

## COMPARISON OF PATIENT SATISFACTION & OCCLUSAL FORCE DISTRIBUTION PATTERN IN CAD/ CAM AND CONVENTIONAL COMPLETE DENTURES USING THE T-SCAN III COMPUTERIZED OCCLUSAL ANALYSIS SYSTEM. (RCT)

Azza Farahat Metwally\*

### ABSTRACT

**Purpose:** This study was conducted to evaluate patient satisfaction & percentage of occlusal force distribution patterns in CAD/CAM and conventional dentures.

**Materials & Methods:** Twenty completely edentulous patients were selected from the out-patient clinic, Faculty of dentistry, Cairo University. Patients were selected with moderately developed residual ridges, sufficient inter-arch space, no muscular disorders & with previous denture experience. Patients were randomly divided into two groups (I) & (II). **Group (I):** Patients had received CAD/ CAM complete dentures. **Group (II):** Patient had received conventionally constructed complete dentures. Patient satisfaction was evaluated in the two studied groups following certain items with the aid of a questionnaire after one week, one month & three months. T-scan device was utilized to evaluate occlusal force distribution in the two studied groups one week after denture insertion. Occlusal adjustment was made after occlusal forces analysis to re equilibrate occlusal force distribution. Mean values were recorded, tabulated & statistically analyzed.

**Results:** The results of this study revealed that patients were more satisfied with CAD/ CAM complete dentures than conventional dentures. Occlusal force % was significantly decreased in anterior area of the dentures in both studied groups after occlusal equilibration made after occlusal adjustment. The % of occlusal force was better distributed on the posterior right & left areas in Group (I) & (II). However, CAD/CAM dentures had shown significantly less % force in the anterior area & better force distribution in the posterior areas than conventional ones especially after T scan analysis & occlusal re-equilibration.

**Conclusions:** Within the limitations of the present study it may be concluded that:

- Patients may be more satisfied with CAD/ CAM than conventional dentures.
- CAD/CAM denture may provide better occlusal force distribution patterns than conventional ones.
- T- Scan computerized occlusal analysis helps to obtain bilateral balanced occlusion in complete dentures.

**Key words:** CAD/ CAM, complete dentures, patient satisfaction, T-Scan, occlusion force distribution

\* Associate Professor at Removable Prosthodontics Department, Faculty of Dentistry, Cairo University

## INTRODUCTION

Computer-aided design and computer-aided manufacturing (CAD/CAM) has emerged as a new approach for complete denture design and construction.<sup>(1,2)</sup> The use of CAD/CAM was limited in complete denture production due to the lack of suitable CAD software until recently.<sup>(3-6)</sup>

The limited literature in the field of CAD/CAM dentures; might be due to the multiple & complicated procedures required for complete dentures construction. The natural looking alignment of teeth and gingiva in harmony with the patient's face remains a challenge for the clinician to perform such denture procedures with the aid of CAD/CAM technology.<sup>(4-6)</sup>

CAD/CAM technology may allow the complete denture construction in only two visits. All impressions, jaw relations, occlusal plane orientation, teeth selection and setting-up of maxillary anterior teeth could be finished in one patient visit. This of course saves a lot of time & materials for both patients and prosthodontist.<sup>(7,8)</sup>

Complete denture stability may be achieved by obtaining bilateral balanced occlusal force distribution to the supporting structures.<sup>(9)</sup>

Presence of deflective occlusal contacts, poor occlusal force summation and unseen collection of unbalanced forces may result in torque and dislodgement of complete denture affecting stability, comfort and patient acceptance.<sup>(10)</sup>

Computerized and dynamic occlusal analysis system as T-scan was developed to measure occlusal load on multiple points in natural dentition.<sup>(11)</sup> T-Scan device is able to record the relative force with dynamic visual evaluation of a patient's occlusion from initial tooth contact to maximum intercuspation in complete denture wearers.<sup>(12)</sup>

T-Scan allows the prosthodontist to record certain parameters as bite length, distribution of occlusal load and the relative forces on the teeth<sup>(13)</sup>

Information regarding occlusal force distribution obtained from T-Scan is helpful to achieve centered and measurable occlusal force nearly 50% right – 50% left occlusal force balance improving the tissue adaptation of the dentures during mastication<sup>(14)</sup>

Premature occlusal contacts may be objectively determined, it is necessary to evaluate the occlusal contact sequence. The use of T-Scan would aid in occlusal analysis and corrections more accurate and can be demonstrated objectively.<sup>(15)</sup>

The denture bearing tissues are known to undergo minor changes in their contour as settling after insertion of complete denture within few days these changes might result in change in occlusal contacts of teeth.<sup>(16,17)</sup>

Patient satisfaction is a multi factorial process including objective and subjective factors as age, sex, prosthetic experience, chewing ability, esthetics, retention, stability, comfort, pain threshold and the psychological profile of the patient.<sup>(18)</sup>

Consequently, this study was formulated to evaluate & compare the patient satisfaction & the % occlusal force distribution in CAD/CAM manufactured complete dentures and complete dentures constructed with the conventional protocol.

## MATERIAL AND METHODOLOGY

The present study had included twenty completely edentulous patients with (50-60) age range selected from the out-patient clinic, Faculty of Dentistry, Cairo University. The study protocol was reviewed & approved by staff members of the Prosthodontic Department and Ethics Committee in the Faculty Dentistry, Cairo University.

### Patient selection Criteria:

Patients were selected with moderately developed residual alveolar ridges (ACP II). With no signs of temporomandibular disorders or lack of

neuromuscular coordination were selected. All patients had previous denture experience.

Selected patients had undergone through intra & extra-oral examination. Patients had been informed about the details concerning the treatment planning, follow-up visits, research protocol. They had signed written informed consents.

#### Patients' Grouping:

Patients were randomly divided in two equal groups each group included ten patients. **Group (I):** Patients had received complete dentures constructed with CAD/ CAM technology. **Group (II):** Patients had received complete dentures constructed according to the conventional protocol.

#### Prosthetic Management:

**For Group (I):** Dentures were constructed with the aid of CAD/CAM technology as follows:

1ry impression, final impression, boxing & jaw

relation registration were made as followed in the conventional protocol. Mid line and canine lines were determined on the occlusion blocks.

#### Procedures of the CAD/CAM denture construction:

On the EXOCAD soft ware; project of complete denture construction was selected. **Fig (1-A)**. The master casts & occlusion blocks were secured to the scanning table to be scanned with the laser scanner after spraying scanning spray in a single step. Three dimensional virtual edentulous models were generated for the edentulous maxilla, mandible & maxilla-mandibular relationship.

**Cast analysis:** The maxillary & mandibular casts had undergone computerized data analysis to record the cast details & anatomic features. **Fig. (1b,c,d)**.

The maxilla-mandibular record was scanned in their closed position & three points were detected on the upper & lower rims at the virtual planning to determine the occlusal plane. **Fig. (1-b & 1-C)**

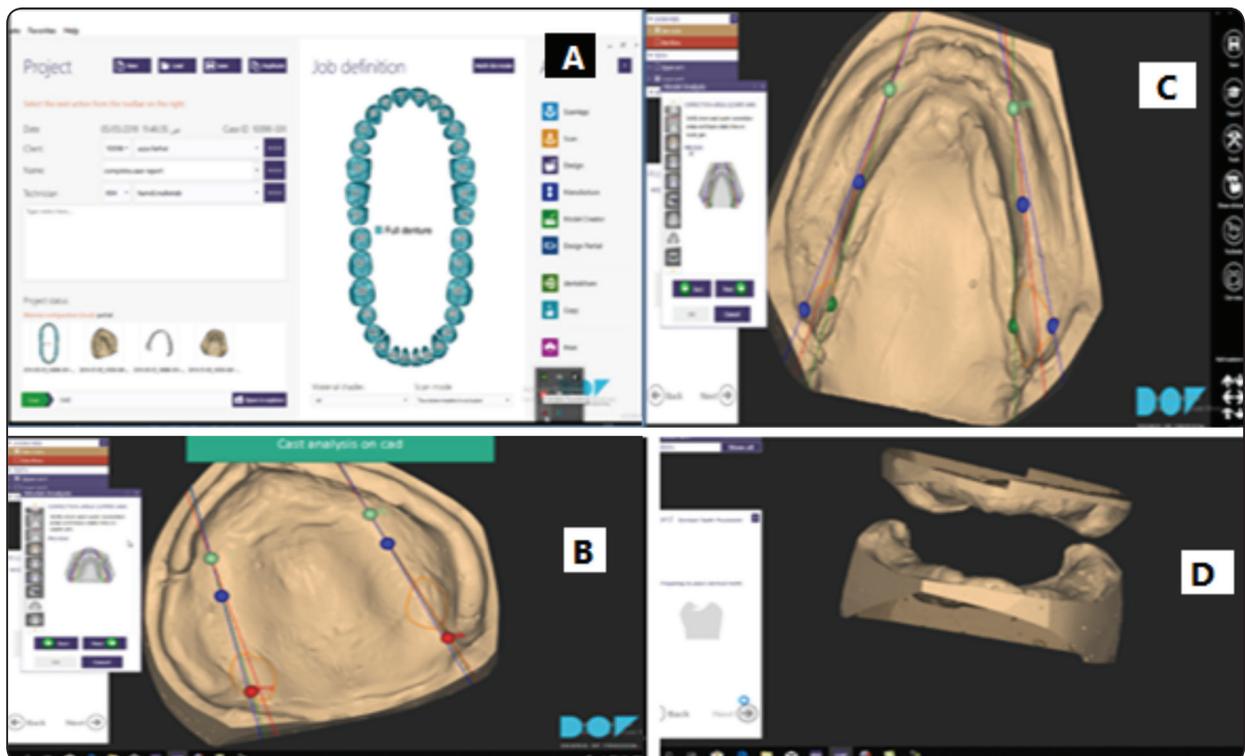


Fig. (1): Steps of designing complete denture on the software program (A): Name the project of CD construction (B): scanning of the lower cast. (C):Scanning of the lower cast. (D): scanning of maxilla-mandibular relationship

Mid line & canine lines were scanned as they were determined at the stage of jaw relation registration.

Artificial teeth were selected from the teeth library option in the EXCOCAD software; according each patient's demands & the desired occlusion concept. **Fig. (2- a, 2-b)**

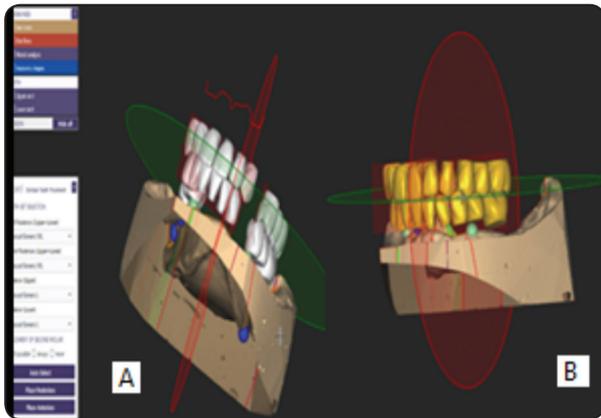


Fig. (2): (A,B): Selection and setting of artificial teeth from the software library

**Set-up of artificial teeth** was made with the aid of the previously determined guide lines. Then the outline of the denture base was drawn & the denture base was modified on the virtual models. Relief areas were detected and relieved on the denture base. **Fig. (3-a)** Then final occlusion adjustment was carried-out on the models. **Fig. (3-b)**

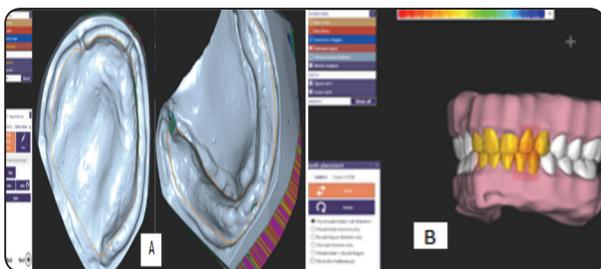


Fig.(3) (A) Drawing of the denture extensions. (B): Final adjustment of artificial teeth

Artificial teeth were hidden thereafter from the virtual denture through a specific option in the **software** leaving their planned positions in the denture base to be printed. The designed virtual dentures were exported as STL files to the three dimensional printer to be printed.

**Printing of the dentures:** The 3 D- printer (DENT 2 DLP Printer) has a supply chamber, fabrication chamber and full HD projector. The liquid resin was poured into the supply chamber of the printer to print the denture base. The denture base was formed by layering technique each layer with 100 micro-meter thickness.

After printing of the denture base, the artificial teeth selected from the artificial teeth library were brought from the Dental supplier each with its specific adhesive. **Fig. (5)**

Teeth were set-up in their corresponding places in the denture base.

Dentures were then inserted into the patient's mouth & Occlusal adjustments were made intra-orally as with group (I). **Fig. (5)**

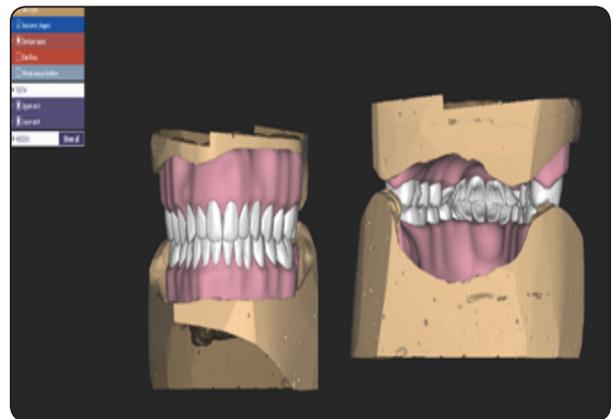


Fig.(4): Finished complete denture design (facial & lingual views)



Fig. (5) Printed Maxillary denture base with & finished CAD/CAM denture inside patient mouth Planned sockets for artificial teeth set-up

**For Group (II):** Complete dentures were constructed according to the conventional procedures using semi-adjustable articulator [Hanau wide view, Whip mix- USA]. Complete dentures were fabricated in balanced articulation. Laboratory Remounting was made to eliminate any processing errors & the dentures were finished and polished thereafter. Complete dentures were inserted into the patient's mouth after verification of denture extension, retention, stability & centric occluding relation & vertical dimension of the face. Any premature occlusal contact was determined with the aid of articulating paper & occlusion was adjusted intra-orally till obtaining balanced occlusal contacts. Patients were recalled after one day, three days and five days to overcome any arising problem.

### Evaluation of Patient satisfaction

Patient satisfaction data was collected in a table containing the items of the questionnaire & number of patients responding by scores from 1-4 (1=bad, 2=neutral, 3= good, 4= very good) for each question were recorded. *Fig.6*

1.	Functional complaint about the dentures
1-1	Have you had trouble pronouncing any words due to your denture?
1-2	Did your taste change because of your denture?
1-3	Did your denture cause pain or sore spot when wearing?
1-4	Did your denture cause pain or sore spot when eating?
1-5	Did your denture loosen easily when eating?
1-6	Did your denture loosen easily when talking?
1-7	Did you feel difficult to swallow liquid food?
1-8	Did you feel food impact under your denture easily?
1-9	Did you feel difficult to open your mouth when wearing your denture?
1-10	Did you have full moth sensation due to your denture?
1-11	Did you find your denture or teeth clicking when eating or talking?
1-12	Did you find your face change when you were wearing your denture?
1-13	Did you bite your cheek or tongue mucosa easily?
	Score: 1-4 (1 = never; 2 = sometimes; 3 = often; 4 = always)
2.	Overall masticating ability
2-1	Did you experience difficulty when chewing?
2-2	Did you have problems with drooling?
2-3	Did you take out your denture for eating?
2-4	Did you feel insecure with your denture when eating?
2-5	Has your diet been unsatisfactory because of your denture?
2-6	Have you had to interrupt your meal because of your denture?
	Score: 1-4 (1 = never; 2 = sometimes; 3 = often; 4 = always)
3.	Masticating ability for different types of food
3-1	Can you eat hard food with your denture?
3-2	Can you eat soft food with your denture?
3-3	Can you eat tough food with your denture?
	Score: 1-3 (1 = well; 2 = moderately; 3 = badly)
4.	Effect on mental and daily life
4-1	Did you feel tense when wearing your denture?
4-2	Did you find it difficult to relax because of your denture?
4-3	Did you feel embarrassed when wearing your denture?
4-4	Did you get upset by the appearance of your profile?
4-5	Have you been a bit irritable with other people because of problems of your denture?
4-6	Did you have difficulty in your daily job because of problems of your denture?
4-7	Are you afraid to go out with other people because of problems of your denture?
	Score: 1-5 (1 = never; 2 = hardly ever; 3 = occasionally; 4 = fairly often; 5 = very often)
5.	Overall denture satisfaction
5-1	How many times do you take out your prosthesis because of discomfort?
5-2	How satisfied are you with your maxillary denture?
5-3	How satisfied are you with your mandibular denture?
5-4	How satisfied are you in general with your dentures?
5-5	How satisfied are you with the functional comfort of your denture?
5-6	How satisfied are you about eating with your denture?
5-7	How satisfied are you about speaking with your denture?
	VAS (Visual Analogue Scale)

Fig (6) Patient satisfaction questionnaire

### Evaluation of Occlusal force distribution with T-scan device:

For both groups occlusion was evaluated with the aid of T-Scan 8 (Tekscan Inc., South Boston, MA, USA) One day & one week after denture insertion.

**Procedures:** The size of the sensor was selected according to the arch size & form of dentures. The Patient was instructed to seat in upright position & the sensor was positioned parallel to the upper denture occlusal plane & the midline was placed between the central incisor denture teeth. Patient was instructed to bite on the sensor 2-4 times for adjusting the sensitivity of the sensor before recording. (*Fig.7*)



Fig. (7): Evaluation of occlusion force distribution with T- Scan device while the patient is biting in maximal intercuspation

Patient was instructed to bite in maximal intercuspation with the sensor positioned between the upper & lower dentures and to keep biting for 1-3 seconds as recommended by the manufacturer. This procedure was repeated three times and movie recording was saved into the computer for analysis. The percentage of occlusal force distribution in the anterior & posterior areas were obtained on each quadrant & saved for data analysis. All measurement procedures were made by one examiner. *Fig. (8a,b)* Any necessary occlusal adjustments were made to re-equilibrate the occlusal contacts.

According to the data obtained from the T-scanning. Patients were recalled after one week. They were instructed to occlude on the same sensor three times consecutively. Occlusion force distribution was evaluated again. The mean values were calculated from the three recordings, saved for data analysis.

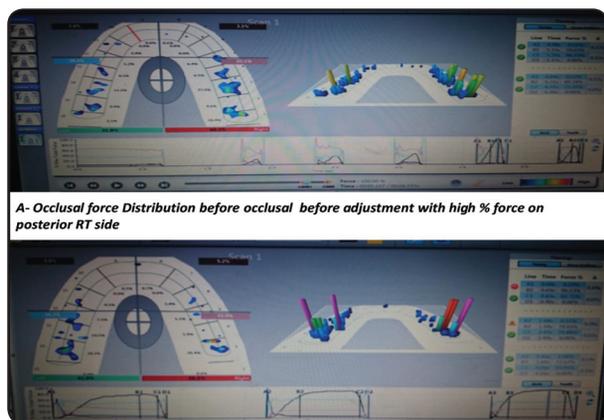


Fig. (8): Occlusal force distribution after occlusion adjustment with better force equilibration on anterior, posterior RT & LT areas

## RESULTS

### Results of patient satisfaction

Patients of the two s groups were satisfied with their dentures. Patients of Group -II were more satisfied with their denture esthetics Group- I. They were more satisfied with CAD/CAM dentures regarding their fitness, retention & less required occlusal adjustments.

The results of the overall patient satisfaction were as follows:

At one week, a higher mean value was recorded in group -I, with no statistically significant difference ( $p=0.3$ ). At four weeks, a higher mean value was recorded in group I, with no statistically significant difference. At three months, a higher mean value was recorded in group I, with a statistically significant difference ( $p=0.001$ )

TABLE (I) Patient satisfaction results and comparison between groups:

<i>Time</i>	<i>Group (I)</i>	<i>Group (II)</i>	<i>P-value</i>
<i>One Week</i>	$3.77 \pm 1.23$	$3.65 \pm 1.09$	0.3 ns
<i>Four weeks</i>	$4.17 \pm 1.02$	$4 \pm 1.06$	0.11 ns
<i>Three Months</i>	$4.52 \pm 0.7$	$4.2 \pm 0.9$	0.001*

\*Significance level at  $P \leq 0.05$

### Results of T- Scan analysis

#### *Effect of T- Scan Analysis On Occlusal Force Distribution In Each Group:*

**In Group (I & II):** The mean value of % occlusion force in the anterior area of the denture was significantly decreased after T -scan analysis & Occlusal equilibration (Intervention) with a significant difference  $p < 0.0001$ .

**In Group (I):** the mean value of occlusion force in the posterior right slightly decreased after intervention with non- significant difference ( $p=0.848$ ). The mean value of posterior left increased after correction with no significant difference ( $p=0.155$ )

**In Group II,** The mean value of posterior right significantly increased after correction with a significant difference ( $p=0.039$ ). The mean value of posterior left significantly increased after correction with a significant difference  $p < 0.0001$

#### **3- Comparison of occlusal force distribution patterns in the studied Groups before and after T-scan analysis: (Table III)**

Comparing **Group I & II** in the anterior region, a higher mean value was recorded in group II before treatment, with no significant difference ( $p=0.746$ ). After treatment, a significantly higher value was recorded in group I ( $P < 0.0001$ ). In the right posterior region, a non-significantly higher value was recorded in Group I before treatment ( $p=0.062$ ), while a non-significantly higher value was recorded in group II ( $p=0.083$ ).

TABLE (II): Values of occlusal force distribution (before/after Occlusal analysis) within the same group (Paired t -test)

Groups		Anterior		Posterior right		Posterior left	
		Before	After	Before	After	Before	After
Group I	Mean ±SD	19.97±5.98	9.56±0.95	46.75±9.45	46.16±1.77	37.81±13.23	44.09±2.03
	t	5.44		0.194		1.48	
	P	<0.0001*		0.848ns		0.155ns	
Group II	Mean± SD	20.95±7.27	5.27±1.13	38.98±7.94	47.39±1.16	38.39±4.93	47.21±1.20
	t	6.74		3.31		5.50	
	P	<0.0001*		0.039*		<0.0001*	

Significance level  $p < 0.05$ , \*significant, ns= non-significant

In the left posterior region, a non-significantly higher value was recorded in group I before treatment ( $p=0.898$ ), while a significantly higher value was recorded in group II ( $p=0.0006$ )

TABLE (III ): Comparison of mean Values of % occlusal force distribution in the studied groups (Independent t- test):

Before Occlusal analysis & Occlusal equilibration				
	Group- I Mean± SD	Group- II Mean± SD	T value	P- value
Anterior area	19.97 ±5.98	20.95±7.27	0.33	0.746 ns
Posterior right	46.75 ±9.45	38.98 ±7.94	1.99	0.062ns
Posterior left	37.81 ±13.23	38.39 ±4.93	0.1299	0.898ns
After Occlusal analysis & Occlusal equilibration				
Anterior area	9.56±0.95	5.27 ±1.13	9.19	<0.0001*
Posterior right	46.16±1.77	47.39±1.16	1.84	0.083 ns
Posterior left	44.09±2.03	47.21±1.20	4.18	0.0006*

Significance level  $p < 0.05$ , \*significant, ns=non-significant

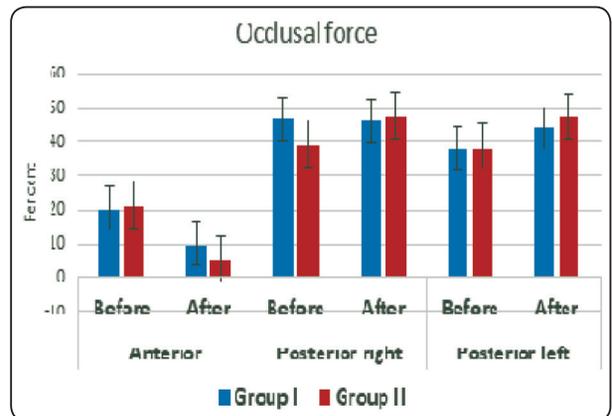


Fig. (9) Bar chart showing mean value of occlusal force

DISCUSSION

This study was conducted to compare the patient satisfaction of CAD/CAM & conventional complete dentures. The results of this study had recorded that patients of both groups were satisfied with their dentures especially by time. This finding may be due to the patients' neuromuscular to their dentures & elimination of any arising problem during the post-insertion recall visits.

Patients of Group-I had non-t more satisfaction than with their dentures than those of Group -II in the 1<sup>st</sup> two follow-up intervals. However, the difference was significant after three months as shown in **Table (I)**

This finding may be attributed to the better denture base thickness, the properly designed denture borders, the better fitness & retention of the CAD / CAM dentures than conventional ones. Moreover, the less occlusal errors & less occlusal adjustments required in the CAD/ CAM dentures.

These results may agree with *Kattadiyil et al. (2015)* who compared the clinical outcomes and patient satisfaction of CAD/CAM & conventional complete dentures. They reported that CAD/CAM complete dentures had given a promising outcome<sup>(19)</sup>

Patient satisfaction is directly affected by the denture stability; which is influenced by presence of balanced occlusal contacts. At the insertion & post- insertion recall visits occlusion of complete denture is adjusted with the aid of articulating paper till reaching an apparent simultaneous occlusal contacts.

**Occlusal force Distribution Pattern:** Recently, digital occlusal analysis with T- scan device had been introduced to evaluate different occlusion parameters. One of these parameters is the occlusal force distribution patterns in complete dentures. T -scan had been utilized to evaluate % occlusal force distribution in two CAD/CAM & conventional dentures.

The results of this study had revealed that the % of force distribution was not balanced on the anterior, right & left sides of the dentures even after occlusal adjustment with laboratory remounting & intra-oral articulating paper techniques in Group (I) & (II) as shown in table (II)

There was a statistically significant difference in the % of force distribution between right & left sides in the two studied groups. This may imply that the articulating paper & laboratory remounting procedures may be not sufficient to obtain bilateral occlusal balance in complete denture prostheses.

After T-scan digital occlusion analysis and adjustment of occlusion; the % of occlusal force was significantly decreased in Group (I) & (II) in

anterior areas **Table (II)**. After Occlusal adjustment the right & left posterior areas of the dentures had recorded comparable occlusal load with insignificant difference.

This may be explained by the value of T-scan analysis in evaluating of %force distribution & determination on unseen premature contacts that couldn't be detected by articulating paper due to mucosal resiliency. Leading to better force distribution patterns on the right & left sides after occlusal corrections & decreasing the anterior share of occlusal load.

**Table (III)** is showing comparison between the two studied groups before & after occlusal analysis; there was a significantly higher % occlusal force in group (II) than group (I) in anterior area. This may be due to the better fitness of the CAD/ CAM denture bases and the accurate virtual set-up of artificial teeth with minimal anterior teeth interferences.

Moreover, statistically non -significant better equilibration of force on the right & left sides after T- scan analysis & occlusion adjustment was noticed in **Group (I)** than **Group (II)** dentures. This may be explained by the proper virtual planning of CAD dentures & setting-up of artificial teeth exactly in their planned sockets that leads to better occlusal force distribution on the posterior denture areas .

Besides the absence of the conventional denture processing step & its accompanying occlusion errors during CAD/CAM denture construction may lead to less post- insertion occlusion adjustment. It is worthy to mention that occlusion refinement is made twice on the EXCOCAD software during the virtual set-up of artificial teeth leading to less premature contacts, better occlusal balance & better dentures stability of the real dentures. This may agree with *McLaughlin et al. (2015)* who proposed the use of CAD/CAM record bases for conventional complete denture fabrication to produce a better-fitting denture with less occlusal errors.<sup>(20)</sup>

## CONCLUSIONS

- CAD/ CAM complete dentures may provide better patient satisfaction, better occlusal force distribution than conventional complete dentures.
- T- Scan digital occlusal analysis helps to obtain bilateral balanced occlusal contacts in complete dentures.

## RECOMMENDATION

Further research may be required, with a larger sample sizes & adequate follow-up periods to evaluate the CAD/CAM dentures.

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