EGYPTIAN DENTAL JOURNAL

VOL. 64, 3623:3630, OCTOBER, 2018

I.S.S.N 0070-9484

FIXED PROSTHODONTICS, DENTAL MATERIALS, CONSERVATIVE DENTISTRY AND ENDODONTICS

www.eda-egypt.org • Codex : 86/1810

A CLINICAL EVALUATION OF RETENTION OF MAXILLARY COMPLETE CAD/CAM AND CONVENTIONAL DENTURES

Shereen M Kabeel* *and* Dina M Kholief**

ABSTRACT

Background: Computer-aided design (CAD)/computer-aided manufacturing (CAM) dentures are suppose to have more favorable material properties than conventional heat - cured acrylic dentures, among them a lesser methacrylate monomer release.

The purpose of this clinical study: Was to evaluate the retention quality of conventional heat-cure acrylic denture bases and digitally milled maxillary complete denture bases.

Material and methods: This study was done on six edentulous patients; CAD/CAM dentures were constructed from six different master casts by using CAD/ CAM system. Conventional heat-cure acrylic dentures acted as a control group. Universal testing machine was used to measure the retention of the denture. Every denture base was subjected to a slowly increasing vertical load until the denture was totally out of place 5 times at 10-minute intervals. The average retention of the two assemble methods was analyzed using Independent t-test & Paired t-test.

Results: CAD/CAM denture showed statistically significant higher mean retention value than conventional denture at insertion and after one-month (P value<0.000, <0.000) respectively.

Conclusion : Compared with the traditional manual method, the retention of the maxillary complete denture prepared using the CAD/CAM method for the edentulous alveolar ridge was significantly higher, meaning that the CAD/CAM method can meet the clinically acceptable precision for design and development of complete dentures as trial for restoring edentulous jaws.

Keyword: CAD-CAM, conventional, complete denture

INTRODUCTION

Currently, complete dentures (CDs) are mainly planed and manufactured using conventional methods, which include a wide series of clinical and laboratory procedures[1]. To obtain CDs, edentulous patients typically have to make five visits to the dental clinics, involving preliminary and secondary impressions, recording jaw relations, trial installation of wax denture, and insertion of CDs. These clinical and laboratory procedures are mainly performed manually. Therefore, it is very

*Lecturer of Removable Prosthodontics, Faculty of Dental Medicine for Girls, Al-Azhar University.
**Assistant Professor of Removable Prosthodontics, Faculty of Dental Medicine for Girls, Al-Azhar University.

challenging to ensure the quality for the manually designed and fabricated dentures. Moreover, it is difficult to keep and re-use those physical models generated in the process to generate additional CDs latter when the patients need them[2].

The construction of complete denture by the computer-aided designing and manufacturing (CAD-CAM) techniques, first authenticated in the 1990s, [3] have considerably growing in the last decade[4].

The manufacturing of CDs using a CAD-CAM technique has possible to facilitate the manufacture procedures. Generally, the yield of CDs is known to be a complicated and time-consuming process, in which precision is crucial. The possibility to construct CDs by using of the CAD-CAM method provides both a high usage of laboratory CAD-CAM technology and therefore effectiveness and high procedures reliability[5-7].

In some CAD-CAM systems, the milling procedure provides the projects of denture bases with customized sockets for the placement of the denture teeth according to the computerized planed occlusion. After that the denture teeth are manually settled into the corresponding sockets by using PMMA resin. However, the other CAD-CAM systems as Baltic Denture System follow a different program: Pucks of resins already having the teeth, which then inserted to the denture base resin puck during its polymerization, is used[8].

Regarding to finishing and polishing CAD-CAM dentures, milling already finishes the fitting surfaces, however the polished surfaces mostly require manually finishing and polishing procedure then, whole dentures are checked and then fully immerse-coated by the manufacturer [9].

In place of mixing the resin polymer and monomer manually and submitting the immersion according to the selected processing protocol, PMMA resin blocks of CAD-CAM denture bases are manufactured [8,9] and processed undergo "great heat and high pressure" [10,11]. Hence the milled CAD-CAM denture base resins are highly compressed and have lesser micro porosities [10]. Therefore, CAD-CAM denture base resins could have higher mechanical properties[12], which may be the reason of some of CAD-CAM denture construction reported that CAD-CAM denture base have less material thickness[13].

This work aimed to describing the alternative techniques presented by CAD-CAM CDs technology in comparison to conventionally curing protocols. The clinical evaluation was used to determine whether transmission to CAD-CAM technology actually participated in improving and facilitating procedures for practitioners and CDs patients.

MATERIAL AND METHODS

After taking approval of the Local Research Ethics Committee (REC), six patients of age ranged between 55-60 years old were chosen from the Out-patient Clinic of Prosthodontic Department, Faculty of Dental Medicine for girls, Al-Azhar University. The patients were selected to be free from systemic and oral diseases, especially those that may affect retention as diabetes mellitus. All the patients had well formed maxillary and mandibular ridges covered with firm mucoperiostium with no bony undercuts to eliminate its effect on retention. All patients informed about practical steps of this study and signed approval consent.

All patients received heat cured acrylic resin maxillary and mandibular CDs made by traditional technique for one month, the patient were asked to take off the denture for two weeks as a washing period then, received CAD/CAM maxillary complete dentures.

Construction of Conventional denture

Maxillary and mandibular preliminary impressions were made for each patient, using irreversible hydrocolloid impression material. Silicone impression material (poly-C-silicone

impression material, thixoflex M, medium, Zhermack, Italy) was used to make final impression after applying an adhesive (Universal Tray Adhesive, impression silicones, Zetaplus, Zhermack, Italy) and border molding with (Putty-C-Silicone). Impression were disinfected, boxed and poured in dental stone (Zesus Dental Stone hard type, Italy) to obtain master casts, which duplicated to produce duplicate model for each one. On each master cast, trial acrylic denture bases (Cold cure denture base material, Acrostone, England) with wax occlusion rims were constructed. Maxillary cast was mounted on semi-adjustable articulator (Hanau model H, Teledyne Buffalo, New York, USA) using maxillary facebow (Hanau engineering company, Inc., Buffalo, New York), centric jaw relation was made using wax wafer technique, the mandibular cast was mounted on the Hanau articulator using the centric jaw relation record taken from the patient at the predetermined vertical dimension of occlusion. A protrusive record was taken to adjust horizontal condylar guidance of the articulator while the lateral condylar guidance was adjusted according to Hanau formula. Cross-linked acrylic resin teeth were selected according to the patient demands (age, sex, arch dimension, etc.). Setting-up of the artificial teeth cross-linked was carried out. Waxing up was done, and the waxed up denture was checked in the patient mouth.

For conventional processing method, the dentures were made from conventional heat cure acrylic resin (Acron Duo, Associated Dental Products Ltd., Kemdent, Purton, Swindon, Wiltshire, UK), in which, flasking, wax elimination, processing, deflasking, finishing and polishing of the dentures were done following the conventional routine method. The dentures are tried and primary equilibration of occlusion was performed the retention was checked for the conventional dentures.

Construction of CAM/CAM denture

1-The clinical sessions of denture design

It was done to produce the duplicate stone casts as mentioned before to start the scanning procedures of the stone models and the inter-arch relationship was recorded in the same session by conventional wax wafer technique.

2-Scanning models

(1) The models were scanned and the future denture bases with pins were proposed (Fig.1). Setting up of teeth is proposed in 3-shape software (Fig.2) to achieve the virtual working models. Scanning of the jaw relation was done and the models were inserted on the virtual articulator and selected reference points were marked as incisal papilla, tips of canine tooth, tuberosities, centers of retro-molar pad and its limits.

(2) The (SHERA eco-mill 5x) software contains archived teeth of variable types, forms and function with an automatic relational size list of both anterior and posterior teeth.

(3) The posterior teeth should be positioned in an ideal way to be convenient for the morphology of selected prosthetic teeth, subsequently to facilitate the integration of occlusion according to the concept of bilateral balanced occlusion .

3- Laboratory steps of complete CAD-CAM denture

(1) The virtual waxes were finished to avoid any defects that could later prevent the milling process.

(2) The command software of the milling machine (SHERA eco-mill 5x milling machine), produces files for the CD bases manufactured on a PMMA discs leads to a product of a highly adapted template (Fig. 3), with specified pins for the denture teeth (TSM Acetal Dental) (Fig. 4).

(3) The proper setting up of the prosthetic teeth should be ensured throughout the process of bonding with a PMMA resin by milling of a definitive positioning key. (Fig. 5)

(4) After the bonding procedure was completed, the discs were return back into the milling machine to mill the fitting surface of the maxillary dentures.

(5) The dentures were taken and scarped from the discs, finished and finally polished according to the traditional procedures. Finishing the CDs surfaces after machining is very satisfactory (Fig. 6).

Finally, during last session the maxillary CDs were tried and primary check of balancing occlusion was carried out, and the retention was checked for CAD/CAM CDs.

II-Evaluation of denture retention

The retention device, that allows applying an increasing vertical force on the denture, is composed of: Attachment part, Chin rest, Universal Testing Machine (this machine provides accurate reading for the force needing to dislodge the denture vertically). The patient was instructed to sit in an upright position and keep his chin firmly seated on a chin support. The bar was rigidly connected to the denture and the attachment part of the universal machine was adjusted. The device was subjected to a slowly increasing vertical load (10mm/min) until the denture was totally out of place. The load at dislodgment manifested by an audible sound tuck and confirmed by a sharp drop recorded using computer software (Nexyge- MT-4.6 ; Lloyd Instruments) and this value was recorded in Newton. The test was repeated five times to obtain five records, the mean of which was calculated. This test was performed for each (Conventional and CAD/CAM) denture at insertion and after one month from delivery.

Statistical Analysis

The data were collected, revised, coded and entered to the Statistical Package for Social Science (IBM SPSS) version 23. Quantitative data were presented as mean±SD and ranges. **Independent t-test** was used to compare between two groups with quantitative data and parametric distribution while **Paired t-test** was used to compare between paired data in the same group**.** The confidence interval was set to 95% and the margin of error accepted was set to 5%. So, the P-value was considered significant at the level of < 0.05.

RESULTS

1. Evaluation of retention of conventional and CAD/CAM CDs

CAD/CAM dentures showed statistically significant higher mean retention values than conventional dentures at insertion and after one month P value (<0.000) (table1, Fig 7)

2. Effect of time on retention of conventional and CAD/CAM CDs

For the conventional CDs, the mean retention value after one month was statistically significant higher than the mean retention value at the insertion time P value (<0.001) (table1, Fig7).

Also, the retention mean value for the CAD/CAM denture after one month was statistically significant higher than the retention mean value at the insertion time P value (<0.002)(table1, Fig7).

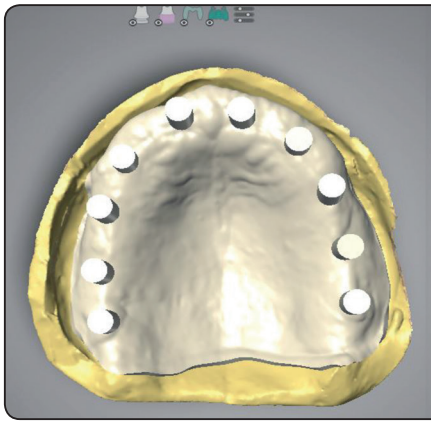

Fig. (1). Drawing a future denture base with pins.

Fig (2). Teeth setting up are proposed by 3-shape software.

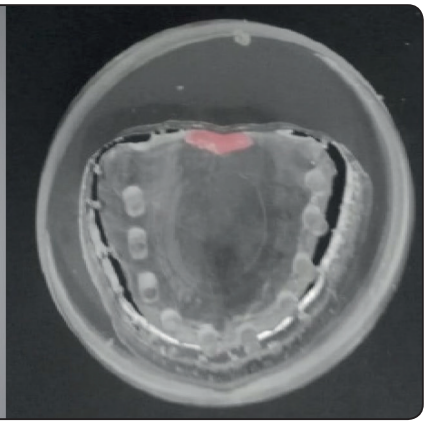

Fig (3). Maxillary denture base template

Fig (4). Milling of Acetal teeth template.

Fig (5). Positioning key for ideal setting of denture teeth.

Fig (6). Finished CAD-CAM maxillary denture.

TABLE (1) Evaluation of the retention values of conventional and CAD/CAM dentures:

Time interval / **Denture type**		**Conventional denture**	**CAD/CAM denture**	**Test value**	**P-value**	**Sig.**
At insertion	Mean ± SD	5.70 ± 0.43	10.81 ± 0.60	-15.491	0.000	HS
	Range	5.21 – 6.12	10.12 – 11.37			
After one month	Mean ± SD	7.71 ± 0.46	12.67 ± 0.50	-16.207	0.000	HS
	Range	7.23 – 8.3	12.16 – 13.25			
Paired t-test	**t**	-8.714	-7.456	–	–	–
	P-value	0.001	0.002			

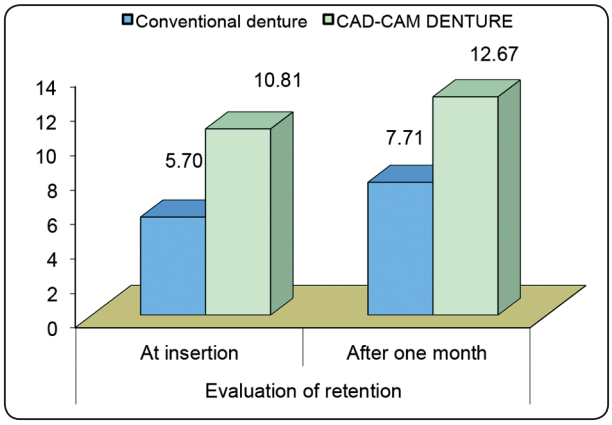

Fig (7) Bar chart representing comparison between mean retention values of conventional and CAD/CAM dentures.

DISCUSSION

CAD-CAM techniques have various prosthetic implementations. In the past, the construction of intra and extra-coronal restorations, fixed partial dentures and nowadays fabrication of CDs and maxillofacial prostheses[14]. CAD-CAM denture base acrylic resin is provided as pre polymerized blocks which are introduced in manufacture controlled circumstances with standard parameters of high pressure and temperature. These blocks are characterized by easily milling; also have increased currency of the construction of removable CDs [14].

Pre polymerized CAD-CAM acrylic resin denture base has numerous properties over conventional acrylic resins related mainly to processing techniques that are done under great heat and high pressure. This results in decrease residual monomer level and thus, no polymerization shrinkage, making it more hydrophobic and more dimensionally stable than conventionally cured resins. Moreover, this method of fabrication produces a clinically smooth surface [15, 16].

To simplify and facilitate the construction of CDs, the application of digital system was progressed and performed in conjugation with CAD-CAM technique. The process considers teeth arrangements, milling of the wax trial denture bases, and adjustment the denture teeth so that they can be inserted into related sockets in the denture bases with wax without additional grinding. In comparing to the traditional construction of CDs, CAD-CAM technique has many advantages; as, easily and excellent recognition and production of visual imaging of the anatomic characteristics of the morphology of both edentulous arches, and automatic detection and signing of the midlines of the maxillary and mandibular ridges. Depending on all of the previous results, the application of digitally constructed CDs confirms reproducible steps enabling expected and precise consequences as documented in the current study.

Compared with the conventional technique for fabricating CDs, the digital workflow has several advantages. Besides reducing the number of visits and reduction of clinical chair time, the repository of digital data in the manufacturer database allows for the rapid future construction of spare or replacement CDs.

In another parameter with high clinical suitability for CDs is the elastic modulus, as CD base materials with high elastic moduli are more resistant against elastic deformation and subsequently allow the construction of CDs with thinner bases. The elastic moduli of CAD/CAM denture base resins investigated in some studies were higher than that of the conventionally processed denture base resins[17, 18].

In this study, when the retention values were compared at insertion and after one month of both CAD-CAM denture resin and conventional heat polymerized acrylic resin, CAD-CAM denture resin showed statistically significant higher retention values over the conventional heat cured acrylic resin, this may be attributed to the dimensional changes and resulting distortion, especially at the post-dam area, due to water sorption of the conventional resin which did not stop after one month. This results supported by the study made by Al Helal et al[19], which concluded that The retention gained by CAD-

CAM CDs bases from pre-polymerized PMMA resin was significantly higher than that offered by conventional heat- polymerized CDs bases.

Since the dentures are milled from a pre-polymerized acrylic resin puck, which is produced under high pressure and heat, polymerization shrinkage does not occur, porosity is decreased [20]. The diminution of polymerization shrinkage commitment to milled CDs may result in a highly accurate denture fit and improved retention[21, 22]. Indeed, the excellent retention and outstanding suction effect of the CDs in the present cases could be resulted from improvement of fit due to the lack of polymerization shrinkage.

The studied CAD-CAM systems were able to reproduce the surfaces of master casts accurately and more precise than traditional manufacturing procedures. The results of this study explain the excellence of the clinical observations of CAD-CAM fabricated CDs regarding the retention, [19].

Darvell et al[23], stated that CDs retention is a functional process, depending on controlling the salivary flow between the fitting surface of the CDs and the underlying mucosa, in addition to, the fluid's viscosity and film thickness with the time scale of the dislodgment loading have a great effect on the evaluation. The retention is also improved by the forces of surface tension at the periphery, however an excellent adaptation of denture base and border seal are the most important factors that must be accomplished, if all advantages are taken of the salivary flow-related effects.

The current research suggests that CDs can be constructed using CAD-CAM technology in the future. This recent technique, which actually much better than the traditional procedure at least in simplifying the laboratory procedures , and reducing chair times with keeping the treatment quality. Furthermore, the CAD-CAM technology can use material that is equipped with innovative properties. Further studies including the construction of CDs under conditions that are closer to clinical situation and measurements of the accuracy of construction should be planned.

CONCLUSION

This study indicates that, construction of a CDs using CAD-CAM system is promising. Current innovations and developments in dental technology provide the construction of CDs using CAD-CAM systems from the beginning to the end, therefore, reducing the chair side and laboratory time for dentists and patients, and enhancing excellent and preferable esthetic and functional feedbacks.

Compared with the traditional manual method, the retention of the maxillary complete denture prepared by using the CAD-CAM method for the edentulous alveolar ridge was significantly different, meaning that the CAD-CAM method can meet the clinically acceptable precision for design and development of CDs as a trial for restoring edentulous jaws.

REFERENCE

1. Cunha TR, Della Vecchia MP, Regis RR, et al. A randomized trial on simplified and conventional methods for complete denture fabrication: Masticatory performance and ability. J Dentistry 2013; 41:133–42.
2. Kawahata N, Ono H, Nish Y, Hamano T, Nagaoka E. Trial of duplication procedure for complete dentures by CAD/CAM. J Oral Rehabil 1997; 24: 540-8.
3. Maeda Y, Minoura M, Tsutsumi S, Okada M, Nokubi T. A CAD/CAM system for removable denture. Part I: Fabrication of complete dentures. Int J Prosthodont 1994; 7: 17-21.
4. Baba NZ, AlRumaih HS, Goodacre BJ, Goodacre CJ. Current techniques in CAD/CAM denture fabrication. Gen Dent 2016; 64: 23-8.
5. Wimmer T, Gallus K, Eichberger M, Stawarczyk B. Complete denture fabrication supported by CAD/CAM. J Prosthet Dent2016; 115:541–6.
6. Inokoshi M, Kanazawa M, MinakuchiS. Evaluation of a complete denture trial method applying rapid prototyping. Dent Mater J2012; 31:40–6.

7. Infante L, Yilmaz B, McGlumphy E, Finger I. Fabricating complete dentures with CAD/CAM technology. J Prosthet Dent2014; 111:351–5.

8. Steinmassl PA, Wiedemair V, Huck C,et al. Do CAD/CAM dentures really release less monomer than conventional dentures? Clin Oral Investig 2017; 21: 1697–705.

9. Steinmassl PA, Klaunzer F, Steinmassl O, Dumfahrt H, Grunert I. Evaluation of currently available cad/cam denture systems.Int JProsthodont2017; 30:116–22.

10. Goodacre CJ, Garbacea A, Naylor WP, Daher T, Marchack CB, Lowry J. Cad/cam fabricated complete dentures: Concepts and clinical methods of obtaining required morphological data. J Prosthet Dent2012; 107:34–46.

11. Han W, Li Y, Zhang Y, et al.Design and fabrication of complete dentures using CAD/CAM technology.Medicine 2017 ;96: 1-8.

12. Steinmassl O, Dumfahrt H, Grunert I, Steinmassl PA. Influence of CAD/CAM fabrication on denture surface properties.J Oral Rehabil2018; 45: 406-13

13. Steinmassl PA, Klaunzer F, Steinmassl O, Dumfahrt H, GrunertI.Evaluation of Currently Available CAD/CAM Denture Systems. Int J Prosthodont. 2017; 30: 116-22.

14. Albero A, Pascual A, Camps I, Grau-Benitez M. Comparative characterization of a novel cad-cam polymer-infiltrated-ceramic-network. J ClinExp Dent. 2015; 7: 495-500.

15. Saponaro PC, Yilmaz B, Heshmati RH, McGlumphy E. Aclinical performance of CAD-CAM-fabricated complete dentures: A cross-sectional study.JProsthet Dent. 2016; 116: 431-5.

16. Stawarczyk B, Sener B, Trottmann A, Roos M, Ozcan M, Hämmerle CH. Discoloration of manually fabricated resins and industrially fabricated CAD/CAMblocks versus glass-ceramic: effect of storage media, duration, and subsequent polishing. Dent Mater J 2012; 31: 377-83.

17. Ates, M, Cilingir A, Sulun T, Sunbuloglu E, Bozdag E. The effect of occlusal contact localization on the stress distribution in complete maxillary denture. J Oral Rehabil 2006; 33: 509–13.

18. WadachiJ,Sato, M, Igarashi Y. Evaluation of the rigidity of dentures made of injection-molded materials.Dent Mater J 2013; 32: 508–11.

19. AlHelal A, AlRumaih HS, Kattadiyil MT, Baba NZ, GoodacreCJ.Comparison of retention between maxillary milled and conventional denture bases: A clinical study. JProsthet Dent 2017; 117: 233-38.

20. Infante L, Yilmaz B, McGlumphy, Finger I. Fabricating complete dentures with CAD/CAM technology. J ProsthetDent 2014; 111:351-5.

21. Goodacre BJ, Goodacre CJ, Baba NZ, Kattadiyil MT. Comparison of denture base adaptation between CAD/CAM and conventional fabrication techniques. J ProsthetDent 2016; 116:249-56.

22. Bidra AS, Taylor TD, Agar JR. Computer-aided technology for fabricating complete dentures: systematic review of historical background, current status, and future perspective. J Prosthet Dent2013; 109:361-6.

23. Darvell, BW. Clark, R.K.F. The physical mechanisms of complete denture retention. Br Dent J 2000; 189:248–52.