Evaluation of Electromyographic Activity in Conventional Denture and Mandibular Implant Supported Over-Denture Wearers with Different Occlusal Schemes

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ABSTRACT

Purpose; This study aimed to evaluate electromyographic activity in completely edentulous patients and mandibular implant supported over-denture with different occlusal schemes (bilateral balanced occlusion with anatomic teeth and canine guided occlusion).

Material and methods: Twelve male patients with completely edentulous upper and lower arches were selected. A complete denture was constructed for each patient in the conventional way, the selected patients were divided into two groups; Group 1: Patientsreceived their dentures with bilateral balanced occlusion with anatomic teeth and wear it for one month then modify the occlusion to canine guided occlusion and use it for another one month. Group II; For all patients, two endosteal implants were installed in the mandible in the premolar region. Then, Patients were asked to use their old dentures after pickup of attachment, with canine guided occlusion for one month. regain the bilateral balanced occlusion with anatomic teeth and the patients were instructed to wear it again. Electromyographic activity was tested after one month of using each type of dentures with different occlusal schemes, the results were collected, tabulated and statistically analyzed by using ANOVA test.

Results: Statistical analysis of electromyographic activity reveled, there was insignificant difference between bilateral balanced occlusion and canine guided occlusal scheme in conventional and implant supported over denture during chewing hard and soft food.

Conclusion: From this study it can be concluded that, both bilateral balanced with anatomic teeth and canine guided occlusal concept can be used effectively in conventional and implant supported mandibular overdentures with no effect on electromyographic activity.

Keywords: bilateral balanced occlusion, canine guidance, implant overdenture,electromyographic activity.

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INTRODUCTION

Patients with edentulous severely resorbed mandible often experience difficulties with wearing the conventional dentures. Construction of a conventional complete denture that offers patient good esthetics, masticatory function, and patient comfort harmony along with improvement of stability and retention during function remains one of the most challenging trials in the dental practice [1].

Overdentures supported by implants have been broadly used to increase retention and stability of conventional complete dentures. Use of attachments to improve stability of the implants and function of the overdenture and increase of patient satisfaction is a well-considered method nowadays. The implant supported overdentures also improves masticatory function inedentulous people [2].

Implants supported overdentures have become a standard substitute to fixed implant-supported prostheses. Advantages include patient satisfaction, speech and esthetics improvement and allows for adequate oral hygiene for patients. Implant supported overdentures may use a variety of splinted bar attachment systems or incorporate a variety of individual abutment based attachments called stud attachments (ball, magnets, telescopic), which may be resilient or non-resilient attachments. [3] Ball type retentive attachments are known to be useful for implant-supported overdentures with regard to enhancing stress, decreasing denture movement, cost effectiveness and simplicity. [4, 5]

Implant occlusal overloading is frequently viewed as one of the chief causes for periimplantloss of bone and prosthesis supported by implant failure as it may lead to loss of crestal bone thusincreases the periimplant diseases condition, if patients can't do post insertion clean of prosthesisand surrounding well. So an appropriate occlusal concept is necessary for long term persistence of implants particularly when a parafunctional habit is occurring. Implant occlusion is so important to ensure uniform stress distribution over the osseointegrated abutment fixtures. [6-8]

Efforts have continued to find the most appropriate occlusal form and teeth arrangement. No conclusive evidence has been provided and most approaches drawing evidences from theoretical assumptions, subjective data and inadequate scientific experimentation by not using acceptable controls [9].

Bilateral balanced occlusion or balanced articulation is bilateral simultaneous anterior and posterior occlusal contact of teeth in centric and eccentric positions. This is mainly useful in construction of complete denture. For minimal occlusal balance, there should be at least three points of contact on theocclusal plane and the more the number of contacts, the better the balance. Bilateral balanced occlusion can be protrusive or lateral balance [10, 11].

Canine guidance can be used successfully in complete dentures as it improves esthetic, masticatory function and mandibular denture retention. They are simple and useful concepts to outline the occlusal guidance pattern. Canine protected/guided occlusion had also been a concept that could protect the occlusion from eccentric forces. The anterior teeth disocclude posterior teeth through all excursions [12].

The study of muscular function by electromyographic activity is defined by analysis of electric signals produced during the muscular contraction, and allows interpretations in pathological and normal conditions. Masseter and temporalis muscles are the main muscles controlling of the jaw closing and chewing functions. Electromyographic device is research equipment for evaluating electrical activity of the muscles. It is a practical and efficient method for the study of muscle function and activity, thus serving as a valuable tool in dental research. To analyze the stomatognathic system activity, it is imperative to determine the features of the masticatory muscle function. Electromyography is usedto study the effect of occlusion in completely edentulous as well as in implant supportedmandibular over denture wearers on normal muscle activity [13-15].

MATERIAL AND METHODS

Patients' selection:

- Twelve completely male edentulous patients were selected from the outpatient's clinic of Removable Prosthodontic Department, Faculty of Dental Medicine for Girls, Al Azhar University in-order to participate in this study.

Patients were selected according to inclusion and exclusion criteria. Patients were included with ages ranged from 50-60 years with class I angel's ridge relationship. Patients with any systemic or temporomandibular joint diseases or any ridge bony exostosis were excludedfrom the study. The patients were informed of all procedures of this study and signed an informed consent. Approval of REC (Research Ethic Committee) of the Faculty of dental medicine for Girls, Al Azhar University was obtained.

I-Complete denture construction:

- All patients' information was recorded and documented in his file. For each patient history, clinical examination and recording data were carried out.

Maxillary and mandibular primary impressions were made using metal stock trays and alginate impression material. Auto polymerizing acrylic resin special trays were made for upper and lower arches. Border tracing using green stick compound was carried out. Final impression using medium silicon rubber base impression material (Zetaplus / Oranwash L, Zhermack, Rovigo, Italy) for upper and lower jaws was made. The final impression was boxed and poured using dental stone (Dental stone manufacture hard stone, Spain). and trimmed to produce master casts.

- Jaw relation records were made and mounted to a semi adjustable articulator using maxillary face bow (Corident, Korea) and centric and protrusive data were recorded.
- Anatomical upper and lower artificial teeth (Vita, acrylic teeth, German) were arranged in waxto make trial denture bases.
- The waxed up maxillary and mandibular trial dentures with anatomical teeth were placed in patient mouth to examine retention, stability, extension, tongue space, occlusal plane height and inclination, evenness of occlusal pressure, balanced articulation, phonetics and shape, shade and size of artificial teeth, esthetics and jaw relationships were evaluated. Any necessary changes were done and the final waxing up of the denture was completed.
- Waxed up dentures were flasked, wax eliminated, packed, cured, deflasked, finished and polished.
- Retention, stability, extension, and occlusion of the finished dentures was examined.
- The patient was given instructions regarding usage of the denture and how to clean it.

II-Clinical remounting:

- Denture undercuts were blocked out, separating medium was applied and the dentures were poured into dental stone. The resultant cast was trimmed.
- Maxillary face bow record was carried out and transferred to articulator then upper cast was mounted.
- Centric relation record: A properly softened wax was applied over the teeth of the lower denture. The maxillary and mandibular dentures were inserted into the patients mouth and guided to close in centric relation until the teeth were almost in occlusion, no teeth contact was allowed to occur. The dentures were removed and chilled under cold tap water. The record was removed and kept in cold water.
- Protrusive record: After suitable training of the patient, another properly softened wax was applied over the teeth of lower denture and the patient is instructed to protrude the mandible about 6 mm and close. The jaw movement was carried in a straight manner with little or no lateral deviations. The dentures were removed from the mouth and chilled under cold tap water and the compound template was separated from the dentures. The maxillary and mandibular casts with dentures were mounted as mentioned before.
- Adjustment of the condylar guidance: After each maxillary and mandibular denture was mounted, the horizontal condylar guidance of the articulator was adjusted using the patient's protrusive interocclusal record. Lateral guidance was obtained from Hanau equation L=H/8+12.

- The finished denture was inspected to remove any rough areas, to be sure that no deficiency in the fitting surface and the denture was highly polished. Articulating papers were used to adjust any occlusal disharmony until reach to bilateral balanced occlusion. The dentures for all group 1 patients were delivered

III-Surgical procedures:

- Pre surgical medication, one gram of broad spectrum antibiotic was prescribed for the patient 24 hours before surgery. The patient was prescribed to rinse his mouth with chlorohexidine mouthwash one week before the surgery.

- After making sure the 3D surgical template was precisely positioned on the underlying mucosa, anchor pins were used to secure the template to the underlying bone on both sides. Then, the implant location was exposed by performing a circular tissue puncture with a tissue puncher. The pilot drill was utilized initially at the implant site under copious normal saline irrigation, followed by sequential implant drills to prepare the osteotomy site. To get rid of any bone shards, perfuse saline was injected onto the osteotomy site. Figure (1)

Figure (1): Surgical template placement with rings to permit placement of implants by flapless technique.

Following the final preparation of the implant site, the implant was manually placed into the bone and then ratchet wrenched into place until the implant platform was level with the bone. Finally, the implant fixture was connected to the smart peg, and the Osstell device was used to hold the probe close to the smart peg without touching it. ISQ is displayed on the device's screen when it beeps. The implant was then covered with a 2 mm healing cap.

Group 1; Conventional complete denture

A- bilateral balanced occlusion with anatomic teeth concept:

- All the patients were instructed to wear their dentures which adjusted to bilaterally balanced occlusion with anatomic teeth for a period of one month for adaptation. Electromyographic activity was tested. After that the dentures were removed for an interval of two weeks, as a washout period.

B- Canine guided occlusal concept:

- Canine guided occlusion was developed by adding autopolymerizing acrylic resin in the lower canines to provide an interarch disocclusion space of 2 mm during eccentric movements [15].
- All patients were instructed to wear their dentures with canine guided occlusion for one month for adaptation. Electromyographic activity was tested. (Fig2)

Figure (2): (A) Bilateral balanced occlusion (B) Canine guided occlusion

Ball and socket attachment insertion:

- After three months, second stage surgery was carried out. the cover screws were removed and the supplied metal housing with nylon liners were attached to the male ball abutment, all undercuts below the attachments were blocked by using softened wax.
- The denture was seated into patient's mouth to determine the locations of the metal housing relative to the tissue- bearing surface of the prosthesis.
- The denture was removed from the patient's mouth and the locations of the assembled housing on the fitting surface of the denture were marked. The areas over the housings were relived with an

acrylic bur until the denture can be fully seated in the patient's mouth.

- Autopolymerizing acrylic was used for pick up. A small amount of auto polymerizing acrylic was mixed and placed into relieved areas within the fitting surface of the denture base and directly on the tops of the housings.
- The denture was placed over the housing in the mouth and the patient was instructed to bite lightly in centric occlusion. After the acrylic resin sets completely, the denture was removed and inspected for voids and filled with additional autopolymerizing acrylic. Excess resin was removed and polished. (Fig 3)

Figure:3 A) Ball and socket attachments **B) Complete denture with housing**

Group 11; Implant supported mandibular overdenture;

A-Implant supported overdenture with canine guided occlusion:

- For canine guidance previously established by adding autopolymerizing acrylic resin in the lower canines to allow for an interarch disocclusion space of 2 mm during eccentric movements.
- All patients were instructed to wear their implant supported overdentures with canine guided occlusal scheme for a period of one month for adaptation. Electromyographic activity was tested.

B-Implant supported overdenture with bilateral balanced occlusion with anatomic teeth:

- Dentures were removed for two weeks as a wash out period, then the added autopolymerizing acrylic resin in the lower canines was removed to regain bilateral balanced occlusion with anatomic teeth.
- Finished overdenture was inserted into patient's mouth and checked for esthetics, stability, retention, and occlusion.
- The patient was instructed in the use and care of implant and prosthesis and good oral hygiene instructions.
- The patients were instructed to wear their dentures for one month. Electromyographic activity was tested.

Electromyographic activity measurement:

- After adaptation period of one month, electromyographic activities of muscles were tested for edentulous and implant supported wearers with bilateral balanced and canine guided occlusal scheme.
- Surface electromyographic records were obtained from Masseter and Temporalis muscles by using an electromyographic device. The patient was instructed to chew as hard as possible, and to maintain the same level of contraction along the test.
- Recordings were obtained during chewing one cm³ of banana which represents soft food and chewing one cm³ of carrot which represents hard food. The impulses were printed by laser printers. (fig.4)

Figure (4) Electromyographic activity measuring of masseter muscle.

Statistical Analysis:

- Data were collected, revised and entered to the Statistical Package for Social Science (SPSS) released 2015 for Windows, Version 23.0. Armonk, New York: IBM Corporation, quantitative data were presented as mean and standard deviations and compared between two groups using Independent t-test; 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

Electromyographic activity:

A- Conventional complete denture evaluation:

Soft and hard food: Comparison of the effect of two concepts of occlusion on electromyographic activity of masseter and temporalis muscle in all patients during chewing soft and hard food; the greater mean value was recorded in canine guided occlusion, whereas the lowest mean value was recorded in bilateral balanced occlusion. ANOVA test revealed that the difference between groups was not statistically significant difference (P=0.738). in soft food **while** statistically significant (P=0.025). in hard food **Table (1)**

Table (1): Comparison of the effect of the two concepts of occlusion on electromyographic activity of Masseter and Temporalis muscles during chewing soft and hard food in all patients.

Conventional complete denture evaluation			Mean value	SD	Min	Max	Test value•	P
Soft	Masseter muscle	Bilateral balanced occlusionwith anatomical teeth	208.80	89.56	74.98	313.52	0.310	0.738^{ns}
		Canine guided occlusion	221.79	61.21	138.35	296.71		
	Temporalis muscle	Bilateral balanced occlusionwith anatomical teeth	127.80	9.21	112.08	139.5	0.588	0.568^{ns}
		Canine guided occlusion	142.64	43.83	95.25	208.39		
	Masseter muscle	Bilateral balanced occlusionwith anatomical teeth	222.91	61.79	196.17	377.41	**4.141**	**0.025***
		Canine guided occlusion	256.19	60.09	202.04	354		

Hard	Temporalis muscle	Bilateral balanced occlusionwith anatomical teeth	139.57	41.80	106.57	223.5	**3.700**	**0.034***
		Canine guided occlusion	172.47	51.54	110.32	238.05		

- : Independent t-test; ns=non- significant; *: Significant

B- Implant supported overdenture evaluation:

Soft and hard food: Comparison of the effect of the two concepts of occlusion on electromyographic activity of masseter and temporalis muscle in all patients during chewing soft and hard food; The greatest mean value was recorded in canine guided occlusion, whereas the lowest mean value was recorded in bilateral balanced occlusion.

For masseter muscle; Statistical analysis using ANOVA test revealed the difference between groups statistically non-significant (P=0.855)**,** (P=0.569) in soft and hard food respectively.

For temporalis muscle: Statistical analysis using ANOVA test revealed the difference between groups statistically non-significant (P= 0.765) (P<0.944) in soft and hard food respectively **Table (3)**

Table (2): Comparison of the effect of the two concepts of occlusion on electromyographic activity of Masseter and Temporalis muscles during chewing Soft and Hard food in all patients.

Implant supported overdenture evaluation			**Mean**	**SD**	**Min**	**Max**	**Test value•**	**P**
Soft	Masseter muscle	Bilateral balanced occlusion with anatomical teeth	201.18	65.74	106.57	290.18	0.158	0.855 ns
		Canine guided occlusion	206.23	73.65	116.22	316.46		
	Temporalis muscle	Bilateral balanced occlusion with anatomical teeth	130.57	46.01	62.85	227.30	0.271	0.765 ns
		Canine guided occlusion	140.49	60.16	68.98	278.40		
Hard	Masseter muscle	Bilateral balanced occlusion with anatomical teeth	276.42	103.44	136.25	475.17	0.577	0.569 ns
		Canine guided occlusion	301.94	107.61	165.13	530.57		
	Temporalis muscle	Bilateral balanced occlusion with anatomical teeth	188.98	47.13	103.82	266.37	0.057	0.944 ns
		Canine guided occlusion	190.91	55.07	106.57	293.17		

- : Independent t-test; ns=non- significant

4003

C- Conventional complete denture versus implant supported overdenture evaluation:

a) Bilateral balanced occlusion with anatomical teeth evaluation:Masseter muscle

Soft and hard food:

Implant supported denture showed a lower mean value compared to conventional complete denture, however with no statistically significant difference (p=0.695) (p=0.957) in soft and hard food respectively.

Temporalis muscle Soft and hard food:

Implant supported denture showed a lower mean value compared to non implant supported overdenture, however with no statistically significant difference (p=0.93) (p=0.818) in soft and hard food respectively.

Table (3) Descriptive statistics and comparison of mean value of electromagnetic activity of Masseterand Temporalis muscle in Implant supported denture and conventional denture using bilateral balanced occlusion with anatomical teeth.

Bilateral balanced occlusion with anatomical teeth evaluation		Masseter muscle		Temporalis muscle	
		Soft food	Hard food	Soft food	Hard food
Implant supported denture	Mean	208.80	262.91	127.80	179.57
	SD	89.56	61.79	9.21	41.80
Conventional denture	Mean	230.11	265.06	129.92	185.86
	SD	121.19	92.61	65.88	62.22
t value		0.399	0.055	0.089	0.235
P value		0.695^{ns}	0.957^{ns}	0.93^{ns}	0.818 ^{ns}

: Independent t-test; ^{ns}=non- significant

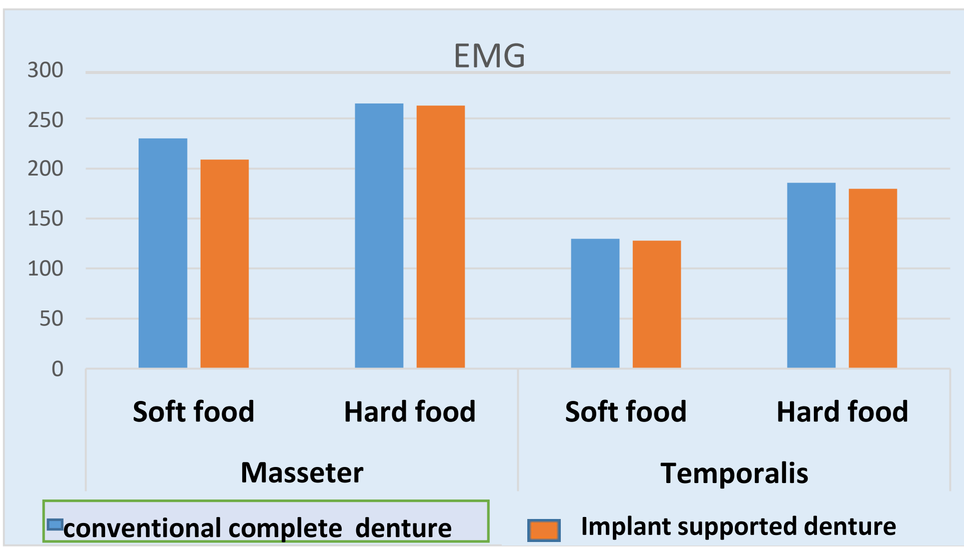

Fig. (5) Bar chart illustrating mean EMG of temporalis and masseter muscle in conventional denture andimplant supported overdenture using bilateral balanced occlusion with anatomical teeth.

b) Canine guided occlusion evaluation:

Masseter muscle Soft food:

conventional denture showed a higher mean value compared to implant supported overdenture, however with no statistically significant difference between both groups (p=0.593).

Hard food:

conventional denture showed a lower mean value compared to implant supported overdenture, however with no statistically significant difference between both groups (p=0.549).

Temporalis muscleSoft food:

conventional denture showed a higher mean value compared to implant supported overdenture, however with no statistically significant difference between both groups (p=0.427).

Hard food:

conventional denture showed a lower mean value compared to implant supported overdenture, however with no statistically significant difference between both groups (p=0.246).

Table (4) Descriptive statistics and comparison of mean value of Electromagnetic activity of masseterand temporalis muscle in conventional denture and implant supported overdenture using canine guided occlusion

Canine guided occlusion evaluation		Masseter muscle		Temporalis muscle	
		Soft food	Hard food	Soft food	Hard food
Conventional complete denture	Mean	221.79	255.51	151.94	62.87
	SD	61.21	58.78	44.55	31.68
Implant supported over denture	Mean	203.08	287.74	131.64	89.75
	SD	75.08	136.41	54.50	54.21
t value		0.547	0.613	0.818	1.21
P value		0.593 ns	0.549ns	0.427 ns	0.246 ns

: Independent t-test; ns=non- significant; *: Significant

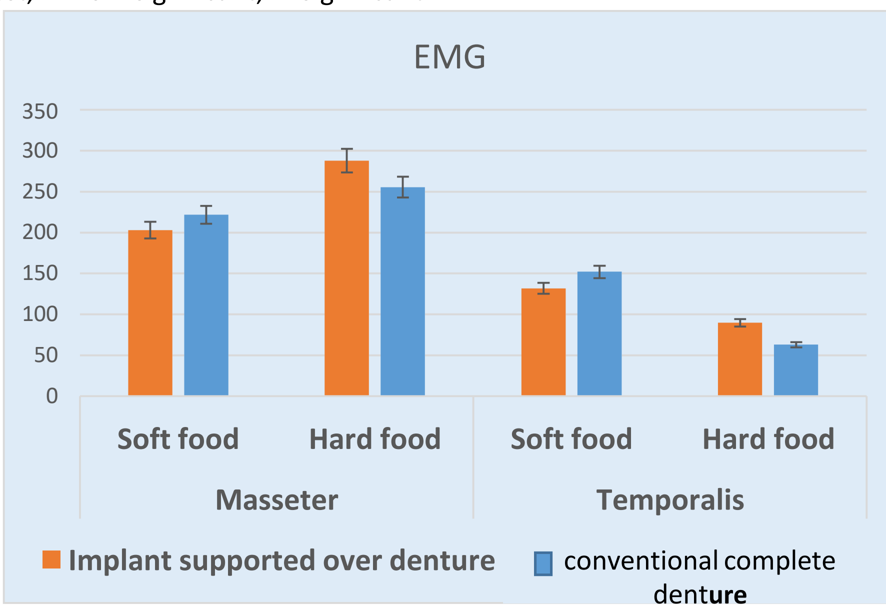

Fig. (6) Bar chart illustrating mean EMG of temporalis and masseter muscle in conventional denture andimplant supported overdenture using canine guided occlusion

4005

DISSCUSSION

The current study was designed as a comparative clinical trial with strict inclusion and exclusion criteria to remove variables that would lead to uncertainty in the validity of data. In this study, all patients received one denture with two different occlusal concepts representing balanced occlusion with anatomic teeth and canine guided occlusion. The occlusal scheme was changed so that all patients in this study were exposed to the two occlusal concepts for the similar periods of time.

Any change in occlusion has a positive impact over muscle activity, and may cause different disorders of different parts of masticatory system. So that complete dentures occlusal concepts stimulate denture support, retention and stability which rises the patient's satisfaction and denture long life [9].

The 3D surgical stent which was used in this study has extended acceptance in the last few years. Anunderstandable improvement is the elimination of the necessity to surgically raised flap and the exposure of the underlying bone to insert the implant, increase in patient comfort and his acceptance, decrease of loss of the soft tissues that heal faster with minimal problems, decreased pain, inflammation,surgical technique time and enhanced recovery [2].

Implant supported mandibular overdenture on two implants is the least expensive implant option as it gives it major increase in retention and stability versus the complete denture and reveals a considerable improvement patient satisfaction [16].

Evaluating the different occlusal schemes on the same denture is a very simple and applicable way when optimum standardization of denture and patients' factors are necessary. In this study two occlusal concepts were established: bilateral balanced occlusion and canine guidance. Bilateral balanced occlusion applies balance of artificial teeth in eccentric movements, while canine guidance disengages posterior teeth during eccentric movements of the mandible. [7]

Electromyographic activity studies performed to compare dentures with bilateral balanced occlusion and canine guided occlusion that both include even contact in centric relation but in eccentric movements, they are different [13].

To evaluate masseter muscle activity surface electromyography was used as it is an effective diagnostic tool that has been largely used after implant-supported prosthesis insertion [14].

In an assessment of different types of test foods used for evaluating electromyographic activity in denture wearers it was concluded that soft food like sausages and banana were between the easiest ones sobanana as an example of soft food and carrot as an example of hard food were chosen in this study to represent normal food varieties that patients use in their diet. So, they are suitable to evaluate electromyographic activity of those patients. Types of food which was used in the study have less variability and hence they are good indicators of the difference between different occlusal concepts during mastication [17].

The present study found that bilateral balanced occlusion with anatomic teeth showed the lower electromyographic activity than canine guided occlusion in all patients this is due to anatomic teeth have better chewing force to penetrate food [14,16].

The current study showed that muscular activity improved in all patients during mastication of hard food than soft food. This agrees with a previous study where authors found that the numberof cycles increased with the hard food rather than with the soft food with the three dentures forms [18].

The current study agrees with previous studies observed lower muscle activity in patients wearing dentures providing bilateral balanced occlusion compared to those with canine guidance and disagrees with results that suggest that bilateral balanced occlusion does not improve the masticatory efficiency in complete denture wearers [18].

The mean EMG activity was higher in canine guidance compared to bilateral balanced occlusion. This could be accredited to larger amount of occlusal surfaces brought into contact at each movement. These results are in contrast with the finding of another author suggest that canine guided occlusion decreased Masseter muscle activity in patients wearing complete dentures [19].

The masticatory function improvement of implant supported overdentures by two implants with ball and socket or bar attachments was significantly improved than with using conventional dentures. This may be attributed to presence attachments that gives stability to the denture and allows the patients to apply higher bite forces during masticatory function. [20]

Muscle function reduction occur with implant-supported overdentures by two implants versus complete dentures. In agreement with this observation, an author found that mandibular overdentures supported by two implants and ball or bar attachments were associated with lower electrical activity of the masseter muscles compared with conventional dentures may be due to improvement of denture occlusion, stability and retention [21].

Conclusion:

It can be concluded that, anatomical posterior form of bilateral balanced occlusion showed low electromyographic activity during chewing of hard food when compared with soft one. Also it was found that both bilateral balanced occlusion and canine guided occlusion can be used successfully in implant supported overdentures by two implants or conventional dentures without disturbing electromyographic activity.

Recommendation

-Further studies are needed to analyze the relationship between longer adaptation period with mandibular implant supported overdenture rehabilitation, to assess whether the adaptation time can influence the current results.

-Further studies are needed with larger sample size and equal gender distribution with other types of more advanced instruments for chewing assessment and bite force measurements

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