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PERI-IMPLANT MARGINAL BONE HEIGHT CHANGES IN IMPLANT-RETAINED OVERDENTURES CONSTRUCTED BY CAD/CAM OR CONVENTIONAL PROCESSING TECHNIQUE- A ONE-YEAR CLINICAL FOLLOW-UP

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ABSTRACT

Objective: To evaluate and compare the peri-implant marginal bone height changes in two implant retained overdentures constructed by either CAD/CAM technology or conventional processing techniques.

Background: The digital denture using CAD/CAM technology has proved high beneficial to the elders and/or the compromised edentulous patient, as it can help decrease the treatment burden on the patient by reducing the clinical procedures, number of visits, treatment time, and incurred costs.

Materials and Methods: Twenty completely edentulous patients participated in this study. The patients were randomly allocated to two equal groups of patients (Group A and group B). Group A patients received complete dentures constructed by conventional heat cured technique. Group B patients received complete dentures constructed by CAD/CAM technology. All the patients received two root form implants bilaterally in the canine regions following delayed loading protocol. Locator attachment was then used to retain the overdenture after 3 months healing period. Marginal bone height was radiographically evaluated at baseline, 6 and 12 months after implant loading.

Results: There was a significant loss in marginal bone height around the supporting implants in each study group. However, no significant differences in marginal bone height were recorded between the study groups over the observation period ($P > 0.05$).

Conclusion: Peri-implant marginal bone height changes with overdentures fabricated by CAD/CAM technique are not different from those changes with overdentures fabricated by a conventional heat curd technique.

KEYWORDS: CAD/CAM, Dental Implant, Overdenture

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INTRODUCTION

There are different treatment choices to restore the edentulous jaw, including traditional full dentures, implant-supported / retained overdentures, and implant-supported fixed prosthesis.

As a results of challenges that accompany the conventional dentures like retention, stability, progressive ridge reduction in addition to patient satisfaction, using implant-supported / retained prosthesis, become a feasible alternative.[1,2] Although, the implant-supported fixed prosthesis provide excellent results as regard masticatory efficiency, patient acceptance and quality of life, this treatment option may be difficult for some patients particularly the elders, due to its high price in addition to the complicated surgical and technical procedures.[3]

Functional and esthetic satisfaction for totally edentulous patients can be achieved by providing maxillary complete denture and 2 implant-retained mandibular overdenture.[4-6] In comparison to conventional dentures, implant-retained prosthesis will improve the denture retention, stability, chewing function, biting force as well as patient satisfaction.[7- 9] It also has a relatively reduced cost and less surgical and prosthetic procedures compared to an implant-supported fixed prosthesis, which are considered particularly important for older edentulous patients.

While the clinical effectiveness of implant-retained overdenture depends on a variety of variables, it can be asserted that the successful outcome of implant-retained overdenture therapy is closely linked to the presence of a harmonious relationship between the prosthetic superstructure and its supporting implants. The faulty prosthesis can produce unfavorable torque forces on the supporting implants and may interfere with their osseointegration.[10]

Theoretically, reduction of undesirable torque forces on the supporting implants can be achieved by improved fit, retention and adaptation of the overlay prosthesis, which is directly related to the technique of denture design and fabrication. Presently complete dentures are mainly designed and fabricated using conventional methods, which involve multiple clinical and laboratory procedures which are mainly performed manually.[11] It is very challenging to guarantee the consistency for the manually designed and fabricated dentures. In addition, it is difficult to store and reuse those physical models to produce additional/spare complete dentures if the patients required them.

Recently, Progress has contributed to the introduction of computer-aided design/computer-aided manufacturing (CAD/CAM) technology into the design and fabrication of complete dentures.[12,13] With this CAD/CAM technology, only 2 appointments are needed for patients to get their complete dentures, saving a lot of time, cost and material for dentists and are crucial for old patients[14]. CAD/CAM denture is milled from pre-polymerized resin pucks produced under controlled conditions of heat and pressure, the outcome is condensed acrylic resins, with reduced shrinkage, porosity or free monomer and enhanced mechanical properties.[12, 15-17] In addition to reduced numbers of clinical appointments, reduced treatment time, easy fabrication of additional/ spare denture from stored digital data, the lack of polymerization shrinkage associated with milled dentures result in a highly precise denture fit and enhanced retention.[13,18]

It has been the aim of the present study to investigate if CAD/CAM fabricated overdentures have a better harmony with the retaining implants than conventionally processed overdentures, as regard the marginal bone resorption around the implant. Therefore, the null hypothesis for this study was that there is no difference in peri-implant marginal bone resorption between CAD/CAM fabricated overdentures and conventional fabricated overdentures after one year observation.

MATERIALS AND METHODS

Twenty completely edentulous patients (men, average 56 years of age) were selected from the undergraduate clinics of the Faculty of Dentistry. At the beginning, the aims, consequences and eventual complications of this clinical study were discussed with all patients, and in case of acceptance to participate, the patient sign an informed consent. This research was done in accordance with the principles of Helsinki Declaration (version, 2008), and was approved by the Institutional Review Board /Scientific Research Committee of the author's institution (Ref. No. alf-20170026).

Inclusion criteria

Eligibility criteria for patient participation in this study as following: Cooperative men patients, with class I Angle jaw relation, asymptomatic with no signs or symptoms of tempromandibular joint disorders. Additionally, adequate interocclusal space for implant retained overdenture with locator attachment, have bone volume in the anterior mandible suitable for the size of the used implant (12 mm length, and 3.3 mm diameter). Along with the ability to maintain good oral and denture hygiene.

Exclusion criteria

Smoking patient, drugs or alcohol abusers, patient with medical condition that complicate the surgery, physical or psychiatric reasons that could affect follow-up, and those who received radiotherapy to the maxillofacial region that may affect the implant site were excluded.

Grouping of patients

Random distribution of the patients to two equal groups, with 10 patients in each group as follows: Group A: The patients received a maxillary complete denture and a mandibular overdenture constructed in a conventional way and retained by two implants. Group B: The patients received a maxillary complete denture and a mandibular overdenture constructed from pre-polymerized resin pucks (AVADENT, Global Dental Science, USA) using milling CAM/CAM technology and retained by two implants.

Construction of the dentures

Dentures for group A were made following the conventional clinical methods in compliance with the recommendations of the British Society for the Study of Prosthetic Dentistry.[19] The acrylic dentures were constructed from PMMA (Ecocryl-Hot-Protechno, Girona, Spain), processed following the conventional compression molding technique, and heat cured in a thermostatically controlled water bath according to the manufacturer recommendations. The water heated up to 80˚C and maintained for 2 hours and then allowed to boil for a further 30 minutes. All the dentures in group A were constructed by the same dental technician.

For patients in group B, CAD/CAM dentures were made by the Ava Dent digital system (AvaDent TM Digital Dentures, Scottsdale, AZ, USA) with materials and techniques supplied by the manufacturer. The CAD/CAM denture was done in two clinical sessions, in the first session, impressions were made using thermoplastic trays and heavy body polyvinyl-siloxane for border molding and light body polyvinyl-siloxane for final impression materials. Jaws relation registration was done using the Anatomic Measuring Device (AMD, Global Dental Science- Scottsdale, AZ- USA) that was supplied. AMD consists of maxillary and mandibular trays, which are present in various sizes. The mandibular AMD tray is provided with a tracing table, and the maxillary tray has a central adjustable bearing pin in order to get a Gothic arch tracing. The maxillary AMD tray also comprises an adjustable flange to support the upper lip. Fast set polyvinyl-siloxane impression was used to reline the maxillary and mandibular AMD trays in order to stabilize them on the residual ridge. After recording of the vertical dimension of occlusion (VDO), and placing the relined AMD trays in the patient's mouth, the patient is asked to close until the adjustable pin touches the tracing table at the

appropriate VDO. After that the patient is asked to move the mandible in protrusive and lateral directions, in order to get Gothic arch tracing with an apex that represent centric jaw relation. The apex is marked by creating small pit using round bur, then the mandible is guided until the pin fits in the created pit. Following that both maxillary and mandibular AMD trays are secured together by injecting an interocclusal recording material in-between. Finally lip support, midline, horizontal lip line, as well as suitable tooth size and shape was recorded by using flange and tooth mould templates. Then all obtained records were sent to the laboratory for scanning and denture fabrication. Prior to milling of the final denture a virtual design of the denture was sent back for evaluation and acceptance. In the second clinical session, after the milling of the complete denture, delivery procedures like those used for the conventional complete denture.

Implant placement

For each patient, the mandibular denture was duplicated to a clear radiographic stent, with 2 metal balls inside to locate the implant site, and bone height in the canine region using digital panoramic radiograph. The bone width in the proposed implant site was mapped by using graduated periodontal probe under topical anesthesia.[20] Each patient received two root form titanium – zirconium implants (Roxolid SL Active; Institut Straumann AG- Switzerland) with a diameter of 3.3 mm and a length of 12 mm following delayed loading protocol. Then healing abutments were connected to the implants, and the mandibular overdenture was modified and relined by soft liner (COE-SOFT; GC America) opposite to the implants, and the patients were instructed for meticulous hygiene as well as using soft diet. After 3 Months healing period, Stud attachments (LOCATOR Attachment System; Zest Dental Solutions) (Figure 1) were placed on each implant and the locator female attachments were attached to the denture by the chair side direct pickup relining technique by using auto-polymerizing hard relining material (Simplex Rapid; Kemdent- UK) according to the conventional method,[21] in this study, a light retention pink replacement male was used (Figure 2). Then the patient was guided

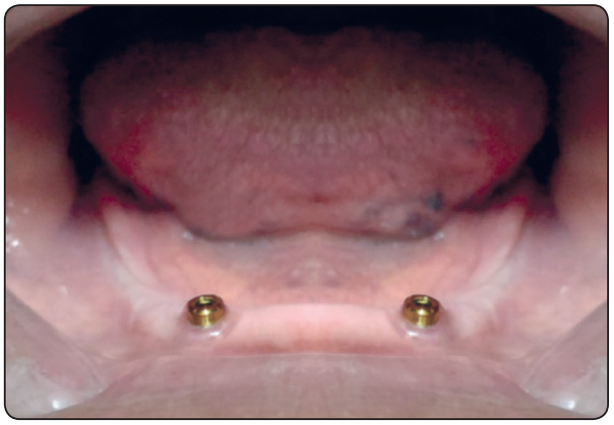

Fig. (1): Implants with locator abutments.

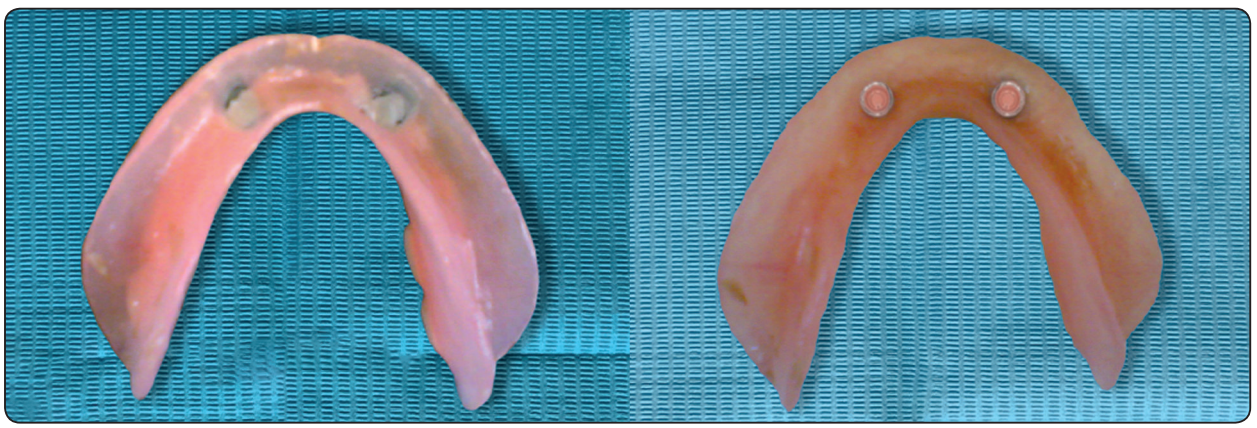

Fig. (2): Mandibular overdenture - locator attachments picked up directly at chair-side, with light retention pink replacement.

the correct way of denture insertion and removal many times. Before patients' dismissal, all were encouraged about denture and implant hygiene and were requested to present in scheduled follow-up visits for assessment.

Evaluation of the marginal bone height changes

Direct digital panoramic radiographs (KODAK, 9000- Carestream Health, Inc. USA) were done for each patient to evaluate the marginal bone height changes around the implants after implant loading (base line), at six and 12 months recall visits. This method was used in many previous studies in implant supported overdenture cases.[22-25] Digora software (Soredex Medical System, Helsinki, Finland) was used to measure the mesial and distal radiographic alveolar bone height around each implant in the panoramic radiograph as follow: Mesial and distal lines were drawn parallel to the long axis of the implant, starting from the apical end of the implant to the crest of the alveolar bone (Figure 3). The following equation was used to calculate the actual bone height (by applying a distortion coefficient): The actual bone height is equal to the actual implant length multiplied by the radiographic bone height, which was then divided by the implant length measured on the radiograph. The mean bone height was calculated for each implant, and the variations in bone height between different periods were measured by deducting the bone height that was measured at the follow up from the base line.[26]

The recorded data were tabulated and analyzed using the SPSS statistical package (IBM SPSS Statistics for Windows, Version 20.0, Released 2011, IBM Corp, Armonk, New York, NY, USA). Differences in bone height changes values within each study group over the follow up periods were evaluated using paired *T*-test. The *T*-test for independent samples was used to compare bone height changes values between both study groups over the follow up intervals. The level of significance was set at 0.05.

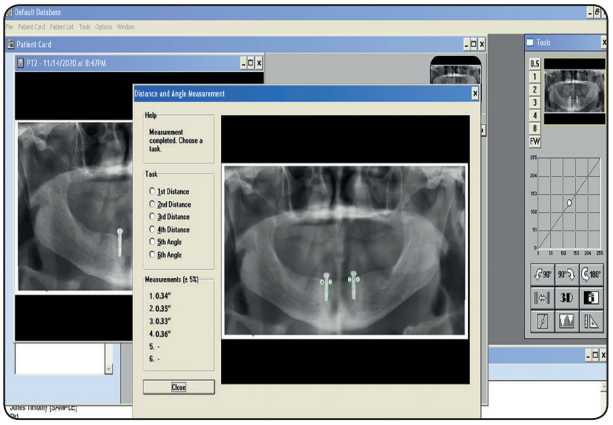

Fig. (3) Digora software for measuring peri-implant bone height.

RESULTS

The flowchart of this clinical study is given in Figure 4. Twenty (100%) patients in the trial completed 12 months evaluation and no implants were lost.

Marginal bone height changes

During the follow -up period following the implant loading, there was a continuous reduction in the marginal bone height around the implants for both groups. Table 1 and figure 5 show a significant reduction in marginal bone height during the follow-up period in group A, the mean marginal bone reduction was 0.456 mm and 0.937 mm at 6 months and 1 year follow-up respectively and the difference in bone reduction within the conventional overdenture group was statistically significant as indicated by paired *T*-test ($P< 0.05$).

Correspondingly, Table 1 and figure 5 illustrate a significant loss in marginal bone height during the follow-up period in group B, the mean marginal bone loss was 0.430 mm and 0.906 mm at 6 months and 1 year follow-up respectively and similarly paired *T*-test denotes statistical significant differences in bone loss within CAD/CAM overdenture group ($P< 0.05$).

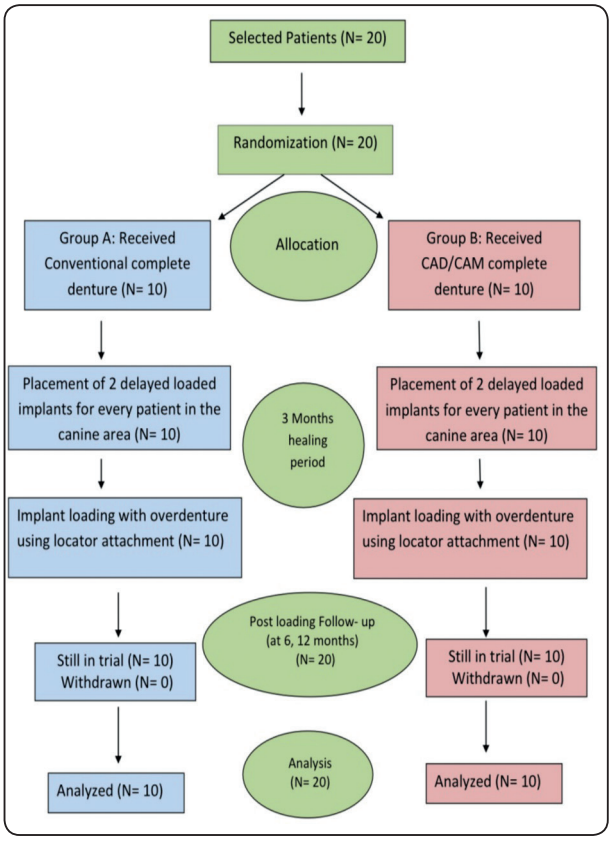

Fig. (4): Flowchart diagram of this clinical study.

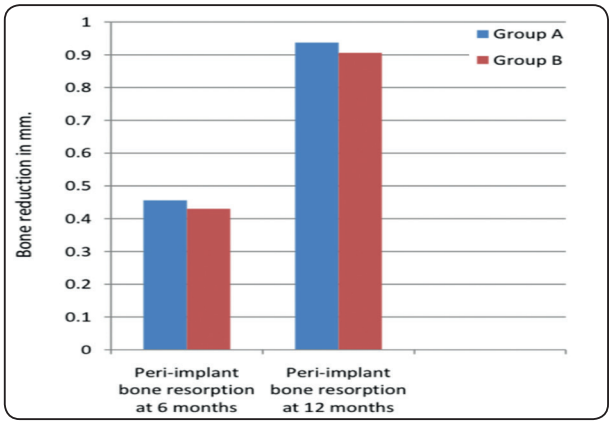

Fig. (5): Peri-implant marginal bone reduction for group A and group B.

Table 1 and figure 5 show that after 6 months the mean crestal bone loss was 0.456 mm for group A, and 0.430 mm for group B, no statistical significant difference between both study groups ($P = 0.277 > 0.05$) as revealed by Independent-Samples *T*- test. At one year follow up the mean crestal bone loss was 0.937mm, and 0.906 mm for group A and group B respectively, similarly the Independent-Samples *T* -test denotes no statistical significant differences between study groups ($P = 0.128 > 0.05$).

TABLE (1): Comparison of Mean peri-implant Bone height reduction (mm) at follow up intervals for patients with conventional and CAD/CAM overdenture using Paired-Samples *T*- test and Independent-Samples *T*- test:

Follow up intervals	Conventional overdenture group	CAD/ CAM overdenture group	*P*- Value (Independent-Samples T- test)
At 6 Months	0.456 (SD. 0.046)	0.430 (SD 0.047)	0.277 (ns) (> 0.05)
At one year	0.937 (SD 0.045)	0.906 (SD 0.042)	0.128 (ns) (> 0.05)
P- Value (Paired-Samples T -test)	0.000* (<0.05)	0.000* (< 0.05)	

SD: Standard deviation * : significant difference (P ≤ 0.05) ns : No significant difference (P > 0.05)

DISCUSSION

It is well recognized that the aim of any prosthetic dental treatment is to provide a satisfactory and long lasting dental prosthesis that preserve the integrity of the supporting dental structures. So, the goal of this study was therefore to evaluate and compare the traditional overdenture construction method and CAD / CAM technique with respect to marginal bone reduction around supporting dental implants after one year of services.

Comparing patients of both groups the null hypothesis for peri-implant marginal bone loss was not rejected, as the amount of marginal bone reduction around supporting implants after loading during the follow-up period did not vary significantly between the study groups. In 1989 Smith and Zarb[27] have pointed out that stability of bone support for the implant is an important criterion for determining success, and the rate of bone loss around dental implants is an important indicator of successful osseointegration. Marginal bone loss increased with time for both study groups as indicated in the results of this study. This could be attributed to healing and bone remodeling after surgery and stresses of function after implant loading by the prosthesis especially within the first year after implant placement as was postulated in the literature review.[28,29] However, the results of this clinical study demonstrate that mean radiographic bone loss of 0.456 mm after 6 months, 0.937 mm after 12 months for conventional denture group and 0.43 mm. after 6 months, 0.906 mm. after 12 months for CAD/CAM denture group was within the normal rate after 12 months observation period. It was reported by Adell *et al*.[30] that mean marginal bone loss for implants should not surpass 1.5 mm. for the first year and 0.1 mm per year following that. This range was confirmed by Cox and Zarb[31] with their report showing a mean bone loss of 1.6 mm. for the first year and a mean of 0.13 mm. in following years. Peri-implant marginal bone loss of less than 1 mm. for both study groups, supported the quality and efficacy of the used implants as well as the surgical protocol followed, in addition to good harmony with the prosthetic superstructure of both study groups. The current study utilized the LOCATOR attachment system with the benefits of light dual retention, minimal vertical space requirement, and the ability to adapt to nonparallel implants. The reduced height of the locator attachment provides the advantages of a lower length of the lever arm above the fulcrum at the marginal bone level against the total implant length embedded in the bone, achieving a favorable lever action. This could explain why the marginal bone level was only affected by changes within the normal range. The radiographic marginal bone loss in this study was consistent with the results of other studies [32-34] in which the implants were delayed loaded with Locator-retained mandibular overdentures. Furthermore, patients in both study groups were subjected to frequent recall visits and instructed to perform high standards of oral hygiene. Moreover, patients with risk factors that may develop peri-implant diseases were not chosen for this study.[35]

It was reported by previous studies [13, 18, 36-39] that CAD/CAM produces denture with improved fit, retention, and stability if compared to the traditional way of denture construction, and the authors claimed these to the unique way of digital prosthesis production through milling a pre-polymerized puck of acrylic resin and the absence of polymerization shrinkage. Since there is a harmonious relationship between the prosthetic superstructure and its supporting implants [10], therefore our study aimed to find out the impact of improved fit, retention, and stability of CAD/ CAM overdenture on the integrity of peri-implant marginal bone. After 12 months of implant loading, the rate of marginal bone loss around the implants supporting conventionally constructed overdenture was similar to that around

the implants supporting overdenture constructed by the CAD/CAM technique. Regardless of the proposed and documented merits of the CAD/CAM technique for denture construction [12-14,18,36-39], it appears that the implementation of the conventional technique in the fabrication of overdentures is enough to produce an appropriate bone response around the supporting implants. Due to high floor of the mouth and advanced ridge resorption of the mandible, periapical films could often not be properly placed, so peri-implant marginal bone height changes were assessed in the current study on panoramic radiograph similar to previous studies.[22-25] Crestal bone measurements of interforaminal implants in cadaver study were compared using different radiographic techniques, the investigators observed that all imaging techniques including digital panoramic radiographs showed acceptable accuracy for peri-implant bone level measurements, without statistically significant differences.[40]

The small sample size, and short observation period (1 year) were a limitation of this study which may account for the lack of significance between overdentures constructed by CAD/ CAM and traditional technique as regard the peri-implant marginal bone changes. The study included only men patients which might be considered as a limitation. Further studies that consider these limitations are advised to validate our findings.

CONCLUSION

By taking the limitations of this study into consideration, it can be concluded that, despite the many advantages of using CAD/CAM technology in denture construction, Peri-implant marginal bone height changes with overdentures fabricated by CAD/CAM technique are not different from those changes with overdentures fabricated by a conventional technique.

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