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RESEARCH ARTICLE

INFLUENCE OF DENTURE ADHESIVES ON ORAL HEALTH QUALITY OF LIFE , OCCLUSION AND DISOCCLUSION TIMES OF DIGITALLY FABRICATED AND DESIGNED REMOVABLE COMPLETE DENTURES (CLINICAL CROSS OVER STUDY)

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Abstract

Background: The efficiency of adhesives in enhancing the retention of complete denture has been well recognized. Yet the correlation of using adhesives with occlusal equilibration has not been investigated especially after introducing digitally fabricated complete dentures in order to overcome the drawbacks of the conventional processing technique of complete dentures. In addition, the competence of the prosthesis and its ability to improve the quality of life of the patient should be given great attention as improvement of patient's life is the main goal of any medical intervention.

Objective: The purpose of this crossover clinical study was to evaluate the influence of using adhesives with the digitally fabricated (3D printed) dentures on occlusal equilibration and Oral Health Quality of Life (OHRQoL).

Materials and Methods: The Study was designed as crossover clinical trial, total of 27 subjects participated in the study, all the patients received digitally fabricated (3D Printed) set of complete dentures.

First: The patients were instructed to wear the complete denture for the first two weeks after that occlusal equilibration was evaluated in terms of occlusion time (OT) and dis-occlusion time (DT).

Second: After two weeks the patients were instructed to use the same (3D printed) complete denture for another two weeks after application of denture adhesive then occlusal equilibration was evaluated again in terms of occlusion time (OT) and disocclusion time (DT).

Oral Health-related Quality of Life (OHQoL) questionnaire was used to evaluate the patient satisfaction at the end of the follow up period of each denture set.

Results: Regarding occlusion time, there was significant difference for all timings as mean \pm standard deviation without adhesive and with adhesive were (0.56 ± 0.018) and (0.31 ± 0.024) respectively as P-value < 0.05 . Regarding oral health effect on the quality of life, the studied domains revealed a significant improvement after adhesive application as the denture with adhesive showed lower scores than without adhesive.

Conclusion: Within the limitations of this study and the given specific patient population, denture adhesives were found to significantly

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reduce occlusion time (OT) and disocclusion time (DT) durations in CAD/CAM complete dentures with fairly balanced occlusion, further improving denture stability and the patients' Oral Health Quality of Life.

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Introduction:-

For comprehensive denture design and fabrication, computer-aided design and manufacture (CAD/CAM) has developed as a novel approach.^{1,2} Due to the absence of adequate CAD software until recently, the use of CAD/CAM in complete denture fabrication was limited.^{3,4}

Denture construction could be completed in as few as two visits thanks to CAD/CAM technology. In one patient visit, all impressions, jaw relations, occlusal plane orientation, teeth selection, and maxillary anterior teeth setting-up may be completed. This, obviously, saves both patients and prosthodontists a lot of time and resources.^{5,6}

Despite milled dentures are more common than printed dentures, this trend may soon reverse because milling has the well-known issues of machining tool wear and waste of denture base material. 3D printed dentures, on the other hand, are more cost-effective since unused material can be reused and several dentures with perfect details replication can be manufactured.^{7,8}

For complete dentures to be successful, they must integrate well with the masticatory system and be acceptable to the patient psychologically as well. All these depend on the retention quality of the dentures which is determined by the complex interaction between cohesion, adhesion, atmospheric pressure and surface tension.⁹

Denture adhesives are sometimes a point of conflict. Denture adhesives appear to be well accepted by patients and are even being considered as a treatment option by some of them. Self-observation studies reported that while using dentures with adhesive, comfort was increased and satisfaction was increased accordingly.^{10,11,12} Professionals, on the other hand, are more cautious. A well-fitted denture does not require adhesives, according to dentistry professionals. The incorrect use of the adhesive may lead to high vertical occlusal dimensions and chronic use may conceal tissue changes that may harm the remaining bone.¹³

Denture adhesives are available in a variety of forms, including pads, wafers, creams, pastes, and powders. Creams, Pastes and powders are soluble, while synthetic wafers and pads are not.¹⁴ In the literature, there is no proof that one form of adhesive is superior to another.¹¹

However, dental journals have not published enough clinical studies which objectively analyze the occlusal balance and occlusal contact simultaneity between complete dentures with and without adhesives. On the other hand, Conventional clinical techniques, such as articulating paper and occlusal indicating wax, make intraoral examination of simultaneous contacts problematic.^{14,15,16}

These procedures are simple and rapid,¹⁴ but none have proven to be capable of providing contact time sequences or quantifying occlusal forces.¹⁶ Although articulating paper is the most widely used technique, it is impacted by many factors, such as occlusal morphology, occlusion, and salivary adsorption of the dental surface, which all influence articulating paper ink, making it less precise.¹⁷ Furthermore, it is fragile during intercuspation and is prone to decomposing and perforation, reducing its reproducibility.¹⁸ It also cannot specify occlusal contact simultaneity or contact force,¹⁸ in addition the size of the paper mark is just a description of surface area and contact area, all of these make articulating paper an insufficient indication of applied occlusal force.¹⁶

In recent years, computerized occlusal analysis has made the objective measurement of occlusal equilibration possible. T-scan was created to evaluate occlusal load in the natural dentition at numerous sites.¹⁹ In complete denture wearers, occlusion can be estimated both visually and numerically from the first to the full tooth contact using the T Scan device.²⁰ T-Scan enables the prosthodontist to record information such as bite length, occlusal load distribution, and relative forces on the teeth.²¹

By presenting numerical values for occlusion and disocclusion times, the program evaluates occlusal balance objectively. Occlusion time (OT) is representing the time from the initial contact of opposing teeth to the maximum intercuspation, while dis-occlusion time (DT) representing the time from the maximum intercuspation to complete disocclusion.^{22,23} Occlusion correction and articulatory linkage during lateral movements can be accomplished with OT and DT.^{24,25,26}

T-Scan information on occlusal force distribution is useful in achieving a centered and measured occlusal force balance of about 50 percent right – 50 percent left, which improves denture tissue adaptation during mastication.²⁷ It is crucial to assess the occlusal contact sequence in order to objectively diagnose premature occlusal interactions. The use of T-Scan would aid in more accurate occlusal analysis and corrections that could be objectively proved.²⁸

Completely edentulous individuals have been rehabilitated with complete removable dentures for a long time in order to improve their quality of life (QL), but this mission has never been scientifically validated. There are some authors who believe that using QL indicators in conjunction with objective clinical tests can aid in the decision to construct new dentures.^{29,30} An effective denture improves the quality of life of completely edentulous people because it offers a greater level of confidence, a better aesthetic, which improves their social lives accordingly. On the contrary, unretentive or unpleasant dentures can jeopardize health and quality of life.²⁴

Oral Health-Related Quality of Life (OHRQoL) is a comprehensive, self-reported evaluation that measures the impact of oral conditions on everyday activities. It is widely being used to assess oral health, as a guideline for selecting resource investment, and as an indicator for assessing the efficacy of oral health interventions and dental care outcomes in groups of old people.³¹

Consequently, this study was formulated to evaluate & compare the occlusion time (OT) and Disocclusion time (DT) occlusal parameters and Oral Health Quality of Life (OHRQoL) in 3D printed complete dentures with and without denture adhesives using the T-Scan III computerized occlusal analysis system.

Subject And Methods:-

Subjects:-

Completely edentulous patients were selected from the outpatient clinic of the Medical Excellence Centre of the National Research Centre, Cairo, Egypt and College of Oral and Dental surgery, Misr University for Science and technology according to the following inclusion criteria: patients aged from 45-75 years and had been completely edentulous for a minimum period of 1-year, normal maxillary-mandibular relationship, healthy mucosa, and normal salivary flow. While the exclusion criteria were: smoker patients or patients having hard or soft tissue pathology, severe ridge undercut, and patients who had received radiation to the head and neck region.

Study Design:

This study was a clinical cross over. Each patient received a set of digitally designed and fabricated 3D- printed complete dentures.

First:

The patients were instructed to wear the complete denture for the first two weeks after that occlusal equilibration was evaluated in terms of OT and DT.

Second:

After two weeks the patients were instructed to use the same 3D printed complete denture for another two weeks after application of denture adhesive then occlusal equilibration was evaluated again in terms of OT and DT.

Oral Health-related Quality of Life (OHQoL) questionnaire was used to evaluate the patient satisfaction at the end of the follow up period of each denture set.

Ethical approval

The present study was conducted with the Code of Ethics of the World Medical Association, according to the principles expressed in the Declaration of Helsinki in 1975. This study has been approved by the Medical Research

Ethical Committee of National Research Center, Cairo, Egypt with approval number **00034052021**. All patients were informed about the practical steps of this study and signed written approval consent.

Sample size calculation

According to previous study, the accepted sample size was 27 per group, when the response within each subject group was normally distributed with a standard deviation of 0.23, the true mean difference was 0.13 when the power was 80 % and type I error probability was 0.05. Independent t-test was performed by using PS Power software.³²

The work flow of the digitally designed and fabricated 3D printed dentures:

Preliminary impressions was made using irreversible Hydrocolloid Alginate(Cavex Holland BV) then definitive impression and recorded horizontal relationship were done in one visit and sent to a digital laboratory for scanning and 3D printing of the CDs.

The definitive casts and the occlusal rims were prepared for scanning with scan spray.

Scanning of the master casts and bite blocks was performed with an optical 3D scanner (iSeries; Dental Wings Inc) the scanned images of the definitive casts and connected occlusal rims were transformed into (STL) files and the complete dentures were designed and virtual teeth were set then previewing the whole denture by the clinician for final modifications. The socketed denture bases were printed using (NextDent Denture 3D+ acrylic resin, Vertex Dental B.V.,Soesterberg, The Netherlands) , and the teeth wereprinted and bonded to perspective sockets in the denture bases(Figures 1, 2).

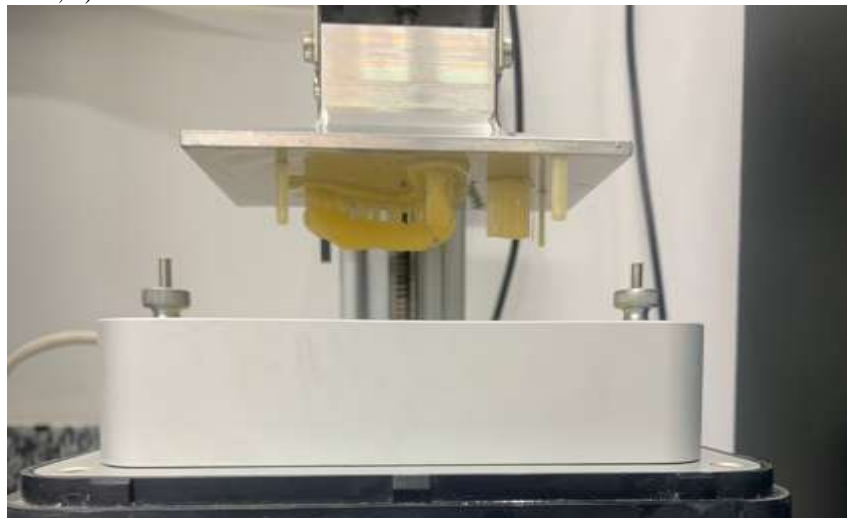


Figure 1:- Printing of the artificial teeth.



Figure2:- The Socketed denture base and printed teeth.

Laboratory remounting was carried out to correct occlusal changes due to processing errors. The necessary intraoral clinical adjustments were then carried out in a conventional manner on the day of denture insertion and continued throughout the first week until participants were free from any discomfort from their dentures. Clinical remounting procedures were then carried out 2 weeks later to refine occlusal contacts after denture settling. Before any occlusal parameter recording, computer-guided occlusal adjustment procedures were carried out on all dentures.

Evaluation of occlusion by using digital occlusal analysis:

Participants were allowed to use their dentures for 2 weeks then were recalled for the occlusion time (OT) and disocclusion time (DT) recording procedures.

Participants were then left without their dentures for 2 weeks (washout period) before adhesive application.

Paste denture adhesive (Corega; Stafford-Miller Ltd) was used in this study. The amount and application of adhesive followed manufacturer's recommendations and were demonstrated to the participants after giving them all necessary instructions. Participants were asked to use the denture adhesive for 2 weeks and then recalled for the second OT and DT recording procedures that were carried out while the participants wore their adhesive-retained dentures.

Digital occlusal analysis was performed for the patients utilizing the T-Scan III computerized system (Tekscan system Tekscan Inc., South Boston, MA, USA). This system is composed of a computer with a specific board and software capable of converting information recorded by the sensor to visual and numerical information on tooth contact. The size of the sensor was selected according to the arch size & form of dentures in all patients in both groups. The patient was instructed to sit in an upright position & the sensor was positioned parallel to the upper denture occlusal plane & the midline was placed between the central incisor denture teeth. Occlusal parameters (OT and DT) were recorded for the occlusally balanced dentures in each participant on 2 occasions: first without adhesives and second after adhesive application. Participants were asked to occlude on the sensor in centric occlusion with normal pressure until maximum intercuspation, then hold their teeth together for a period of 1 to 3 seconds, start a right or left excursion from that completely intercuscated position, and then disocclude. This was repeated 4 times for the right excursion (DT-right) and 4 times for the left excursion (DT-left). Mean OT, DT-right, and DT-left were then calculated by taking the averages of the recordings. (Figure 3).

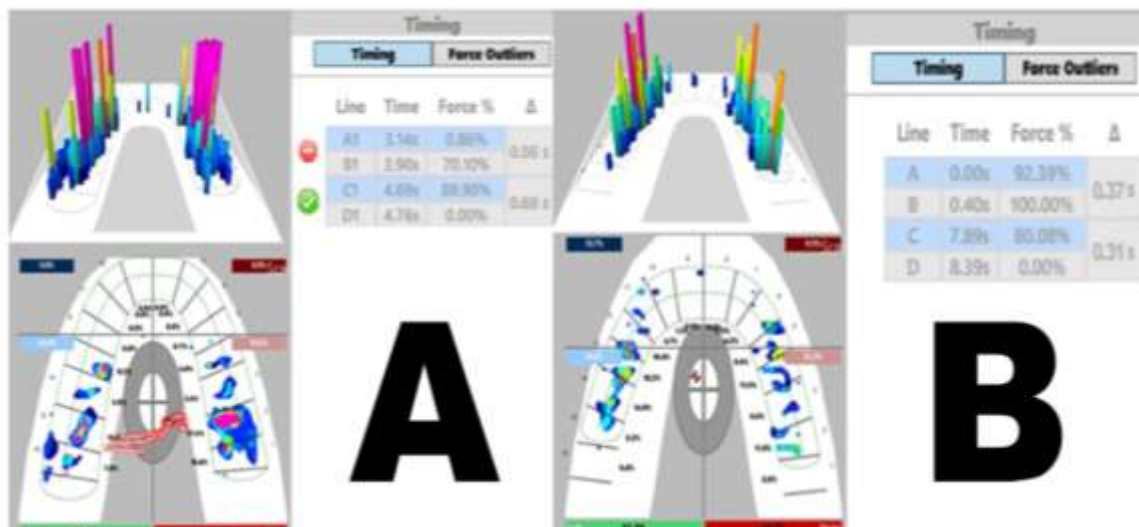


Figure 3:- Analysis of occlusal force in each quadrant:
A- Without adhesive. B- With adhesive

Evaluation of Oral Health Quality of Life (OHRQoL):

The Oral Health Impact Profile for Edentulous Patients (OHIP-EDENT) consists of 19 questions which were obtained from each of the seven conceptual domains of the OHIP (functional limitation, physical pain, psychologic discomfort, physical disability, psychologic disability, social disability, and handicap) as shown in (table 1). It was used to evaluate the patient satisfaction for each participant at the end of each follow up period: first without adhesives and second after adhesive application.

The OHIP-EDENT questionnaire was translated into Arabic by linguistic professionals who worked in collaboration with the authors to prepare the final version, the five categories of response for each item were never (= 1), hardly ever (=2), occasionally (=3), fairly often (= 4), and very often (= 5) The sum ranges from 0-76. Higher OHIP-EDENT summary scores indicate OHRQoL impairment.

Table (1):- Questions for the Oral Health Impact Profile for Edentulous Patients.

Functional limitation	Q1	Have you had difficulty chewing any foods?
Q2		Have you had food catching in your dentures?
Q3		Have you felt that your dentures have not been fitting properly?
Physical pain	Q4	Have you had painful aching in your mouth?
Q5		Have you found it uncomfortable to eat any foods because of problems with your dentures?
Q6		Have you had sore spots in your mouth?
Q7		Have you had uncomfortable dentures?
Psychological discomfort	Q8	Have you been worried by dental problems?
Q9		Have you been self-conscious because of your dentures?
Physical disability	Q10	Have you had to avoid eating some foods because of problems with your dentures?
Q11		Have you been unable to eat with your dentures because of problems with them?
Q12		Have you had to interrupt meals because of problems with your dentures?
Psychological disability	Q13	Have you been upset because of problems with your dentures?
Q14		Have you been a bit embarrassed because of problems with your dentures?
Social disability	Q15	Have you avoided going out because of problems with your dentures?
Q16		Have you been less tolerant of your spouse or family because of problems with your dentures?
Q17		Have you been a bit irritable with other people because of problems with your dentures?
Handicap	Q18	Have you been unable to enjoy other people's company as much because of problems with your dentures?
Q19		Have you felt that life, in general, was less satisfying because of problems with your dentures?

Result:-

Occlusal equilibrium analysis using T-scan system before and after denture adhesive application was evaluated as cross-over study two weeks after denture insertion without adhesive and two weeks after denture insertion with adhesive.

Regarding occlusion time, mean \pm standard deviation without adhesive and with adhesive were (0.56 \pm 0.018) and (0.31 \pm 0.024) respectively. While for right disocclusion time, mean \pm standard deviation without adhesive and with adhesive were (0.64 \pm 0.049) and (0.37 \pm 0.061) respectively. Finally for left disocclusion time, mean \pm standard deviation without adhesive and with adhesive were (0.68 \pm 0.037) and (0.34 \pm 0.028) respectively, showed in (figure 4). Performing paired t-test for significance evaluation of dependent variables, it revealed that there was significant difference for all timings as P-value < 0.05, listed in(table 2).

Analysis of oral health effect on the quality of life, studied domains revealed a significant improvement after adhesive application as the denture with adhesive showed lower scores than without adhesive, as investigated in(table 3) and shown in (figure4,5).

Table (2):- Comparative Values of Effect of Denture Adhesive on Occlusal Load Analysis:

	Two Weeks after Wearing Complete Denture without Adhesive (M \pm SD)	Two Weeks after Wearing Complete Denture with Adhesive (M \pm SD)	P-value
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OT	0.56±0.018	0.31±0.024	<0.0001*
DT-Right	0.64±0.049	0.37±0.061	<0.0001*
DT-Left	0.68±0.037	0.34±0.028	<0.0001*

M; Mean, SD; Standard Deviation, P; Probability Level

OT; Occlusion Time, DT; Disocclusion Time

*significant Difference

Table (3):- Evaluation of Effect of Denture Adhesive on OHIP-EDENT Questionnaire Score:

	Two Weeks after Wearing Complete Denture without Adhesive (M±SD)	Two Weeks after Wearing Complete Denture with Adhesive (M±SD)	P-value
Functional Limitation	9.2±2.54	4.5±1.38	<0.0001*
Physical Pain	8.7±2.41	3.8±1.16	<0.0001*
Psychological Discomfort	6.1±1.69	1.9±0.58	<0.0001*
Physical Disability	5.7±1.58	2.8±0.86	<0.0001*
Psychological Disability	4.8±1.33	1.1±0.34	<0.0001*
Social Disability	3.9±1.08	0.83±0.25	<0.0001*
Handicap	2.81±0.78	0.97±0.30	<0.0001*
Overall OHIP-EDENT	41.21±11.40	15.9±4.87	<0.0001*

M; Mean, SD; Standard Deviation, P; Probability Level

*significant Difference

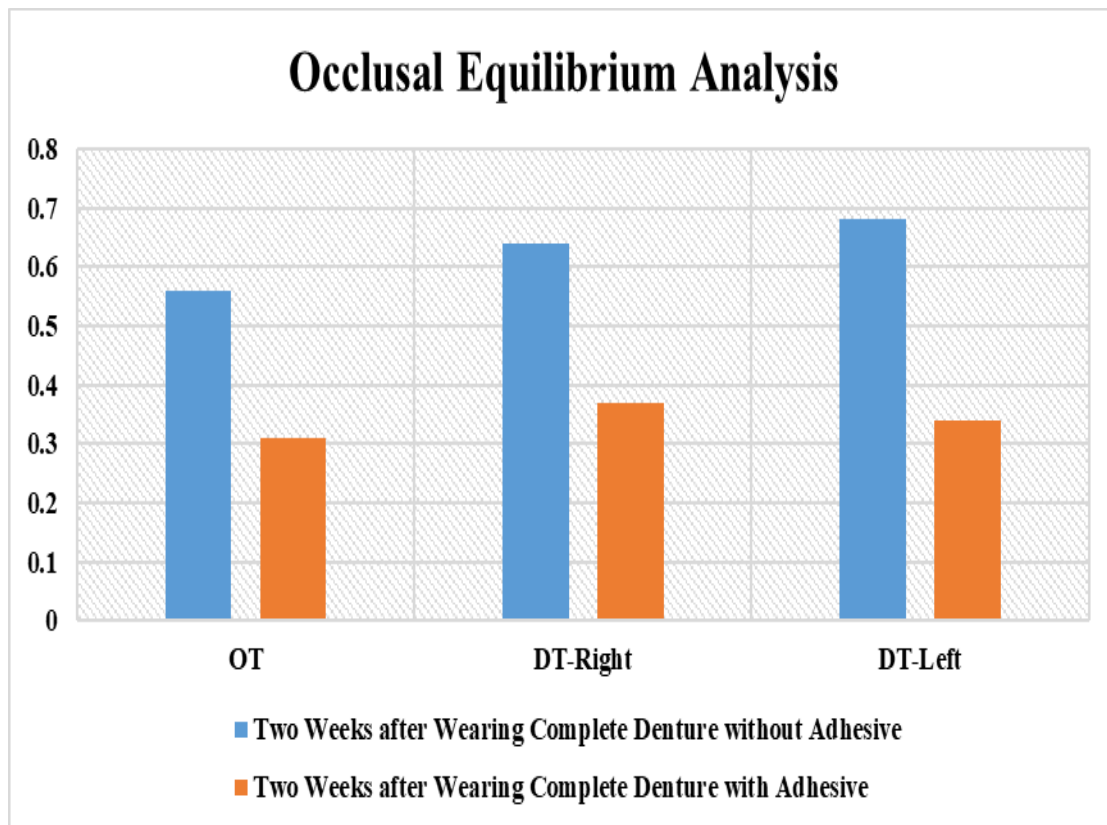


Figure (4):- Bar Chart revealing Comparative Values of Effect of Denture Adhesive on Occlusal Load Analysis.

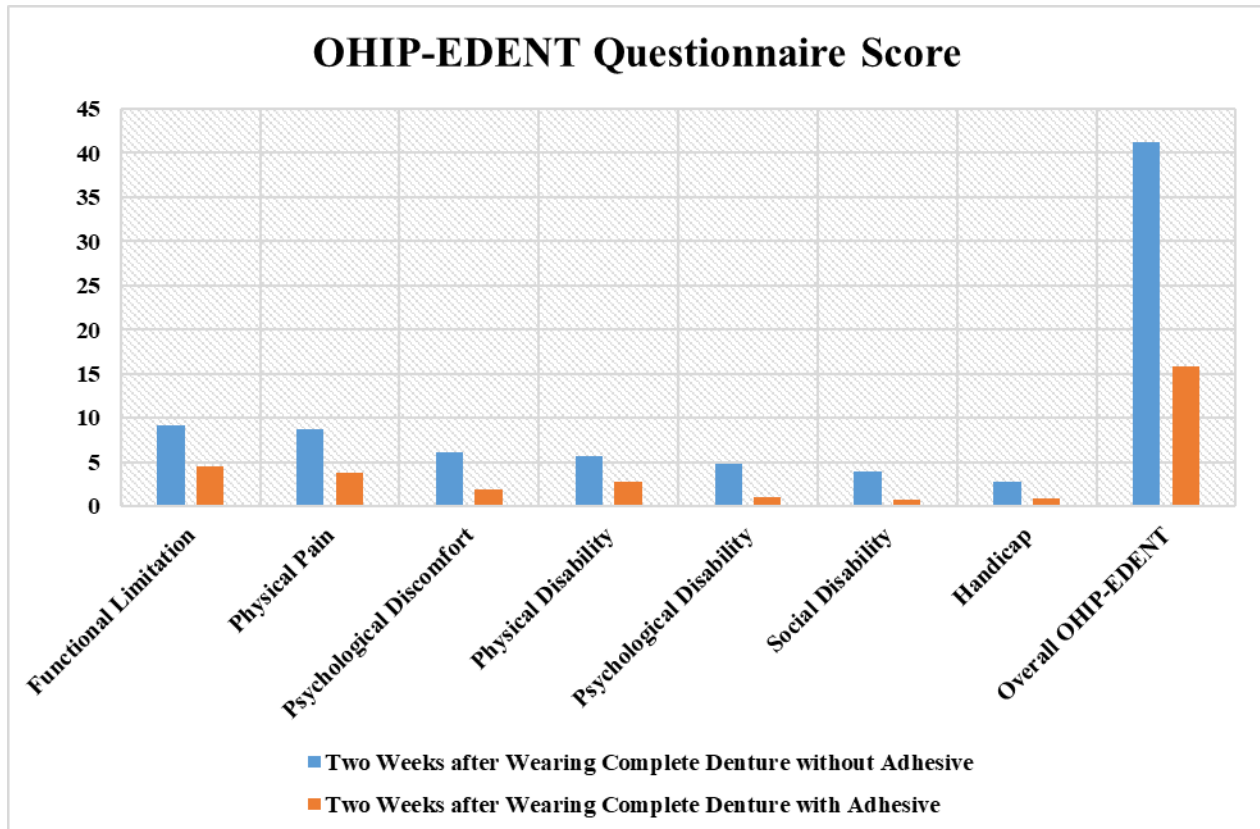


Figure (5):- Bar Chart revealing Evaluation of Effect of Denture Adhesive on OHIP-EDENT Questionnaire Score.

Discussion:-

For edentulous individuals, complete maxillary and mandibular dentures have long been seen the gold standard of care. While most edentulous patients are happy with their maxillary complete dentures, many may not have the same level of satisfaction with their mandibular dentures.^{33,34}

To improve total denture retention and stability, a denture adhesive could be prescribed. When well-designed complete dentures do not meet the patient's expectations for stability and retention, adhesives should be used on a regular basis.³⁵

In this investigation, the T-scan was employed to detect occlusal contacts since it could link occlusion to other elements of the articulatory system via OT and DT, as well as more precisely find premature contacts and occlusal interference.^{36,37} OT has been considered a capable description of occlusion^{25,38} since it is closely related to patients' occlusal contact pattern.²⁴ DT, on the other hand, could link tooth contacts to muscle activity.²³ An OT of less than 0.2 second and a DT of less than 0.4 second is recommended by the manufacturer.^{22,23}

Several precautions were taken to guarantee that the results were valid and reliable. To account for individual differences, the study was structured as a cross-over clinical trial. One clinician performed all occlusal modifications and recorded all occlusal parameters. This was done to exclude inter-examiner inconsistencies.³⁹

Prior to denture placement, the T Scan III centered of force analysis was used to perform a computer-guided occlusal correction.^{40,41} This was required to guarantee a constant baseline for previously well-fitted dentures with a well-balanced occlusion, as well as to avoid the effects of offset deflective occlusal contacts and instability on the results. A two-week washout period was also applied to confirm that the "with" adhesive values were due to the use of the adhesive rather than participant adaptation to his dentures.^{42,43} The subjects were only allowed to wear their dentures for two weeks because denture adaptation takes 90 days.⁴⁴

The current research found that using denture adhesives reduced OT and DT times significantly. This may be due to the way they work. Adhesives generally use an intermediary layer made up of a mixture of the adhesive, saliva, and other oral fluids to build a retentive force between the denture and the oral mucosa.⁴⁵ This increases the extent of denture surface area in touch with the denture bearing tissues, increasing the prosthesis resistance to dislodging.^{46,47}

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 software during the virtual set-up of artificial teeth leading to less premature contacts, better occlusal balance & better dentures stability of the real dentures.⁴⁸

In this study, the OHIP-EDENT was utilised to assess and compare participant OHR-QoL. The findings of this study revealed that when complete denture adhesives were used, there was a statistically significant improvement in patient QL. This is due to the adhesives' composition, which results in an increase in adhesive and cohesive characteristics while also increasing the viscosity between complete dentures and the oral mucosa. As a result, the adhesives utilized help to reduce complete denture movement, resulting in improved function and masticatory efficiency, as well as enhanced patient satisfaction.^{49,50}

The findings of this study are consistent with those of other authors, who reported that adhesives greatly reduced movement of the maxillary and mandibular dentures during mastication and increased comfort. Furthermore, patients indicated that applying adhesives eliminated the difficulties caused by food particles introduced below denture during mastication, producing discomfort and inflammation in the mucosa owing to friction.^{51,52,53}

Conclusions:-

Within the limitations of the current study and the selected population sample, denture adhesives were found to significantly decrease occlusion time(OT) and disocclusion time (DT) durations in CAD/CAM complete dentures with fairly balanced occlusion, further improving denture retention, stability and the patients' Oral Health Quality of Life.

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