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Effect of Dentures in Preservation of Muscles of Masticationan Ultrasongraphic And Electromyographic Study

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ABSTRACT:

This study was done to scientifically investigate the effect of complete denture prosthesis on masticatory muscle activity by using ultrasonography and surface electromyographytechniques in 20 completely edentulous patients. These patients presented with a history of 3-6 months of edentulousness and were subsequently rehabilitated with conventional complete dentures. Patients who fulfilled the inclusion and exclusion criteria were recruited into the study after obtaining individual informed consent. Baseline parameters like the bulk, tone and power of muscles of mastication, namely the masseter and temporalis, were documented after clinical examination and the muscle thickness and electrophysiological activity were measured using ultrasonography and bipolar surface electromyography using standard protocols for all 20 patients. The clinical examination, ultrasonography and surface electromyography were repeated after 6months. The study was successfully completed in 17 patients (11males and 6 females). Following denture usage, the temporalis and masseter muscles showed progressive gain in muscle thickness as measured by ultrasonography and overall improvement in the electromyography parameters during the study period. This study illustrates that the masticatory muscle activity and thickness lost due to edentulousness is restored and maintained by successful rehabilitation within 3-6 months with use of complete denture.

Key words: Electromyography, Complete Dentures, Muscle tone, Muscle activity, Vertical dimension

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Introduction:

The muscles of mastication are important in the natural functioning of the stomatognathicsystem. When the teeth are lost, the masticatory muscles are unable to function as vigorously as when natural teeth were present. Apart from its cosmetic role in improving the facial appearance and as a tough material for physical substitution for the lost teeth in aiding the process of chewing, the dental prosthesis (either natural dentition or with artificial dentures), is also suspected to help preserve the bulk and activity of the muscles of mastication and thus aid in prosthetic rehabilitation of edentulous patient. It could be hypothesized that the total loss of the teeth (complete edentulism) changes the masticatory muscle activity, accompanied bymeasurable changes in muscular function parameters, such as bite force, thickness and tone. The masseter and temporalis muscles are the two muscles which are well suited for investigating these features using ultrasonographic structural and electromyographicfunctional studies due to their superficial anatomic positioning[1]. This study aims at scientifically exploring the effect of dentures on muscle activity using ultrasonographic and electromyographic methods.

Materials and Methods:

20 consecutive edentulous patients were rehabilitated freshly with complete denturesduring a special drive in the union territory of Puducherry to provide dentures to the edentulouspatients. Sample size was determined using G power analysis. Patients who fulfilled the inclusion criteria were recruited in the study after obtaining informed consent. Baseline clinical parameters like the bulk, tone and power were checked on both the sides for the jaw muscles, masseter and temporalis using bipolar surface electromyography with standard protocols. The masticatory muscle thickness was evaluated using ultrasonography. The clinical examination, ultrasonography and surface electromyography were repeated at 6 months after continuous use of dentures.

The study protocol was approved by Institutional Ethical and Scientific Committees of Mahatma Gandhi Postgraduate Institute of Dental Sciences and Jawaharlal Institute of Postgraduate Medical Education and Research. Twenty patients (age range: 30-70 years) wereevaluated. All twenty patients were totally edentulous (denture wearers for the first time) with a history of complete edentulism for 3-6 months. The study group was assessed for changes in masseter muscle cross-sectional thickness by using ultrasonography and masseter and temporalis muscle activity by using electromyography at the time of denture insertion, and 6 months follow up. The criteria for the selection of the sample were: (a) healthy individuals without a history of any systemic illness or neuromuscular disorders; (b) no pain or tenderness on palpation in muscles of mastication and temporomandibular joint on both sides; (c) edentulous individuals selected were complete denture wearers for the first time, with complete healing of the upper and lower residual ridges. Dentures were constructed with bilateral balanced occlusion by the same

operator at the postgraduate clinic of the Department of Prosthodontics, Mahatma Gandhi Post graduate Institute of Dental Sciences, Pondicherry, India.

Ultrasonography recording

For the ultrasonography recording, the cross-sectional thickness of the masseter musclewas measured at the mid-belly level of muscle bilaterally using an ultrasound unit (SequinaColor Doppler Imaging Unit; M/S Larsen and Toubro Ltd System, Chennai, No- P07Q3020) with a 12-MHz linear-phased array transducer probe (SequinaColor Doppler Imaging Unit; M/S Larsen and Toubro Ltd System) at the Department of General Medicine, Mahatma Gandhi Post graduate Institute of Dental Sciences, Pondicherry, India. Ultrasound scan was performed with the patients in supine position. The mid belly of the masseter muscle was identified by asking the patients to clench the posterior denture teeth for 10 sec and the ultrasound scanning were made.[1]A generous amount of ultrasound transducer gel (Sona Gel Ultrasound; Proto Pharma, Gurgaon, India) was applied on the skin to avoid tissue compression by the transducer probe at the time of scanning. The transducer was held perpendicular to the skin. The angulation of the transducerwas adjusted until optimum visualization of the muscle was obtained. Recordings were made by the same operator to avoid inter-operator error. Measurements were made directly from theimage obtained on the monitor of the ultrasound unit using an electronic caliper available within the software of the ultrasound unit[2].Thickness measurements for the patients were made in both relaxed-state and contracted state. Thickness in the contracted state was measured by asking the patients to clench bilaterally the posterior denture teeth for approximately 10 sec. The sameprocedure was followed after 6 months follow up. The patients were instructed to continue wearing their dentures without fail prior to recording the follow-up readings[3].

Image 1. Ultrasound of masseter muscle

Image 2. Resting and contracted view of masseter muscle

Electromyography

The EMG measurements of the masseter and temporal muscles were performed in Jawaharlal Institute of Postgraduate Medical Education & Research, Pondicherry on an electromyography unit (NIHON KOHDEN EP/EMG MEASURING SYSTEM, JAPAN. MODEL: MEB-9200K) interfaced to a computer for evaluation of data. The muscular activity parameters were measured at the time of denture insertion and 6 months intervals. All recordings were made with the patients in the natural upright sitting position by the same operator to avoid inter-operator error. Surface electrodes were taped bilaterally on the bellies of the masseter and temporal muscles respectively. Three electrodes were used to record the muscle activity, namely recording electrode, reference electrode and the ground electrode. The recording electrode was placed on the middle of muscle belly, approximately at the motor point located by palpation of muscle surface and confirmed by the recording of the tallest CMAP at that point. Reference electrode was placed 2-3mm away from the recording electrode. Ground electrode plate was placed over the forehead to avoid any electrical interference. The muscular activities were registered at resting position of the muscles and at maximum clench position for 10 seconds. The integrated EMG signals were obtained as motor unit potentials using the quantitative EMG software and the muscle activity parameters namely amplitude, area and rise time weremeasured.

Image 3. EMG of masseter muscle

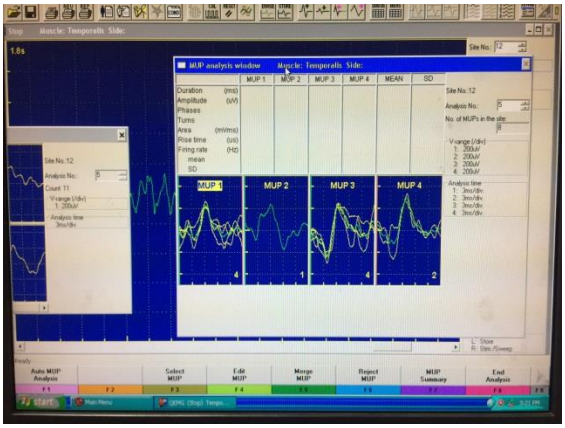

Image 4. Firing of MUP on clenching

Results:

The data was analyzed by using t test based on the normalcy test.Results are in separate file attached. The study is designed as a single group study with two arms pre and postintervention data, with the preintervention arm serving as the comparator. We have done appropriate statistical analysis for such two arm single group comparison using paired t test.

Discussion

In ultrasonography, the present study used a 7.5-MHz scanning probe based on the assumption of Muller et al that, with changes in vertical dimension, the sarcomere length of the muscle changes progressively, to restore optimal working length and maximal bite force at 3 months and so on[4]. Comparison of ultrasound muscle thickness in relaxed and contracted phaseat different time periods showed that there was statistically significant improvement observedbetween baseline and 6 months ($p<0.001$). The increased thickness of the muscle observed at the contraction was due to the reduction in the vertical

height of the muscle and increase in the diameter of the muscle fiber by sliding of the actin and myosin filaments over each other by the sliding filament mechanism[5].

The integrated EMG signals were obtained as motor unit potentials using the quantitative EMG software and the muscle activity parameters namely amplitude, area and rise time were obtained for baseline and 6months. Comparison of the different parameters in different time period showed that there was statistically significant improvement in several of the muscle activity parameters, such as amplitude, area and rise time. In other parameters too, there was a non-significant trend for improvement[7] (Table 1, 3; Fig 1, 3). Despite the low sample size for the study parameters, a consistent though non-significant trend for improvement in the remaining muscle activity parameters can be observed. An increase in MUP amplitude, a reduction in MUP rise time and duration indicates improvement in motor activity. For technical reasons, firing rates of MUPs could not be measured in this study.

Muller et al[8]mentioned that the changes in the vertical dimension have both short term and less immediate effects on the capacity of muscles to exert maximum tension. The immediateeffect is a function of optimum working length of the sarcomeres. The less immediate effect results from the capacity of the muscles to graft in new sarcomeres in series on the elongated muscle restoring the optimum working length. A reduction in fiber size and a loss in the amount of muscle fibers related to ageing is shown to be connected especially to type II fibers(Larsson, 1982)[9]. Edentulousness further results in shortening of muscle length at rest and accentuates these changes. It seems that the adaption of the neuromuscular system to new dentures takes time and can initially be determinative to muscular activity[10].(Newton,1993) studied the effects of ageing and dental state on cross-sectional area and density of two jawmuscles, the masseter and medial pterygoidand concluded that the cross-.sectional area of both muscles showed a significant reduction with age.[10] In addition, theadaptation period may be highly individualized, especially in elderly patients, so that the followup time ideally should be longer than what was employed here, taking into account the fact that a long edentulous period is reflected not only in the functioning of the masticatory muscles, in terms of reduced EMG activity, but also as decreased density of the muscles, implying muscle atrophy.[11,12]

Oral rehabilitation with complete dentures, on the other hand, restores the vertical dimension of the face, thereby exerting the stretch on the masseter muscle, increasing protein synthesis for adjusting muscle fiber length, as well as the cross-sectional area[14]. In this series of 20 consecutive completely edentulous elderly patients, first time use of dentures continuously for a period of 6 months, restored the bulk and activity of masseter and temporalis in the tested EMG parameters in a convincing manner[16]. This study once again confirms the importance of early rehabilitation of edentulous patients with use of appropriate dentures and provides evidence supporting policy decisions on provisions for use of dentures in edentulous patients in dental care health programs for community dwellers in India.Months is too short a

time to illustrate any change in bulk of jaw muscles. This is a short follow up study using surrogate markers.The sample size is adequate to provide the necessary inference on surrogate markers of improvement of masticatory mechanisms, though an illustration of improvement of muscle power (which we are not targeting in this study) may need a larger sample size.

Conclusion:

Complete edentulousness on long time process leads to attrition of the masticatory muscles which leads to loss of chewing efficiency and nutritional deficiency in edentulous patients. In this study, on rehabilitation of edentulous patients with complete dentures and the follow up at 3 and 6 months using ultrasound and EMG showed that there is increase in muscle thickness and activity. The study can be further improved by checking the chewing efficiency and patient's nutritional status.

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TABLE 1: MEAN SEMG ACTIVITY(MUP AMPLITUDES) FOR RIGHT AND LEFT SIDE MASSETER AND TEMPORALIS MUSCLES OVER A PERIOD OF 0 AND 6 MONTHS

Variables	SEMG: Mean MUP amplitude and SD (μV)		Paired t test; P Value
	Baseline	6 Months	
Right masseter	402.81(82.94)	404.47(54.37)	0.953
Left masseter	360.31(113.53)	371.31(132.28)	0.767
Right temporalis	339.51(104.78)	364.77(115.81)	0.247
Left temporalis	323.86(145.18)	377.96(71.32)	0.198

Table illustrating the improvement in the MUP amplitudes of masseter and temporalis muscles, 6 months after the use of dentures.

FIGURE 1: COMPARISON OF MUP AMPLITUDES BETWEEN 0 AND 6 MONTHS

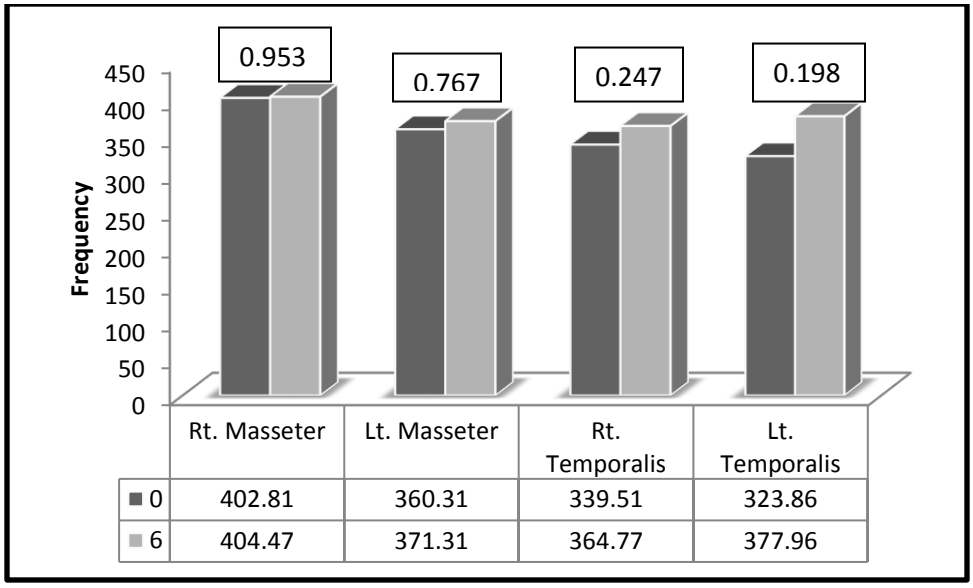

Figure illustrating the improvement in the MUP amplitudes of masseter and temporalis muscles, 6 months after the use of dentures.

TABLE 2: MEAN EMG ACTIVITY(AREA) FOR RIGHT AND LEFT SIDE MASSETER AND TEMPORALIS MUSCLE OVER A PERIOD OF 0 AND 6 MONTHS

Variables	SEMG: Mean Area and SD (mVms)		Paired t test; P Value
	Baseline	6 Months	
Rt masseter	0.77(0.25)	0.67(0.14)	0.228
Lt masseter	0.66(0.37)	0.57(0.21)	0.379
Rt temporalis	0.53(0.20)	0.67(0.14)	0.017
Lt temporalis	0.52(0.25)	0.60(0.14)	0.467

Table illustrating the improvement in the MUP area of temporalis muscle after the use of dentures for 6 months. A significant difference ($P<0.05$) was observed in Right Temporalis. Whereas masseter muscle shows a slight decrease in MUP area.

FIGURE 2: COMPARISON OF MUP AREA BETWEEN 0 AND 6 MONTHS

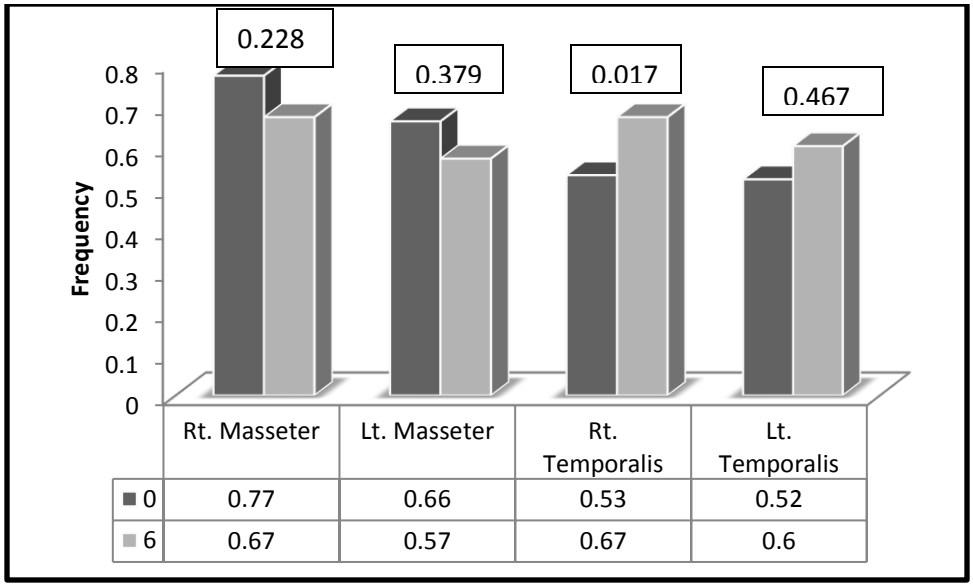

Figure illustrating the improvement in the MUP area of temporalis muscle after the use of dentures for 6 months. A significant difference ($P<0.05$) was observed in Right Temporalis. Whereas masseter muscle shows a slight decrease in MUP area.

TABLE 3: MEAN EMG ACTIVITY(RISE TIME) FOR RIGHT AND LEFT SIDE MASSETER AND TEMPORALIS MUSCLE OVER A PERIOD OF 0AND 6 MONTHS

	SEMG: Mean Rise time and SD (µs)		Paired t test; P Value
Variables	**Baseline**	**6 Months**	
Rt masseter	**1523.52(348.10)**	**1350.85(320.10)**	**0.207**
Lt masseter	**1310.73(628.95)**	**1152.64(554.97)**	**0.428**
Rt temporalis	**1289.55(441.35)**	**1008.73(367.92)**	**0.003**
Lt temporalis	**1332.64(558.42)**	**1175.26(410.15)**	**0.380**

Table illustrating the improvement in masseter and temporalis muscles with reduction in the MUP rise time after the denture use for 6 months. A significant difference ($P<0.05$) was observed in Right Temporalis

FIGURE 3: COMPARISON OF MUP RISE TIME BETWEEN 0 AND 6 MONTHS

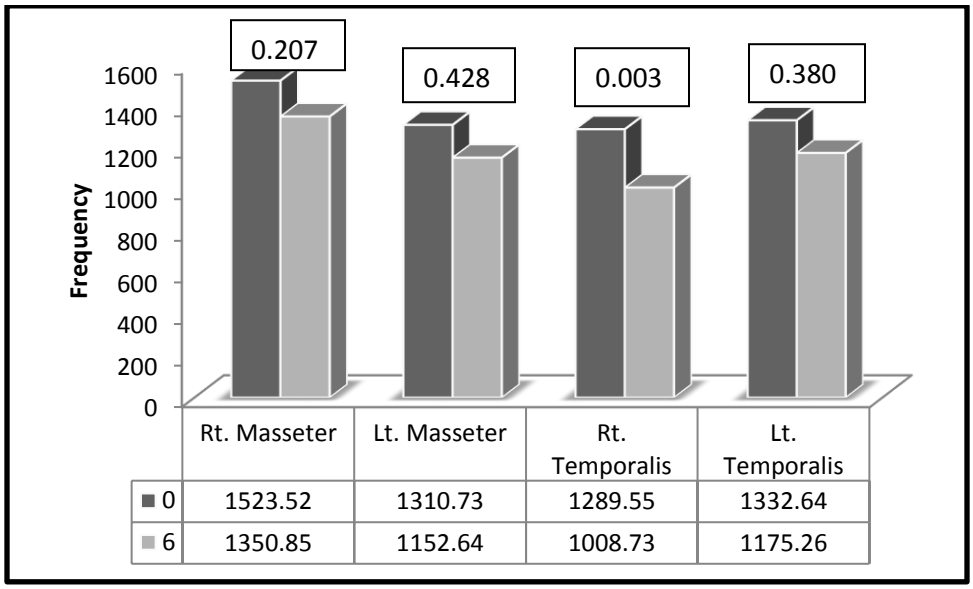

Figure illustrating the improvement in masseter and temporalis muscles with reduction in the MUP rise time after the denture use for 6 months. A significant difference ($P<0.05$) was observed in Right Temporalis

TABLE 4: COMPARISON OF CROSS SECTIONAL THICKNESS (MEAN) FOR MASSETER AND TEMPORALIS MUSCLE ON RIGHT AND LEFT SIDE AT RESTING AND CONTRACTION STATE OVER A PERIOD OF 0 AND 6 MONTHS

Variables	USG: Mean MUP amplitude and SD (mm)		Paired t test; P Value
	Baseline	6 Months	
Rt masseter relaxed	7.84(1.56)	9.18(2.07)	0.01
Lt masseter relaxed	7.47(1.12)	8.82(1.71)	0.00
Rt masseter contraction	9.42(1.64)	11.83(2.45)	0.00
Lt masseter contraction	9.17(1.81)	11.80(1.99)	0.00

Table illustrating the improvement in masseter muscle thickness in both relaxed and contracted state after the use of dentures for 6 months. A significant difference (P<0.05) was observed in all the variables.

FIGURE 4: COMPARISON OF USG OF MASSETER MUSCLE BETWEEN 0 AND 6 MONTHS

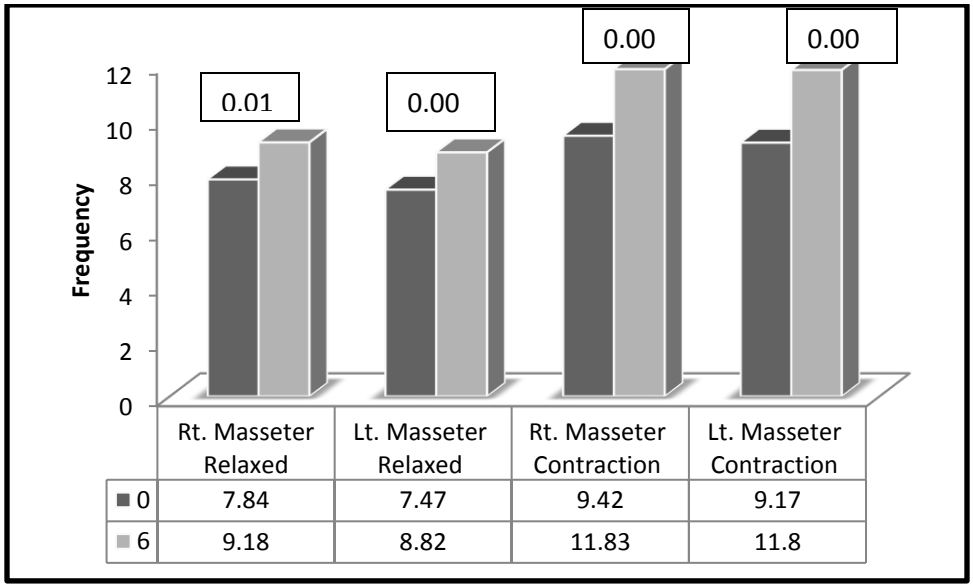

Figure illustrating the improvement in masseter muscle thickness in both relaxed and contracted state after the use of dentures for 6 months. A significant difference (P<0.05) was observed in all the variables.