantitative data

The analysis of data done to test statistical significant difference between groups for

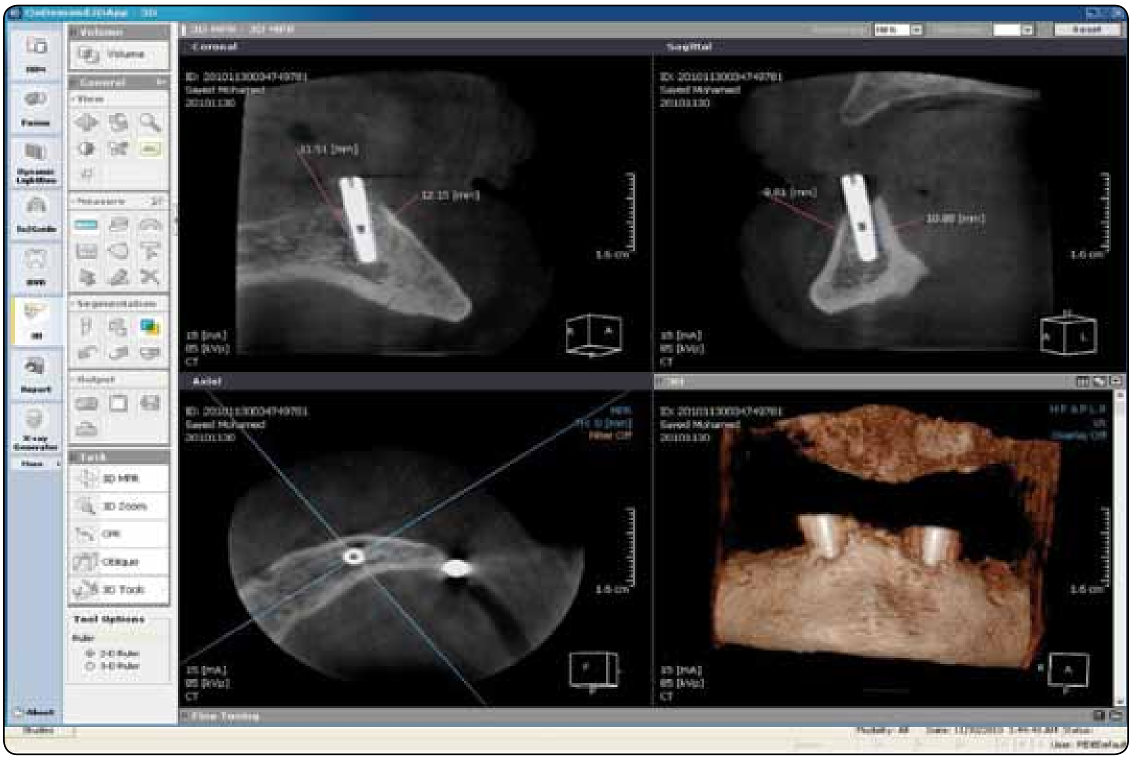

Fig. 2: Crestal bone height measurements using CBCT

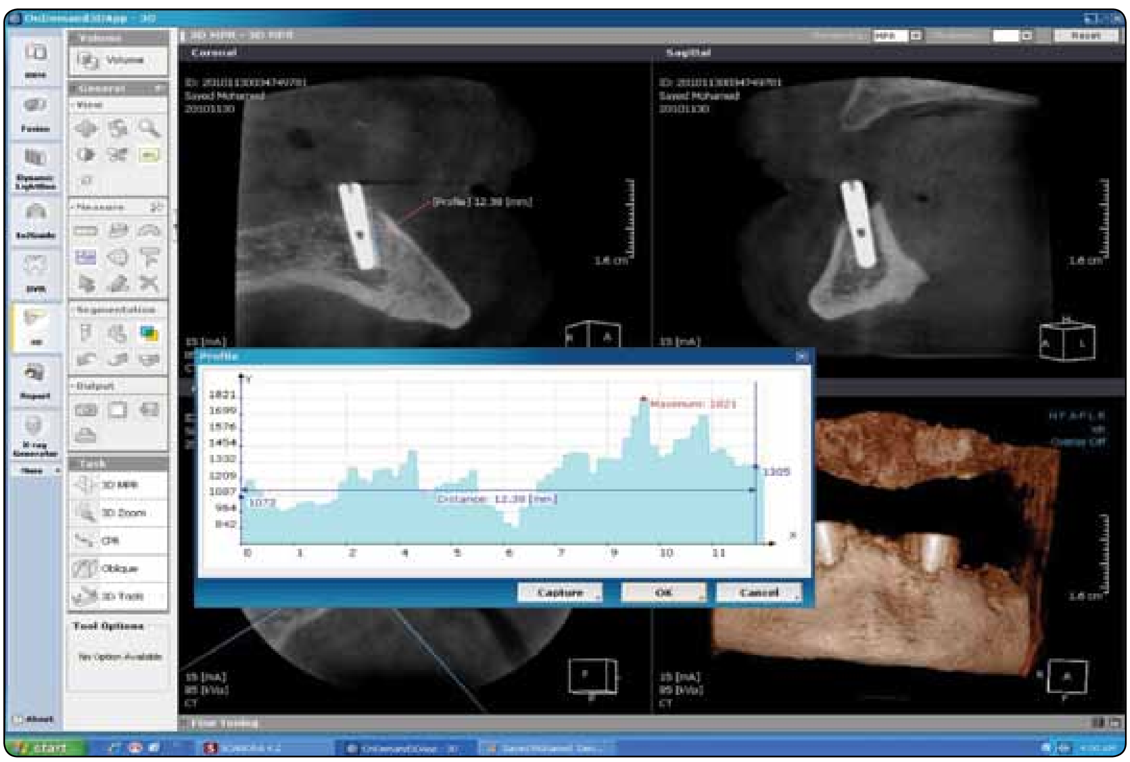

Fig. (3) Assessment of bone density on CBCT quantitative data normally distributed (mean ± SD)

Paired and unpaired student t-test was used to compare the two studied groups.

P value is significant if ≤ 0.0 5 at confidence interval of 95%

RESULTS

Crestal Bone height

Table I shows decrease in mean value of crestal bone height surrounding the implants throughout the study period in both groups. This decrease was highly significant in both groups through all intervals of follow-up period.

Table II shows statistically highly significant differences between the two studied groups on crestal bone height surrounding the implants through all intervals of follow-up period where Legacy I implants showed higher crestal bone height reduction than NanoTite implants.

TABLE (I) Effect of time on crestal bone height surrounding the implants in both studied groups at different intervals of follow-up period.

	Group I: Legacy I Implant System		Group II: NanoTite Tapered Implant System	
Period	Mean (mm)	SD	Mean (mm)	SD
At-insertion	12.24	0.79	11.59	0.66
At- 6 months	11.83	0.80	11.43	0.65
At 12 months	11.28	0.82	11.26	0.68
	paired t- value	P value	paired t- value	P value
0-6 months	21.31	0.0000001**	10.8`	0.0000001**
0-12months	31.87	0.0000001**	17.43	0.0000001**
6-12 months	20.11	0.0000001**	16.79	0.0000001**

** p value < 0.05: significant. ** p value < 0.01: highly significant. ns= P value >0.05: non-significant*

TABLE (II) Comparison between crestal bone height changes surrounding the implants in both studied groups at different intervals of follow-up period.

Period	Group I: Legacy I Implant System		Group II: NanoTite Tapered Implant System		Unpaired t-test	p-value
	Mean difference (mm)	SD	Mean difference (mm)	SD		
0-6 months	0.41	0.07	0.16	0.05	10. 41	0.0001**
6-12 Months	0.55	0.10	0.17	0.04	13.05	0.0001**
0-12 Months	0.95	0.11	0.33	0.07	17. 81	0.0001**

**Significant (P<0.05) Ns= non-significant(P>0.05)*

Bone density

Table III shows increase in mean value of bone density surrounding the implants throughout the study period in both groups. This increase was highly significant in both groups through all intervals of follow-up period.

Table IV shows statistically non-significant differences between the two studied groups on bone density surrounding the implants through all intervals of follow-up period.

TABLE (III) Effect of time on bone density surrounding the implants in both studied groups at different intervals of follow-up period.

	Group I: Legacy I Implant System		Group II: NanoTite Tapered Implant System	
Period	Mean (HU)	SD	Mean(HU)	SD
At-insertion	978.99	514.51	970.96	519.03
At 6 months	1056.83	203.06	1064.99	242.46
At 12 months	1136.38	202.64	1143.60	240.78
	paired t- value (HU)	P value	paired t- value (HU)	P value
0-6 months	9.86	0.0000001**	6.83	0.0000001**
0-12months	11.55	0.0000001**	9.58	0.0000001**
6-12 months	7.03	0.0000001**	8.29	0.0000001**

* P value < 0.05: significant. ** P value < 0.01: highly significant. Ns= P value >0.05: non-significant

TABLE (IV) Comparison between changes in bone density surrounding the implants in both studied groups at different intervals of follow-up period.

	Group I: Legacy I Implant System		Group II: NanoTite Tapered Implant System		Unpaired t-test	p-value
Period	Mean difference (HU)	SD	Mean difference (HU)	SD		
0-6 months	-77.84	48.13	-94.02	62.9	1.02	0.319 ns
6-12 Months	-79.55	35.82	-78.61	44.09	0.06	0.95 ns
0-12 Months	-157.39	60.7	-172.64	71.31	0.67	0.506 ns

**P value < 0.05: significant. ** P value < 0.01: highly significant. Ns= P value >0.05: non-significant*

DISCUSSION

In the current report, no implant failure occurred because of the concern for bone loading trauma, proper selection of cases, proper selection of implants regarding implant dimensions and surface textures, atraumatic surgical technique based on achieving primary stability ,proper implant installation and angulation, adjusting the direction of occlusal forces and finally proper application of oral hygiene measures.[67–70]

The number of implants supporting the mandibular overdenture was restricted to two, as the number of implants has shown minor importance in treatment outcomes. [71]

Cone beam (CBCT) tomography is a precise and fast method which can be used to assess with high resolution digital images representing the trabecular structure in detail, allowing a three-dimensional reconstruction of the bone structure to be achieved. CBCT was utilized successfully whenever direct measurements of bone height &density are required. Consequently, using CBCT for assessment of bone changes around the studied implants added accuracy to the results. [72]

Significant decrease of crestal bone height surrounding the implants for the two groups was found throughout all time intervals during this study. This bone reduction might be due to surgical trauma, bone osteotomy and healing process. Also it might be considered an immediate bone reaction after insertion of the prosthesis which attributed to the healing and reorganization following trauma to the bone and periosteum combined with remodeling due to functional stresses following prosthesis connection. [72, 73]

The crestal bone loss values at the end of one year follow-up were 0.95 mm and 0.33 mm for Legacy I and Nanotite implants respectively. These results are within the acceptable range of implant success which has shown a mean marginal bone loss around dental implants of 1.5-2 mm in the first year after prosthetic restoration and 0.1-0.2 mm annually after that.[66,74] This also agrees with the findings of Cox and Zarb [75] who stated that mean crestal bone loss reaching 1.6 mm is accepted as a radiographic sign for implant success during the first year of implant loading. Selecting implants with proven designs and surface textures reduces stresses in the critical crestal bone region and shows increased surface area and high primary fixation. [50-54,66,76]

In the results of the present study Legacy I implants show higher crestal bone height reduction than NanoTite implants. This may be due to increased surface area and high primary fixation of Nanotite implants. In Nanotite implants the Discrete Crystalline Deposition (DCD) of calcium phosphate (CaP) nanoparticles on titanium surfaces increases the micro surface area by 200% over the osseotite surface, providing greater micro complexity. This nanometer-scale surface enhancement shows increase in early bone formation and early fixation outcomes promoting early osseointegration and bone bonding at the implant bone interface which consequently led to less stresses at the bone implant interface. [50-54] This supported the findings of Goene´ and co-workers [77] who observed greater bone formation at 4 and 8 weeks after placement of Nanotite implants and concluded that the addition of a nanometer-scale calcium phosphate treatment to a dual acid-etched implant surface appeared to increase the extent of bone development after 4 and 8 weeks of healing.

In the end of this study Nanotite implants recorded 0.33 mm reduction in crestal bone level which supported the findings of Ostman et al., [78, 79] who recorded 0.37mm during the first year of function.

Regarding the bone density changes, there was a significant increase in the mean value of bone density throughout the study period in Group I and II. This could be considered as a positive response to the applied forces within the physiologic limit and adaptive capacity. Since the thickness and closeness of the bone trabeculae vary directly with the stresses transmitted to them thus, the reduction and proper distribution of the load falling on the implants might have enhanced the structural orientation of bone trabeculae and hence increased the bone density around the implants. These findings are in agreement with the studies of Grretto et al., [80] and Baker and Goodkind. [81]

Misch in 2005 [82] reported that higher bone density as well as reduced amounts of crestal bone loss were noticed around the delayed loaded implants. This might be due to the passive mechanical loads which may be applied to the dental implants during the healing stage through contact of the prosthesis with the first stage cover screw. Such increase in physiologic loading of the implant enhances bone density. These findings supported the findings of Appleton et al.2005[83] who noted that progressively loaded implants had increased bone density as well as reduced amount of crestal bone loss.

The bone density values recorded in the present study were within the acceptable limit as recorded in another retrospective clinical study[84] who reported bone density values of 846 ± 234 HU.

CONCLUSION

Within the limitations of this study CBCT evaluation of bone adjacent to implants revealed that NanoTite Tapered Implant System is more compatible with crestal bone height however, regarding bone density there is no significant difference between using NanoTite Tapered Implant System and Legacy I Implant System in cases of implant-retained overdenture.

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