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Ultrasonographic evaluation of masseter muscle thickness in chronic areca nut/ tobacco chewers and oral submucous fibrosis patients

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ABSTRACT

Background: The benign increase in the size of the masseter muscle is referred to as masseter muscle hypertrophy (MMH). It may affect unilaterally or bilaterally. Frequent and prolonged chewing of areca nut, betel quid, and tobacco exerts undue pressure on muscles of mastication. This may lead to hypertrophy of masticatory muscles, especially the masseter. The objective of the study is to evaluate the difference in cross-sectional thickness of masseter muscle at rest and at maximum clenching position using USG in chronic areca nut/tobacco chewers, OSMF patients, and the control group.
Methods: The study included 20 chronic areca nut/tobacco chewers and 18 OSMF consecutive patients. The control group comprised of 42 age, sex, and body mass index-matched healthy individuals. Ultrasonographic measurements were performed in all the subjects in both contracted and relaxed states. Intergroup comparison of ultrasonographic cross-sectional thickness was done using ANOVA with post hoc.
Results: Masseter muscle thickness significantly increased in chronic chewers in both relaxed & contracted states bilaterally when compared to OSMF & control group. Muscle thickness decreased in the OSMF group compared to controls.
Conclusion: In patients with chronic chewing habits without OSMF, due to prolonged chewing muscle thickness increased whereas, in OSMF patients, reduction in mouth opening leads to a decrease in bite force and consequent atrophy of muscle.

1. Introduction

The masseter is a muscle of mastication located lateral to the mandibular ramus. It plays an important role in mastication and facial aesthetics. Masseter muscle hypertrophy (MMH) is a benign increase in the size of muscle, that may affect unilaterally or bilaterally. MMH was first described by Legg in 1880.[1]

MMH is usually a benign condition. The patient may occasionally complain of pain, but most frequently a clinician is consulted for cosmetic reasons. In some cases, it presents along with prominent exostoses at the angle of the mandible. This condition should be differentiated from parotid gland pathology, odontogenic problems, and other rare neoplasms of muscular origin.[2,3] MMH is associated with variable causative factors such as genetic predisposition, bruxism, clenching associated with

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psychological stress, anxiety, sleep disorder, malocclusion, TMJ disorders, and unilateral chewing.[4,5]

Areca nut chewing is an ancient ethnic practice in India and other South Asian countries. In these populations, use of areca nut is strongly interwoven into social customs, religious practices, and cultural rituals.[6] In some commercial preparations, betel leaf is excluded, and tobacco is added to quid which is referred to as pan masala & gutkha. There is a greater spectrum of variations in ingredients & ways of preparations.[7] The composition and method of chewing can vary widely. In India, according to National Family Health Survey (NFHS)-3 conducted in 2005-06 showed 38% of men, 9.9% of women use smokeless tobacco (with/ without betel quid).[8] The products are used mainly because of their euphoric stimulant effect caused due to the presence of high levels of psychoactive alkaloids. Nicotine and areca nut are second & fourth most common psychoactive substances used worldwide.[9] Chronic areca nut/ betel quid/ tobacco chewing can lead to generalized fibrosis of oral tissues, a condition known as oral submucous fibrosis (OSMF).[10] The overall prevalence rate of OSMF in India is about 0.2-0.5% with a range of 0.2 – 1.2% in different regions of the country.[11]

Frequent and prolonged chewing of areca nut, betel quid, and tobacco exerts undue pressure on muscles of mastication. This leads to hypertrophy of masticatory muscle.[12] Masseter muscle thickness has been measured by several investigators using various imaging techniques including computed tomography (CT) by Weijs and Hillen (1984),[13] Ultrasonography (USG) by Wilson and Crocker (1985),[14] and Magnetic Resonance Imaging (MRI) by Hannam and Wood (1989).[15] For the measurement of the masseter muscle, USG was proved to be superior to CT and MRI. USG is rapid, inexpensive and has no known cumulative biological hazards.[16]

Chronic areca nut/ betel quid/ tobacco chewing are common adverse oral habits. Few studies have tried to assess the relation between masseter muscle thickness and OSMF. There is limited data regarding the effect of quid/ tobacco chewing on masseter muscle thickness. This study aims to evaluate the difference in cross-sectional thickness of masseter muscle at rest and at maximum clenching position using USG in chronic arecanut /tobacco chewers, OSMF patients and control group.

2. Materials and Methods

This study was designed and conducted among patients visiting the Department of Oral Medicine and Radiology, Narayana Dental College and Hospital, Nellore, after obtaining ethical clearance from the institutional ethical committee. Written informed consent of willingness and voluntary nature of participation in the study was taken. The study was carried out on patients attending hospital between November 2013 to January 2014. The study included consecutive 20 chronic chewers and 18 OSMF patients between the age group 20 – 40 years. 42 healthy patients were included as the control group.

2.1. Inclusion criteria

Patients with gutkha/areca nut chewing habit for more than 2years & duration of chewing >5minutes (defined as chronic chewers). Clinically diagnosed OSMF patients with gutkha/areca nut chewing habit for more than 2years & duration of chewing >5minutes. For the control group, age, sex, body mass index-matched healthy subjects with no history of areca nut/tobacco chewing, no appreciable malocclusion, bruxism, or any other mucosal lesions.

2.2. Exclusion criteria

Patients with systemic illnesses, masticatory muscle disorders, parotid pathology, TMJ disorders, developmental anomalies affecting the maxillofacial region.

A detailed case history was recorded including the history of chewing habits, duration and frequency. The inter incisal distance was measured using a divider and scale. The reading was recorded in millimeters (mm). Clinical staging of oral submucous fibrosis was done according to criteria provided by Chandramani more et al.[17]

All patients were subjected to Ultrasonographic imaging for recording the cross-sectional thickness of the masseter muscle. Scans were performed in the Department of Radio-Diagnosis, Narayana Medical College and hospital, Nellore using Philips Hd6 Ultrasonographic Scanner using a multi-frequency 3.5-5.0 MHZ broadband transducer. An ultrasound gel was applied to the skin before the imaging procedure. The transducer was placed perpendicular to the skin surface. USG examination of masseter muscle was done by a line drawn on skin parallel to and 2cms above the inferior border of the mandible, approximately corresponding to the bulkiest portion of the masseter. On the line three markings were made, P, M, A (P-Posterior, M – middle, A- anterior) (Figure 1). The average of 3 measurements was recorded in millimeters. The imaging and measurements were performed bilaterally with the subjects under two different conditions: 1. When teeth are occluding gently with muscle in a relaxed position 2. During maximal clenching with masseter muscle contracted. To avoid muscle fatigue, an interval of at least 1 min was kept between two successive measurements. The measurement protocol was similar to that described by Bakke et al.[18] and Kamala et al.[12]

2.3. Statistical analysis

Statistical analysis of data was performed using software SPSS version 20. The difference between masseter muscle thickness among the 3 groups bilaterally in contracted and relaxed state was evaluated. For continuous variables, data

values are represented as mean and standard deviation. To test the association between groups the Chi-square test was used. To test the difference between 3 groups Anova was used with Post hoc.

3. Results

The age of participants ranged from 20 – 40 years with the mean age being 32.08 years. (Table 1)

3.1. Right side

In chronic chewers, there is a significant increase in mean masseter muscle thickness both in contracted (15.84 ± 1.68mm) and relaxed state (13.41 ±1.82mm) compared to other groups. In OSMF subjects, there is a decrease in mean masseter thickness both in the contracted and relaxed state (12.80 ± 1.75mm, 10.0 ± 1.55mm respectively) compared to control group (13.12 ± 1.91mm, 10.45 ± 1.70mm). (Tables 2 and 3)

3.2. Left side

In chronic chewers, there is a significant increase in masseter muscle thickness both in contracted (15.83 ± 2.02mm) and relaxed state (13.31 ± 2.28mm) when compared to other groups. In OSMF subjects, there is slight decrease in muscle thickness (contracted -13.03 ± 1.69mm, relaxed -10.42 ± 1.40mm) compared to control group (13.67 ± 1.66mm, 10.93 ± 1.65mm) (Tables 2 and 3).

The mean muscle thickness in the control group on both sides were less than chronic chewers but higher than OSMF in both contracted and relaxed states. However, the decrease in muscle thickness of the OSMF group compared to control group is statistically not significant.

Fig. 1: Measurement points used for USG evaluation of masseter muscle (P – posterior M- middle, A- anterior)

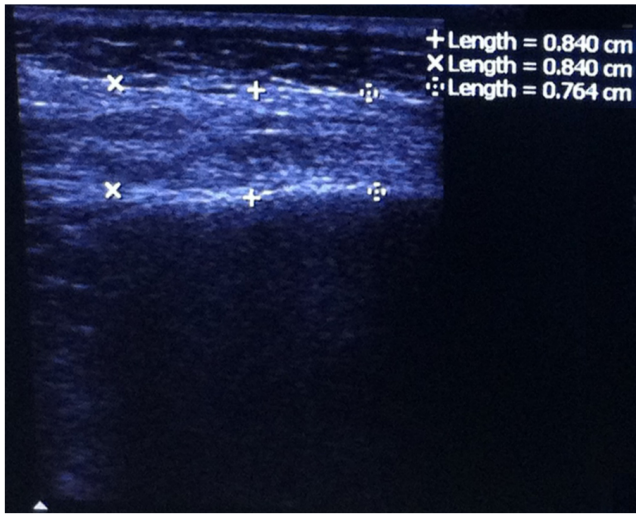

Fig. 2: Ultrasonographic image of the masseter muscle in a healthy person – contracted state

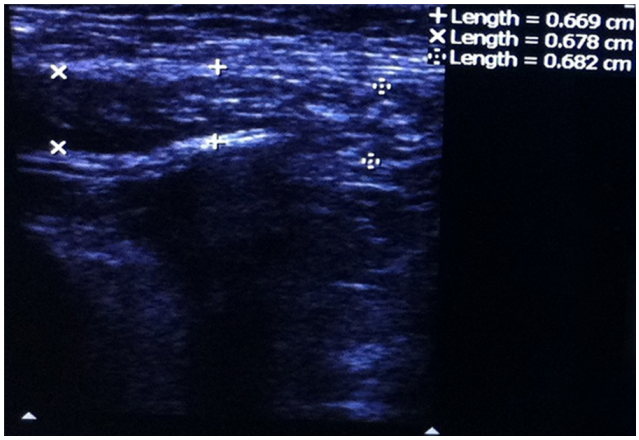

Fig. 3: Ultrasonographic image of the masseter muscle in a healthy person – contracted state

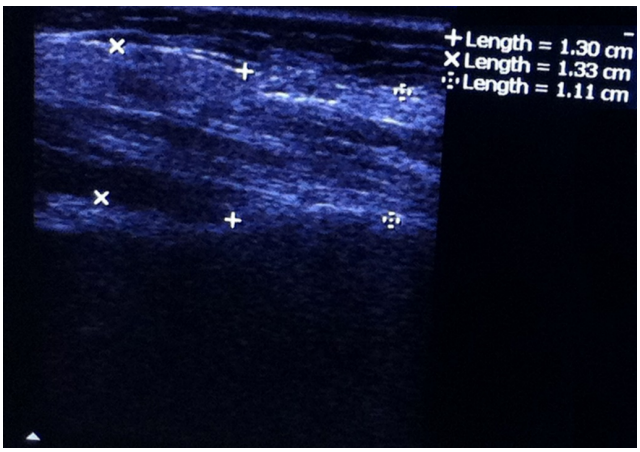

Fig. 4: Ultrasonographic image of the masseter muscle in chronic chewer – contracted state

Table 1: Demographic distribution of the study groups and control group

Group	No. of patients (N)	Sex		Total
		Male	Female	
Chronic chewers	**N**	**17**	**3**	**20**
	%	5.0%	15.0%	100.0%
OSMF	**N**	**15**	**3**	**18**
	%	83.3%	16.7%	100.0%
Controls	**N**	**32**	**10**	**42**
	%	6.2%	23.8%	100.0%
Total	**N**	**64**	**16**	**80**
	%	80.0%	20.0%	100.0%

* Significant P < 0.05 HS – Highly significant

Table 2: Comparison of mean & standard deviation of USG measurements of masseter muscle thickness among chronic chewers, OSMF and control group in the relaxed and contracted state on right & left side

Mean ± SD of the masseter muscle (measured in mm)							
Groups	**No. of patients**	**Right contracted**	**Right Relaxed**	**P-value**	**Left contracted**	**Left relaxed**	**P-value**
Chronic chewers	20	15.84 ± 1.68	13.41 ± 1.82	< 0.0001* HS	15.83 ± 2.02	13.31 ± 2.28	< 0.0001*
OSMF	18	12.80 ± 1.75	10.00 ± 1.55		13.03 ± 1.69	10.42 ± 1.40	
Control	42	13.12 ± 1.91	10.45 ± 1.70		13.67± 1.66	10.93 ± 1.65	

Table 3: Comparison of the mean difference of USG measurements of Masseter muscle thickness in between groups on both sides

Dependent variable	Group (I)	Group (J)	Mean Difference (I-J)	Standard error	P-value	95% confidence interval	
						Lower Bound	Upper bound
Right contracted	Chronic chewers	OSMF	3.03794*	.59276	<0.0001 HS	1.6213	4.4546
		Control	2.71493*	.49568	<0.0001 HS	1.5303	3.8995
	Control	OSMF	.32302	.51399	0.805 NS	-.9054	1.5514
Right relaxed	Chronic chewers	OSMF	3.41050*	.55459	<0.0001 HS	2.0851	4.7359
		Control	2.96050*	.46375	<0.0001 HS	1.8522	4.0688
	Control	OSMF	.45000	.48089	0.619 NS	-.6993	1.5993
Left contracted	Chronic chewers	OSMF	2.79711*	.57411	<0.0001 HS	1.4251	4.1692
		Control	2.16219*	.48008	<0.0001 HS	1.0149	3.3095
	Control	OSMF	.63492	.49782	.413 NS	-.5548	1.8246
Left Relaxed	Chronic chewers	OSMF	2.88711*	.57874	<0.0001 HS	1.5040	4.2702
		Control	2.37529*	.48395	<0.0001 HS	1.2187	3.5319
	Control	OSMF	.51183	.50183	.567 NS	-.6875	1.7111

N – No. of patients * Significant P < 0.05, HS – Highly significant, NS-Not significant

4. Discussion

In the present study, Pearson's correlation analysis for the entire sample revealed no correlation between the thickness of the masseter muscle and the age of subjects. This finding correlates with the study by Kiliaridis et al.[19] The age group of patients ranged from 21 to 35 years, similar to the present study**.** However, Newton et al.,[20] found a strong correlation between the thickness of masseter muscle and age. This study included elderly people; age-related atrophy of the muscles might have contributed to altered muscle thickness. Palinkas et al.[21] reported a decrease in thickness of the masseter muscle after 60 years. Structural and functional alterations in the muscles of mastication might be associated with aging.

In the control group, the mean thickness of the masseter on the right and left side during the contracted state is13.12 ± 1.91mm & 13.67 ± 1.66mm respectively whereas in the relaxed state is 10.45 ± 1.70 & 10.93 ± 1.65 mm, respectively. The values of present study correlated with Bakke et al.[18] Raadsheer et al.[22] reported higher value in both contracted and relaxed states bilaterally. They measured muscle thickness at 3 levels, upper, middle and lower. Benington et al.[23] reported slightly lower value in the contracted state. Kiliaridis et al.,[19] Benington et al.[23] reported gender variations in muscle thickness. The mean muscle thickness of males is slightly higher than females. The measurement location site of the present study

corresponds to Bakke et al.[18] and middle level of Raadsheer et al.[22] Kiliaridis et al.[19] measured the masseter at the level of the occlusal plane. Benington et al.[23] measured thickness at the anteroposterior midpoint of the muscle belly. Mild discrepancies of muscle measurement values in the present study and those found by other investigators may be due to disparities between sample, the difference in skeletal morphology, genetic variations, dietary habits, and masticatory forces.

Muscle thickness is measured both in the relaxed and contracted state. Previous studies by Kiliaridis et al.,[19] Raadsheer et al.,[22] Emshoff et al.[24] stated the measurement of muscle thickness in relaxed state is less accurate, owing to the pressure changes induced by the transducer on the cheek. This error can be minimized by maintaining slight interocclusal contacts during the relaxed state.[25] The thickness of the masseter was more in the contracted state than in the relaxed state in all 3 groups bilaterally. This finding is similar to previous studies by Kiliaridis et al.,[19] Raadsheer et al.,[22] Kamala et al.[12] During contraction, filaments of muscle slide actively towards the center of the sarcomere, resulting in shortening of the whole muscle. Muscle width increases during shortening.[26]

Masseter thickness increased in chronic chewers bilaterally when compared to other groups. When bite force is increased, due to prolonged and frequent chewing of hard substances like areca nut it will result in over-development/ hypertrophy of muscles of mastication. Studies have shown training of skeletal muscle leads to muscle fiber hypertrophy resulting in increased thickness of the muscle.[27] Exercise training elicits a range of morphological and neurological adaptations that contribute to changes in skeletal muscle size, strength, and power.[28] These adaptations might lead to an increase in muscle cross-section or an increase in non-contractile tissues such as collagen.[29] Gibbs et al.[30] reported extremely great bite strength in bruxers, clenchers who had developed extensive masticatory muscle hypertrophy. Masticatory muscles of the contemporary man are in an untrained condition compared to the primitive races and training exercises could increase the maximum bite force.

There is a reduction in masseter thickness in OSMF compared to other groups. The decrease in muscle thickness in OSMF patients might be due to a reduction in mouth opening and subsequent reduction in biteforce. The mouth opening of most of the patients (15 out of 18) in the present study ranged between 25 mm to 35mm. However, studies by Devathambi JR et al.,[31] Kamala et al.[12] reported a significant increase in masseter thickness in OSMF patients compared to the control group. Kant et al.[32] reported decreased thickness of masseter muscle during advanced stages of OSMF. Reduction in muscle thickness correlated with the stage of OSMF.

The earliest reports on muscle involvement in OSMF was reported by Binnie and cawson,[33] Caniff et al.[34] Gollnick et al.[35] stated that glycogen consumption is physiologically related to cellular activity. Hyperactivity of muscle leads to excess glycogen consumption followed by its depletion. Glycogen depletion coupled with connective tissue changes and reduction in vascularity results in muscle atrophy and fibrosis.[36] In OSMF patients, during early stages due to chronic chewing habit muscle thickness increases. But as the disease progresses, mouth opening decreases, which leads to a significant decrease in bite force. Detraining or immobilization of a muscle leads to disuse atrophy. Both slow and fast fibers are affected by a decrease in their cross-sectional areas. These factors might contribute to the atrophy of muscle fibers in OSMF patients.

One of the limitations of the present study is, biteforce of the patients were not recorded. Also, due to the limited sample size, we could not correlate the muscle thickness of OSMF patients and the stage of the disease.

5. Conclusion

This study was performed to evaluate the difference between the cross-sectional thickness of masseter muscle among chronic chewers, OSMF patients, and the control group. The results showed that there was a statistically significant increase in masseter muscle thickness in chronic chewers in both relaxed and contracted state bilaterally when compared to OSMF patients and control group. Slight atrophy of muscle was noted in OSMF patients compared to control group. To validate these findings prospective studies using larger sample size are recommended.

6. Source of Funding

None.

7. Conflict of Interest

None.

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