Computerized assessment of occlusal contact and masseter muscle activity for mandibular All-on-Four fixed-detachable provisional versus definitive prosthesis

Original Article

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ABSTRACT

Background: All-on-four concept is widely applied in dental clinics, which comprises only four implants placed in the anterior region and requires two phases in its treatment plan; the provisional and definitive prosthesis. For the provisional, the patient's denture is altered and screwed to implants for immediate loading and used in the osseointegration period for nearly four month then replaced with the hybrid definitive prosthesis.

Objective: The purpose of the current study was to assess and correlate the short-term changes in occlusal contacts distribution and masseter muscle activity in patients rehabilitated with mandibular All-on-Four fixed-detachable and to compare between provisional acrylic versus definitive porcelain fused to metal prosthesis.

Material and method: For this within-subject crossover clinical study; seven completely edentulous patients were selected following certain criteria to receive mandibular hybrid prosthesis based on All-on-Four concept using guided surgical procedures following flapless approach. Patient's new lower denture were modified and screwed to act as "provisional prosthesis" and after three month of using the prosthesis, the occlusal contacts were assessed using T scan and masseter muscle activity were evaluated with Surface Electromyography. After one month washout period, the "definitive hybrid prosthesis" was constructed using porcelain fused to metal and screwed on the multiunit abutments. Patients were allowed to wear it for 3 month after which the same records were obtained. The collected data were statistically analyzed and correlated.

Results: The EMG records analysis showed; On comparison between soft and hard food using Independent t-test revealed that hard food was significantly higher than soft in both groups. While comparing provisional and definitive groups the data showed that the provisional group was significantly higher than the definitive group. Regarding the T scan records analysis showed on comparison between provisional and definitive groups that the former was significantly higher than last one at right side, while provisional group was significant lower at left side. Correlation between EMG and T-scan revealed positive insignificant correlation in soft food provisional group. While in hard food, provisional group revealed negative significant correlation. On the other hand both types of food in definitive group revealed positive insignificant correlation.

Conclusions: The T scan and EMG outcomes in the current study revealed that both provisional and definitive All-on-Four fixed detachable prostheses can be considered a functionally efficient treatment option for edentulous mandible as detected by the favorable masseter muscle activity. However the definitive prosthesis better maintain the occlusal equilibrium. Based on these findings frequent occlusal adjustments are required for the provisional prosthesis whenever long-term use of it is planned.

Key Words: All-on-four, implant supported, fixed-detachable prosthesis, T scan, electromyography, muscle activity.t

Received: 12 March 2022, **Accepted:** 17 March 2022.

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ISSN: 2090-097X, XXX 2022, Vol. 13, No. 2

INTRODUCTION

Using implants for prosthetic rehabilitation of completely edentulous patients is a well-recognized and consistent treatment approach. Conventionally, it is well-known that masticatory forces essentially to be directed along the long axis of the tooth or implant that enhances its longevity and decreases the rate of bone resorption. The amount of bone available in severely resorbed ridges is reduced thus investigators have been trying to find a suitable alternate treatment modality other than using bone augmentation and sinus lift procedures thought avoid these additional surgical procedures [1].

All-on-four treatment protocol to rehabilitate completely edentulous arch was proposed by Malo´ et al[2] in 2003 using Branemark system implant. In which placing four implants in the anterior maxillary or mandibular region. Then full arch hybrid prosthesis is screwed following immediate loading protocol.

The advantages of this treatment option that implants are placed in high density bone, tilting the two distal implants permits the use of longer implants, enhanced more distal position of the abutments with prosthetic support of shorter cantilever extension, enhanced inter-implant distance and increased anchorage to bone [3- 5]

Distal implants angulation facilitates for the surgeon to avoid the critical anatomical structures. Biomechanically,

 DOI: 10.21608/OMX.2022.143758.1166

using tilted distal implants are more favorable than putting distal cantilever units. Tilted distal implants, without the burden of bone grafts or sinus lift, shorten the length of cantilever required [1, 6- 8]. Thus avoid the incidence of exerting load on the cantilever part that may cause hinging effect, which provokes significant stresses on the closest distal implant [9]. Increasing in the distal cantilevers length can result in deformation of the framework that may lead to fracture of the prosthetic screw, fracture of acrylic resin teeth or even occurs in the framework itself [10].

All-on-four concept demonstrated excellent prognosis in both short and long term[5]. Implants in all-on-four concept are well spaced, can be easily cleaned, provide immediate function and esthetics. The final prosthesis used can be fixed or removable in addition it decreases the cost because of using less number of implants [11]. Placement of implants requires extreme accuracy that is very important for the success and longevity of the prostheses. This can be accomplished by using accurate surgical guide which provides the operator adequate information about exact implant location in relation to the surrounding vital structures and according the available bone quantity and quality [1,5,12].

The biomechanical aspects of occlusal design, configuration, and anatomy significantly influence the ultimate success of implant. Most of the problems of implants that arise between first and sixth week post-operative are directly related to occlusion [13]. Though the prosthesis must be accurately constructed as possible so as to achieve long-term success. If the prosthesis have poor occlusal management, implants will be vulnerable to overload and excessive micro motion beside they do not have periodontal ligaments consequently pathologic bone strain and fibrotic healing rather than osseointegration will take place [14]. Providing that forces and implant micromotion are controlled, immediately loaded implant osseointegrates [15].

Conventional occlusal analysis approaches using articulating paper, shim stock, wax and silicone impressions are denoted as qualitative methods. Because of their static nature, subjective interpretation, and not reliable or reproducible, they are considered incomplete method for evaluation [16]. Quantitative occlusal analysis method can provide ample data as T-scan system (Tekscan Inc., South Boston, MA, USA), it is one of the modern technologies that evaluate and diagnose occlusion digitally [17]. which is a diagnostic device that records bite force dynamics when the patient bites on pressure-measuring sensor and occlusal changes are displayed straightforward on the computer screen and recorded. Afterwards the force distribution ratios of all teeth are presented in 2D and 3D graph [18].

T-Scan occlusal analysis system (Tekscan) is a Microsoft compliant system which can record the contact sequence in 0.01-s increments. It detects time magnitude and the distribution of occlusal contacts where it can record the initial contact of tooth, its relative force and timing [19, 20].

It is used in many clinical situations when occlusal adjustment is necessary as it is sensitive, reliable, reproducible recording method used for effective digital occlusal analysis [21].

Occlusion may change muscle activity and related mandibular movements during mastication. Muscle activity is considered the reflection of the patient's masticatory function, it can be objectively assessed using surface electromyography (EMG) [22]. It safely and non-invasively measures muscle activity using surface electrodes positioned on the skin covering the muscle to record the muscle contraction timing and to examine the performance of the muscle during stomatognathic system functions in static and dynamic activities. Thus allowed reliable quantification of the muscle energy [23,24].

EMG is a diagnostic device that uses electrical potentials to record muscle action potential for assessing muscle function and efficiency. It recognizes the electrical signals that are proportional to the energy consumed to produce contractions and record them [19,25]. This can be during normal or abnormal conditions as occlusion and bruxism to estimate the effectiveness of muscle activity per treatment [26]. However due to the increased demand to employ the All-on-four concept for implant supported hybrid prosthesis as means to solve the severely resorbed mandibular arch problems, the purpose of the current study is to assess the occlusal contacts and muscle activity of masseter muscle fibers in the two prosthetic phases of the All-on-four treatment protocol; the fixed-detachable provisional acrylic versus the definitive porcelain fused to metal prosthesis as an indicator to their oral function. The null hypothesis was that the use of either of the prosthetic types does not affect the occlusion when expressed within T-Scan and EMG after its use for three month.

MATERIALS AND METHODS

Patients' selection:

Seven Patients for this study having problems adapting to their mandibular complete dentures were selected and managed in Prosthodontic Clinic, Faculty of Dentistry, Ain Shams University. The inclusion criteria were healthy patients aged 50-65 years old, having completely edentulous maxillary and mandibular ridges. The mandibular ridge to be covered with firm, healthy mucosa with no signs of inflammation or bony undercuts. Patients with Angle's class I maxillomandibular relationship and have adequate restorative space for the mandibular prosthesis of minimum 12 mm from the oral mucosa to occlusal plane to permit the hybrid prosthesis.

Patients free from any systemic disease e.g. uncontrolled diabetes, cardiovascular diseases and bone diseases, hyperparathyroidism and impaired psychological conditions that might affect the oral tissues or the bone metabolic

rate and may interfere with implant placement and/or osseointegration.

Patients who had bone metabolic disorders and diseases that may complicate surgical procedures as liver, heart, autoimmune diseases and radiation to head and neck were excluded. Also, Heavy smokers or who have habitual habits as bruxism or clenching and patients with neuromuscular disease, any impairment of muscle control or coordination that could affect the measured outcomes were excluded. Patients with history of tooth extraction due to periodontal disease were also excluded.

All participants were informed about the surgical and prosthetic steps of this treatment option and the needed steps for the participation and completion of this study records. They were also informed about the importance to properly follow all the instructions. They accepted and signed an informed consent. All means to keep their information secure were followed.

Visual and digital intraoral examination were carried out to ensure the prementioned criteria. Examination of the temporomandibular joint (TMJ) was carried out to detect any disorders as clicking, dislocation or pain. To assess the ridge relationship and the restorative space mounted diagnostic cast using provisional jaw relation was preformed.

Radiopaque markers (gutta percha) were added vertically to the facial surface of their old lower denture at the implants' planned sites (two between the lateral incisor and canine and two at first premolar bilaterally). Cone beam computed tomography (CBCT) (i-CAT FLX series Imaging Sciences International, LLC, Hatfield) was done to evaluate the bone quality and quantity and to ensure presence of sufficient bone width and length to receive four implants in the predetermined sites guided by the markers.

- For All participants new upper and lower conventional complete dentures were constructed following the conventional steps. Modified cross-linked acrylic teeth (Vita-pan acrylic teeth, Vita Bad Sackingen- Germany) were set following the lingualized occlusion. At denture insertion visit, occlusion was checked and balanced using the T scan.

Construction of the 3D surgical guide:

Virtual planning was done with dual scan protocol where adding seven spherical radiographic composite markers in a staggered pattern at different levels to the occlusal plan on buccal and labial flanges of patient's lower denture to be used as radiographic guide. Using CBCT scan for each patient while wearing the radiographic guide and his upper denture and biting in centric occlusion. Another scan was made for the modified lower denture alone on the table.

The two scans were superimposed onto each other guided by the visible spherical radiographic markers and the CBCT raw data was converted into 3D information by in 2guide cyber med software (2guide cyber med software, Seoul, Korea). The final file contained reformatted images in 3D bone model, 3D radiological dataset and 3D radiographic modified denture guide model.

The Software allows to rotate the 3D images and put the proper treatment plan and select the suitable implant's location, length and diameter according to the patient's bone quantity and approximation to mental foramen following the all on 4 concept.

The produced sterolithographic surgical guide with a rapid prototyping machine was provided with 4 metallic sleeves matching the precise depth, angulation, mesiodistal and buccolingual positioning of each implant as the virtually planned drilling sites. In addition it had three windows labially for fixation screws away from the planned implants' drilling sites.

Study grouping

This study has a within-subject crossover clinical trial design, grouping was done according to the type of prosthesis to be assessed; the provisional prosthesis and the definitive prosthesis.

Four implants were placed in the interforaminal area following all-on-four treatment protocol and applying immediate loading by screwing the modified lower denture "the provisional prosthesis". Three month later the records were taken for the occlusal contact using T scan while for muscle activity electromyogram was used. Then the provisional prosthesis was removed and the patient was left with no prosthesis for one month (washout period) during which the porcelain fused to metal prosthesis was constructed. Then it is screwed and the same records were obtained after three month of using "the definitive prosthesis".

Surgical and prosthetic procedures:

One day before surgery, participants were premedicated by antibiotics (Augmentin 1gm) and mouth rinse 0.12% chlorhexidine digluconate (15 minutes before surgery) and continued for five days after surgery. The 3D surgical guide was secured in place on the mandibular ridge through the fixation pins. The sequential drilling was done for each implant (V plus implant, Vitronex, Italy) following flapless surgical approach. The two anterior implants were placed vertically in the canine regions and the posterior implants were placed distally inclined at angle (30^{o}- 40^{o}) in the first premolar region (in the planned positions) according to the report provided with the surgical guide about the exact drill length and diameter to be used, according to surgical and prosthetic protocol recommended by the manufacturer. The insertion torque at implant placement ranged from 35-45 N.

Immediate placement implant stability quotient (ISQ)

using Osstell (Osstell ISQ device, Gothenburg, Sweden). For immediate loading the implants average ISQ be ranged between 57-60.

Straight multiunit abutments (Vitronex, Italy) were screwed on anterior implants and 17° or 30° angled multiunit abutments were connected to posterior implants for better orientation of the screw access hole according to the planned prosthesis with torque 25 N.

Converting complete lower denture to fixed hybrid prosthesis

Four titanium sleeves (temporary coping multiunit cylinders) were attached to the multiunit abutments. The patient's lower denture was modified by shortening all the labial and lingual flanges and opening four windows opposing to the implant sites.

Then the modified lower denture was placed in position and the holes were widened to ensure the denture was passively seated with no interferences.

Denture conversion was then made by reducing the length of all denture flanges just above the crest of the ridge level. The denture fitting surface was then made convex and polished.

Short cantilevers were used to minimize the fracture risk and excessive stresses over the posterior implants.

The titanium sleeves were marked to the level of occlusal plane of the lower denture then were shortened. Figure (1a,b)

Rubber dam material was attached around the titanium sleeves for blocking out the undercuts and small pieces of cotton were put into its screw access then they were picked up using pink autopolymerizing hard pick-up material (Qu-resin, bredent, Germany).

The patient was guided to close in centric occlusion till setting of acrylic resin. Figure (1c,d)

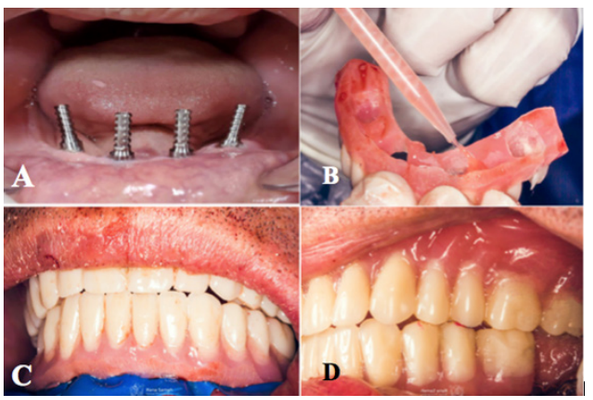

Figure (1): A) Temporary coping multiunit cylinders attached to the multiunit abutments. B) Pink pick-up material added on fitting surface of modified denture. C,D) patient closing in centric occlusion.

The acrylic provisional prosthesis was screwed to the multiunit abutments and the occlusion was rechecked with T scan to be adjusted in centric and eccentric positions. Teeth with premature contact were reduced according to the records shown on the 3D graph and the procedure was repeated until almost all the contacts are nearly equal in intensity and distribution. Occlusal adjustments were made to keep bilateral occulsion in canine and first premolar region besides preventing any contact at the distal part of the restoration [27].

Patients were instructed to take their post-operative medications as previously prescribed. Oral hygiene instructions were given and the patients were advised to follow soft diet to chew carefully and avoid hard or tough foods during first month. Patients were recalled 3 month later for computerized assessment of the occlusal contact distribution and electromyographic activity of the masseter muscle. Unscrewing and removal of the provisional prosthesis was done and one month washout period was allowed during which the definitive prosthesis was constructed.

Construction of the definitive prosthesis

Open tray multi-unit impression copings were placed onto the multiunit abutments that were then splinted with a low shrinkage autopolymerizing resin. Figure (2) An open tray impression technique was made with a rigid polyvinyl siloxane material (Kettenbach Panasil) to record the positions of the implants and the soft tissues. Then Verification jig was done on the master cast to ensure accuracy of the impression then transferred back to the patient's mouth for verification of passivity of the impression.

Figure (2): Splinting of multi-unit impression copings with autopolymerizing resin.

Try in of the metal framework (cobalt chromium alloy) was done intraorally then jaw relation was made using wax wafer technique. Figure (3)

The definitive prostheses porcelain fused to metal were fabricated and screwed on the multiunit abutments using standard prosthetic screws. Figure (4) the screw holes were filled with small cotton pellets and covered by light cured composite with same shade of porcelain.

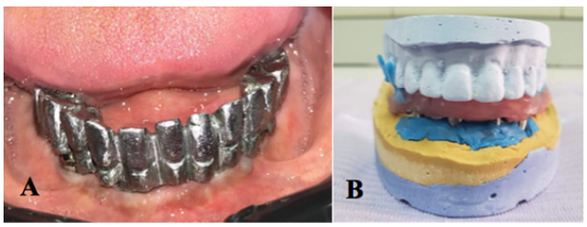

Figure (3): A) Metal framework try in and B) jaw relation record on the cast.

Figure (4): The definitive prosthesis screwed intraoral.

Finally T scan was used for the identification of any needed occlusal adjustments as done previously with the provisional prosthesis. The data shown on the 3D graph aid to locate the premature teeth contact that were reduced and repeated the procedure until reach occlusal equilibrium. Besides the biting force intensity in both sides are approximately equivalent. Figure (5) The patient were recalled 3 month later for follow up and patients evaluation.

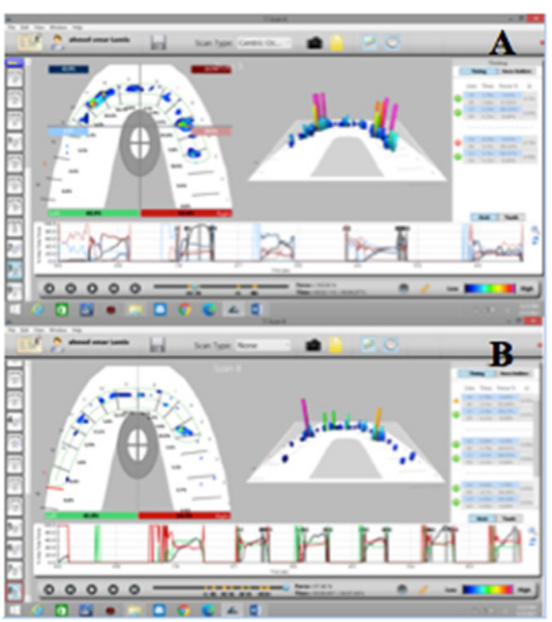

Figure (5): 3D graph color-coded "traces" denoting the forces applied on each tooth A) before and B) after occlusal adjustments till reach uniform force distribution.

Patient evaluation

For all the participating patients masseter muscle activity analysis using surface electromyography (sEMG) and occlusal analysis using the T-scan was performed for the two prosthesis at the scheduled follow up period.

1- Recording masseter muscle activity by EMG
All recordings were made with the patient seated in an upright position with unsupported head, their arms relaxing on the legs and their feet lying on the floor. The skin was cleaned with cotton moistened with alcohol (70% isopropyl rubbing alcohol) before placement of electrodes. The masseter muscle was first located by asking the patient to clench and the muscle was marked 1 cm behind the palpated anterior border. A conductive gel was applied on the inner side of the electrode before its fixation in the planned position. Active surface electrodes were positioned onto the masseter muscle bilaterally on the most palpable contractile fibers (the maximum bulge) of the muscle along the main direction of the fibers (that could record higher electric activity) and fixed to the patient's face by means of adhesive strips to avoid inaccuracy due to movements. The ground surface electrode was located on the patient's forehead.

The electrodes were connected to the measuring system (Keypoint. Alpine Biomed, USA). The patients were instructed to chew on sample of food with standardized size (2 cm × 2 cm) piece of banana (soft food) and carrot (hard food) and the EMG was recorded. The patients chewed the test samples on the right and left sides at 10-s intervals using their arbitrary chewing frequency and the EMG activity from the beginning of chewing until swallowing was recorded.

Four peaks of EMG muscle activity were assessed and their average was recorded. The test was repeated 5 times for each type of food where at least 2 min. separated in between as recovery rest period. The analysis of EMG signals was performed with programs of EMG equipment. The sum of the recorded mean values amplitude of the left and right masseter muscle activity were tabulated and statistically analyzed.

At the end of the record and before removing the surface electrodes, for each patient a transparent template was made, the electrodes locations were marked on it relative to certain landmarks; corner of the mouth, outer canthus of the eye, and tragus of the ear.

This template was used in the subsequent assessment of the definitive prosthesis as a guide to accurately relocate the surface electrodes. Figure (6)

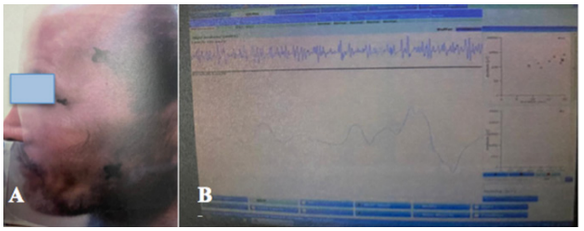

Figure (6): A) The marked transparent template B) Masseter muscle EMG record

2- Recording occlusal contact by T scan

Computerized occlusal analysis using the systems T-Scan III (Tekscan, Boston, MA, USA) was done. First the patient was seated with his back straight such that the sensor support pointer was between the two central incisors and the T-Scan handle was parallel to the occlusal plane and the horizontal plane as possible and T-Scan hand piece was connected to the computer. The patient was instructed to close and bite down on the sensor for 2 seconds and the teeth contact were observed on the screen then to open slowly. Three records were taken for each patient and the average value was calculated for the right and left side.

T-scan system recorded the occlusion time (OT) and force distribution in a centric occluding relation position and the disclusion time (DT) in protrusive and left/right excursive movements and force distribution. Resulting records were processed with the software T-Scan III.

Statistical analysis

Statistical analysis was performed with SPSS 20, Graph Pad Prism and Microsoft Excel 2016. All data were explored for normality by using Shapiro Wilk Normality test that revealed that all data were normal data. All data were presented as means and standard deviation (SD) values in the following tables and figures. P value is significant when < 0.05

There was 100% survival and success rate for all implants placed in this study. All patients completed the analysis without dropouts as the follow up period was small and all patients attend the follow up recalls thus All participants' data were included. All patients reported an acceptable masticatory efficiency and were satisfied with their screw retained hybrid prostheses compared to their old conventional lower denture. This treatment modality helped the patients' self-confidence and comfort.

Participants in this study minimum age (56), maximum age (64), mean ± standard deviation (61 ± 3.03).

1- EMG Masseter muscle records:

EMG evaluation of masseter muscle in the provisional prosthesis group was (100.43 ± 0.76) and (123.10 ± 1.59) regarding soft and hard food respectively. While in the definitive prosthesis group, EMG evaluation of masseter muscle was (92.09 ± 2.98) and (99.74 ± 2.62) regarding soft and hard food respectively. As presented in table (1) and Figure (7).

Comparison between soft and hard food was performed using Independent t-test which revealed that hard food was significantly higher than soft in both provisional and definitive prosthesis groups as P <0.05, as presented in table (1).

Comparison between provisional and definitive prosthesis groups was performed by using Independent t-test. Statistical analysis of the data revealed significantly higher muscle activity in the provisional prosthesis during chewing soft and hard food compared to the definitive prosthesis group as P <0.05, as presented in table (1).

Table (1): Mean and standard deviation and Independent t-test for the EMG Masseter muscle activity for the studied groups during chewing soft and hard food:

EMG Masseter	Soft		Hard		P-value
	M	SD	M	SD	
Provisional prosthesis	100.43	0.76	123.10	1.59	<0.0001*
Definitive prosthesis	92.09	2.98	99.74	2.62	0.0003*
P value	<0.0001*		<0.0001*		

M: mean SD: standard deviation
P value is significant when < 0.05

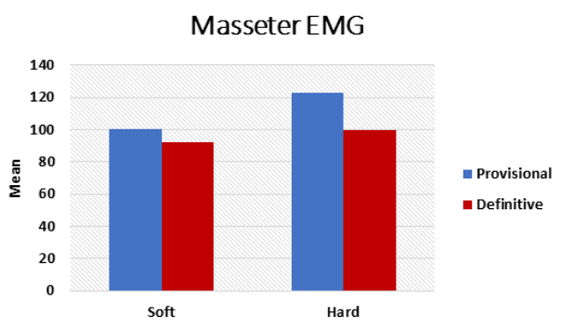

Figure (7): Bar chart showing Masseter EMG record in the studied groups during chewing soft and hard food.

2- T- scan:

For the provisional prosthesis group, T-scan revealed that percentage force distributions was (76.71 ± 0.04) and (23.29 ± 0.04) for right and left sides respectively, while in definitive prosthesis group was (57 ± 0.06) and (43 ± 0.06)

for right and left sides respectively, as presented in table (2) and Figure (8)

Comparison between right and left sides was performed by using independent t-test which revealed that right side was significantly higher than left side in both provisional and definitive prosthesis groups as P <0.05, as presented in table (2).

Comparison between provisional and definitive prosthesis groups was performed by using Independent t-test which revealed that provisional prosthesis group was significantly higher than definitive prosthesis group at right side, while provisional prosthesis group was significant lower at left side as P <0.05, as presented in table (2)

Table (2): Mean and standard deviation of T-scan in the studied groups among right and left sides:

T-scan	Right		Left		P value
	M	SD	M	SD	
Provisional prosthesis	76.71%	0.04	23.29%	0.04	<0.0001*
Definitive prosthesis	57.00%	0.06	43.00%	0.06	<0.0001*
P value	<0.0001*		<0.0001*		

M: mean SD: standard deviation
P value is significant when < 0.05

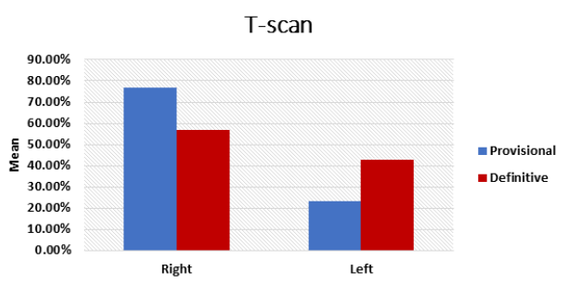

Figure (8): Bar chart showing T-scan in both provisional and definitive prosthesis groups among right and left sides.

3- Correlation between EMG and T-scan:

Correlation between EMG and T-scan was calculated by using Spearman1s correlation coefficient that revealed weak, positive insignificant correlation in soft provisional prosthesis group. While in hard provisional prosthesis group revealed weak, negative, and significant correlation. On the other hand soft and hard definitive prosthesis group revealed moderate positive insignificant correlation as presented in table (3) and Figure (9).

Table (3): Correlation between T-scan and EMG in provisional and definitive prosthesis during chewing hard and soft food:

		T-scan			
		Provisional prosthesis		Definitive prosthesis	
EMG		r	P value	r	P value
	Soft	0.01	0.96	0.50	0.25
	Hard	-0.107	0.01*	0.53	0.21

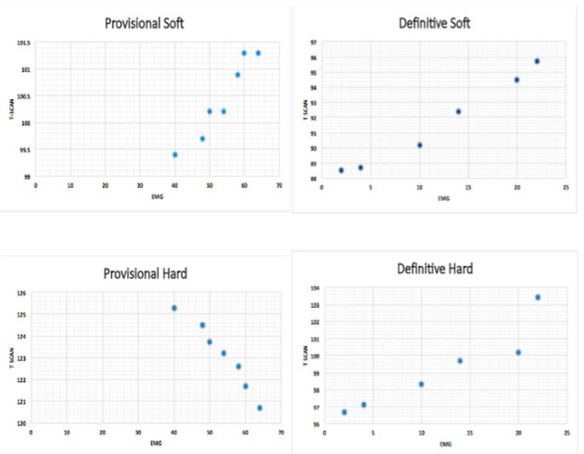

Figure (9): Charts representing the correlation between T-scan and EMG in provisional and definitive prosthesis during chewing both hard and soft food.

DISCUSSION

In completely edentulous mandible cases, insertion of implant in the posterior region is very challenging because of the anatomical limitations (inferior alveolar nerve) and the continuous bone resorption in the posterior region to place the implants without surgical intervention like bone augmentation or nerve transportation. While anterior region of the mandible can withstand the load of full-arch bridge construction. Hence implant placement in the mandibular posterior region should be avoided[28]

All-on-four protocol help to achieve high success rate, this may be attributed to that anteroposterior spread of implants is maximized, the provisional prosthesis is immediately placed and provided firm splinting to implants.

Occlusal overload, excessive bite forces beside premature contacts lead to peri implant bone loss and implant failure. Thus, assessment of occlusion is of ultimate importance to reduce these occlusal concerns. Recently computer-guided

T Scan occlusal analysis is used to accurately aid in occlusal adjustments to modify improper contact sequence into multiple contacts equal in intensity bilaterally thus permitting to distribute the load evenly throughout the prosthesis and implants [29] .

The within-subject crossover study design allows the use of decreased patient sample since the same patients receive different treatments, in addition this standardizes patient-related factors that may affect EMG activity such as age, sex, muscle activity, muscle power and ridge morphology[25].

In this study computer guided surgery was followed that allowed precise planning for positions and angulations of the four implants and fabrication of accurate 3D surgical guide that permit transferring these locations accurately to the surgical site. Though computer guided surgery had the advantage to have fast and simple, more predictable and less stressful surgery, implants are placed in a prosthesis driven manner, decrease patient chair time [30].

Patient's new denture was converted to screw-retained implant fixed prosthesis acted to splint the four implants together by the denture base, this can be accomplished chair-side and enables the prosthodontist to deliver All-acrylic prosthesis to accomplish immediate function. As for immediate loading All-acrylic prostheses are commonly used as provisional restorations [31]. Although acrylic resin material is considered a semi-rigid material still it is rigid enough to not have a negative effect on the implant stability [32].

The provisional prostheses were designed with convex shapes on the intaglio surfaces with no sharp line angles or concavities in order to minimize plaque accumulation, facilitating home care procedures [33]. Besides cross-linked acrylic resin teeth has the benefit of its resiliency to act as shock absorber consequently decreasing undue stresses to be transmitted on the implants and less resorption to the residual ridge and they are the easiest teeth to equilibrate [34 , 35].

Kerstein [36] recommended the use of T-scan and EMG systems for occlusal adjustment procedures. The concurrent recording using them permits analyzing and correlating certain occlusal moments to particular muscle alterations.

The occlusal contacts and muscle activity records of the prosthesis to be evaluated was done after 3 month of its insertion as it was reported that after 3 months of adaptation significant improvement occur in the masticatory performance that is enhanced contractile capacity of the muscles studied occur as a result of neuromuscular system reorganization [37].

T Scan III analysis detects the amount and location of the highest intensity contacts of every tooth specifically and registers the contact-time sequence and the percentage of relative occlusal force among various occlusal contacts then presents these data for dynamic analysis.

The masseter muscle on both sides was evaluated as it is one of the largest and strongest masticatory muscles, being superficial become accessible for surface EMG examination. Surface EMG record provides an easy and non-invasive technique that allowed objective quantification of the muscle energy [24]. Amounts and sizes of banana and carrot used were standardized to decrease patients variability. They represented an example of soft and hard food respectively and gave indication about the effect of different types of food on muscle activity during function [38]

This in agreement that diet is one of the factors that influence occlusal forces and that implants should not exposed to load with hard food for at least the twelveth week post insertion where bone healing in the sixth weeks till the twelveth forms woven bone that is not mineralized completely [33].

The results showed increase in mean the muscle activity Records when chewing hard food than with soft food and this is in agreement with the results of Bakke et al.[39] who stated that with hard food higher EMG amplitude are recorded than with soft food and concluded that food type and texture can have significant influence on the muscle activity. Similarly Van der Bilt et al. [40] found that harder food consistency needed higher muscle activity records because of greater muscle force is required to comminute hard food. In addition the results are with the findings of Karkazis [41] that harder foods required higher electrical activity of the masseter muscle.

There was high muscle activity recorded for both provisional and definitive fixed detachable prosthesis, these results may be attributed to the increased stability of the prosthesis by the implants during function that directed the muscle activity of superficial masseter muscle towards masticatory function rather than exerting some of the effort needed to stabilize or retain removable prosthesis [42]. The increased muscle activity may be attributed to the increased ability to comminute food during mastication [43]. Moreover, this may explain the improved patient satisfaction with their prosthesis whether the provisional or the definitive compared to their old conventional complete denture and the decreased discomfort during chewing.

All-on-four fixed detachable prosthesis exhibited improved support, retention and stability that provided more stable occlusion that keeps better distribution of occlusal forces. In addition because of their association with a more stabilized occlusion, satisfaction and comfort of patients consequently provided a considerable improvement in muscular activity.

Furthermore, implants improved the functional state of the masticatory apparatus. They aided in the establishment of

better neuromuscular coordination and enhanced masticatory efficiency by improving the support, stability, and retention of the prosthesis to an extent that is comparable with healthy dentate individuals.

Although the provisional all acrylic fixed detachable prosthesis has many advantages including reducing the impact force of dynamic occlusal load, the definitive porcelain fused to metal was accompanied with better occlusal stability as indicated by the T scan record obtained in this study. It seems reasonable to suggest that inevitable wear of the acrylic teeth in the provisional prosthesis and the rigidity of the metal cobalt chromium alloy are the reason for these results [44,45]. Higher rate of fracture of the provisional restoration is a common complication when converting an existing denture because of the weakening produced by the access holes beside its low rigidity to withstand an extended period of heavy occlusal loads [46,47]. Based on these findings frequent occlusal adjustments are required for the provisional prosthesis whenever long-term use of this prosthesis is planned.

CONCLUSION

The results of T scan and EMG outcomes in the current study revealed that both provisional and definitive All-on-Four fixed detachable prostheses can be considered a functionally efficient treatment option for mandibular ridge as detected with the favorable masseter muscle activity however the definitive prosthesis showed better maintenance of the occlusal equilibrium. Based on these findings frequent occlusal adjustments are required for the provisional prosthesis whenever long-term use of this prosthesis is planned.

ACKNOWLEDGMENT

The authors would like to acknowledge the patients participated in this study.

CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest.

FUNDING

Not applicable

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