Ultrasonographic evaluation of effectiveness of circumoral muscle exercises in adenotonsillectomized children

T.V. Anupam kumar* / Sobha kuriakose**

Mouth breathing due to obstructive adenoids and tonsils has deleterious effects on craniofacial morphology especially on dentition and dental arches. Reports confirm that removal of nasal obstruction, adenoids and tonsils has not given beneficial development of circumoral musculature. Use of muscles to correct malocclusion was first recommended by Alfred Paul Rogers. This study highlights the imaging of circumoral musculature using ultrasound to evaluate the effectiveness of muscle exercises in adenotonsillectomized children. Definite changes in muscle thickness were noted in subjects, who were given muscle exercises.
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INTRODUCTION

The effects of mouth breathing on craniofacial morphology and development of dental malocclusion have come in to focus during the last few years. Obstructive adenoids and tonsils, which are the major causes of chronic mouth breathing alter the dentition and dental arches.[12,24,27] Although this is an old issue, a cause and effect relationship has been difficult to establish.

The theory advanced by Tomes almost one hundred years ago was that it is the perioral musculature and the tongue, which principally determined the position of the teeth has long been accepted by the dental profession.

Ballard[5] and Tulley[47] have also suggested that the tongue adopts an interdental resting posture to assist formation of an anterior oral seal.

The relationship between lip competency and malocclusion has also not come under serious scrutiny though everyone is keen to see how small or great is the influence of the lip musculature on the dentition.

Alfred Paul Rogers[2] was among the first to recommend the use of muscles to correct malocclusion. The essence of myofunctional therapy was to use muscle activity as a primary source of force for resolution of malocclusion. Reports confirm that removal of nasal obstruction, adenoids and tonsils has not given beneficial results in the reversion of habit and improvement of tone and development of the circumoral musculature. Rogers[2] concluded from his experience that the problem of overcoming the habit of mouth breathing is through giving exercise to involved muscles. Proper systematic exercise alone was found to be more effective than any other method to produce a harmonious development.

Frankel[37] in his study stressed the importance of lip seal therapy or exercises using functional regulator devices, which has been proved to be effective in overcoming poor posture of the whole of orofacial musculature. These therapies or exercises are suitable means of activating and improving the tone and thickness of the muscles creating proper lip seal and suspending the mandible in a proper postural position and helping the patient acquire normal habits.

Our present knowledge of the anatomy of the mimic muscles including the circumoral musculature is based on an extensive series of cadaver preparations.[6,7,9,10,17,26,32] While they yield a general description of the form and distribution of muscles within the circumoral soft tissue, none provides an accurate description of the relationship between contraction and relaxation of the muscle.

Ultrasound imaging has been used to study movements of the tongue, floor of the mouth, hyoid bone and larynx. Ikai *et al*.[18] and Dons *et al*.[11] have used ultrasound to measure the changes in muscle size as a result of weight lifting.

Prabhu, and Munshi[30] in a study of ultrasonographic observation of the circumoral musculature with varying classes and types of malocclusions found definite changes in the thickness of circumoral muscle in the relaxed and contracted states in various malocclusion states. They also observed that definite changes in the muscle thickness after the subjects were given muscle exercises. The effect of mouth breathing on facial

* Send all correspondence to T.V. Anupam kumar, BDS, MDS, Senior lecturer, Department of Pedodontics, Government Dental college, Kozhikode, Kerala, India.
** Sobha kuriakose,BDS, MDS, Professor and Head, Department of Pedodontics, Government. Dental College,Trivandrum, Kerala, India.

morphology is probably greatest during growth period. This justifies the need for further investigations on children using ultrasound to evaluate the effectiveness of muscle exercises in circumoral musculature especially in adenotonsillectomized children.

The present study aimed to:

- To determine the thickness of circum oral musculature sonologically in adenotonsillectomized control group and experimental group children.
- To compare the thickness in circum oral musculature of experimental group, who have done lipseal therapy and exercises with oral screen for 6 months period, with control group, who have not done exercises during this period.
- To determine the degree of improvement in lip seal clinically in adenotonsillectomized experimental group children after prescribed 6 months lipseal therapy and exercises with oral screen.
- To determine the degree of reduction of overjet clinically in adenotonsillectomized experimental group children after 6 months lip seal therapy and exercises using oral screen.

MATERIALS AND METHODS

Twenty-eight children aged between 5 and 10 years (fourteen - experimental group and fourteen-control group), who were confirmed to have enlargement of adenoid and tonsils and who were posted for surgery were selected. In the both groups, seven were boys and seven were girls. Two performas were prepared, one for ENT department and second for Dental department.

ENT evaluation was done in the ENT department, Medical College, Trivandrum, where the concerned doctor, who was in-charge examined the patients. History of nasal obstruction, mouth breathing, snoring, sleep apnea, nasal/skin allergy, chronic rhinitis, nasal bleeding, choanal atresia were the main variables. Family history and socioeconomic status were asked. Clinical examination included nasal airway checking (cold spatula test), Conventional anterior rhinoscopy and examination of the oropharynx.

Lateral oblique views of the skull were taken to confirm the presence of adenoid enlargement. Cold spatula test were done before surgery and after 6 months therapy period. In dental performa, shape of face, proclination of teeth, lip thickness-stiffness, lip competancy, perioral tonicity, mentalis muscle activity, were examined. Habits and oral hygiene status were seen and measures for brushing were asked. Clinical examination included: checking of labial and buccal mucosa, tongue, gingiva, floor of the mouth, number of teeth present, caries teeth, root stumps, missing teeth and restored teeth.

Dental treatment including extractions, restorative treatment and full mouth prophylaxis were done before surgery. All patients were called back two weeks after the surgery and were sent for ultrasonographic evaluation of the circumoral musculature.

Patients in the experimental group were shown exercises, using oral screen, and a set of lip seal therapy, which included the following:

- Blowing balloons
- Lip pulls
- Lip puffer
- Holding water in the mouth
- Button and string therapy

All these exercises were done for 10 to 20 times for 3 times daily. These exercises helps lip strengthening, lengthening, lip mobility, improving the lip line and lip closure.

Co-operation of patients and complete involvement of parents were very important in this study. Each time parents were asked to note down the time and number of times the patients did the exercises. This record was brought each time during recall visit, was seen and approved. This method of checking highlighted the importance of the treatment, so until the completion of the study, all the patients and parents were enthusiastically responding.

The time limit for the therapy period was fixed at 6 months.

Ultrasonographic evaluations were done at a private clinic using Esaote Bio Medica AU3 Partner with high resolution linear probe of 12mHz. Scan of upper and lower lip in relaxed and contracted state was done. As linear probe was used, entire area of upper or lower lip was covered for taking the image at a single stretch. From the image the thickness of the lip in the center as well as in the periphery on both side of upper and lower lip in contracted and relaxed states were taken.

Upper lip and lower lip were divided into three portions, right, middle and left (R.M.L.) for the convenience of scanning and measurements were taken in millimeters. After the 6 months therapy period, the same procedure was repeated. No sedation or premedication was given to these patients, as all of them were very cooperative.

For overjet measurements, upper/lower impressions of all patients were taken after surgery and cast prepared. Overjet was measured using calipers and values noted down. After 6 months period, impressions were again taken, cast prepared and overjet measurements were done. All results were tabulated and statistically analyzed using paired t test.

RESULTS

ENT variables before and after treatment in the control groups and experimental groups were compared. Nasal obstruction, snoring, sleep apnea, mouth breathing and proclinations of teeth, were the

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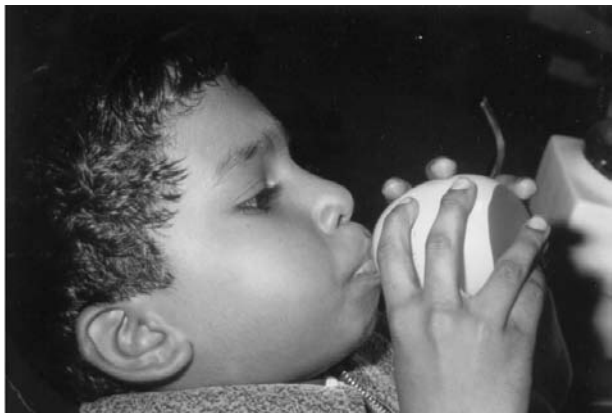

Figure 1. Blowing a balloon.

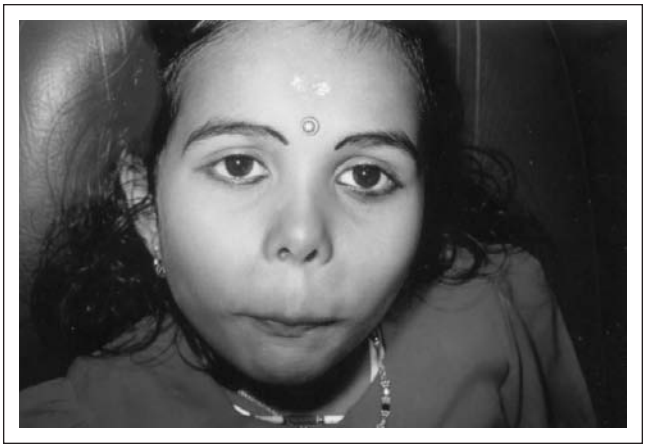

Figure 2. Lip pulls

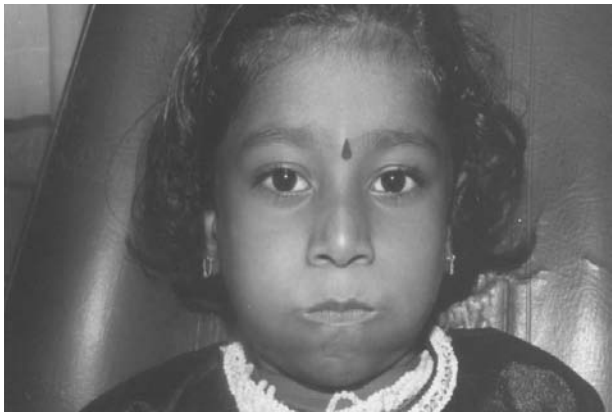

Figure 3. Lip puffer

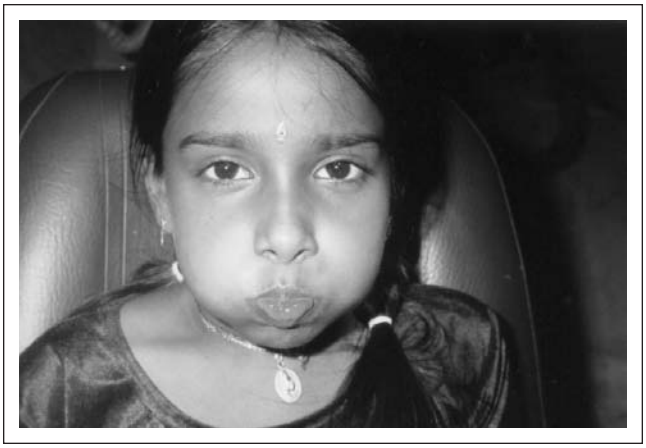

Figure 4. Holding water in the mouth

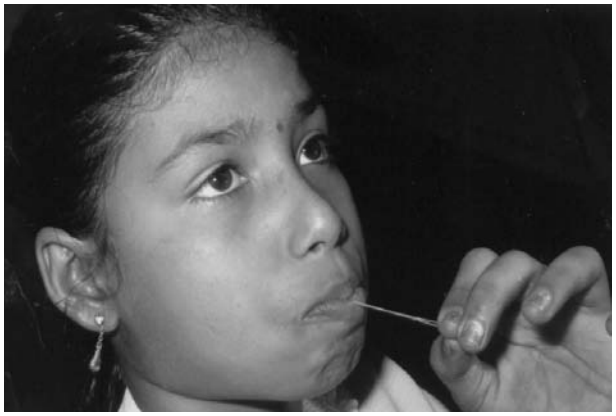

Figure 5. Button and string therapy

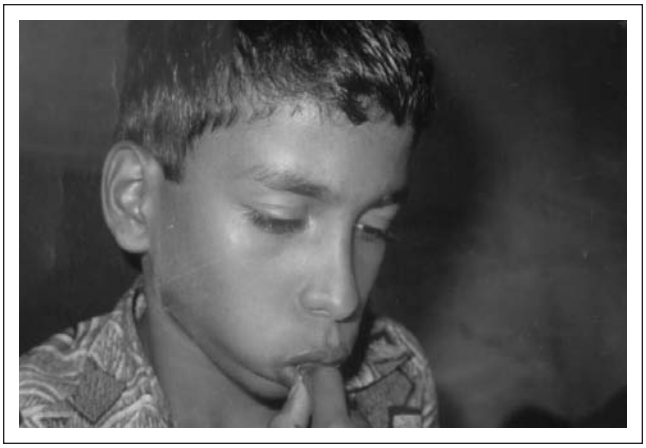

Figure 6. Exercise with oral screen

variables considered as it showed considerable changes in the pre and post treatment periods. Of these, the first 3 showed improvement in all the patients in control as well as treatment group regardless of lipseal therapy and exercises with oral screen. However, proclination of teeth and mouth breathing, remained the same in all the patients in the control group, while it showed improvement in all the patients in the experimental group.

Dental variables before and after treatment in the control group and experimental groups were compared. Proclination, lip incompetence, perioral tonicity, and mentalis muscle activity were the variables considered, which showed significant changes. None of the

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Table I. Comparison of change in muscle thickness in the lower lip in contracted state between experimental group and control group

Group Lower Contracted	Pre-Treatment Mean	Pre-Treatment SD	Post-Treatment Mean	Post-Treatment SD	Mean Difference	SD of Mean Difference	t	p
Experimental	2.84	.40	3.02	.36	0.170	0.13	4.72	0.001
Control	2.81	.29	2.82	.29	0.005	0.02		(HS)

Table II. Comparison of change muscle thickness in the lower lip in relaxed state between experimental group and control group

Group Lower Relaxed	Pre-Treatment Mean		Post-Treatment SD		Mean Difference	SD of Mean Difference	T	P
Experimental	2.58	0.29	2.65	0.33	0.07	0.070	4.02	0.01
Control	2.72	0.28	2.72	0.28	0.00	0.001		(HS)

Table III. Comparison of change muscle thickness in the upper lip in relaxed state between experimental group and control group

Group Upper Contracted	Pre-Treatment		Post-Treatment		Mean Difference	SD of Mean Difference	t	P
Experimental	2.80	0.55	3.01	0.49	0.07	0.13	3.48	0.002
Control	2.80	0.36	3.01	2.81	0.36	0.00		(HS)

patients in the control group showed improvement with regard to these variables, where as, almost all the patients in the experimental group showed decrease of proclinations of the teeth, decrease in the perioral tonicity and mentalis muscle activity and improvement in the lip competence. Two of the 11 patients (22%), who had hypertonic musculatures did not show improvement in the experimental group.

Table I shows comparison of change in the muscle thickness in the lower lip in the contracted state between the experimental group and the control group. Mean increase in muscle thickness was 0.17mm in the experimental group, while it was only 0.005 in the control group. Paired t test was used for significance testing and increase in thickness in the experimental group is found to be highly significant (P= 0.001).

Table II shows comparison of change in the muscle thickness in the lower lip in the relaxed state between the experimental group and the control group. Taking the mean there was no increase in the muscle thickness in the control group while there was a mean increase of 0.07 mm in the experimental group and this difference is found to be highly significant (P=0.002).

Table III shows comparison of change in the muscle thickness in the upper lip in the contracted state between the experimental group and the control group. Mean increase in muscle thickness in the experimental group was 0.07, whereas in the control group there was no mean increase of muscle thickness and the difference is found to be highly significant (P= 0.001).

Table IV shows comparison of change in the muscle thickness in the upper lip in the relaxed state between the experimental group and the control group. Mean increases in muscle thickness were 0.1 and 0.03 in the experimental group and the control group respectively. Significance testing showed mean increase in muscle thickness in the experimental group is highly significantly different from the control group (P= .03).

Table V compares the change in overjet in the control and experimental group. Mean difference between control and experimental group were –2.28 and –0.71 respectively. Paired t test was used for significance testing. There was a mean reduction of –0.71 in the experimental group and this difference is found to be highly significant (P=0. 001) which shows that overjet has reduced in experimental group.

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Table IV. Comparison of change muscle thickness in the upper lip in relaxed state between experimental group and control group.

Group Upper Relaxed	Pre-Treatment		Post-Treatment		Mean Difference	SD of Mean Difference	T	p
Experimental	2.82	0.37	2.86	0.37	0.03	0.09	2.29	0.03
Control	2.49	0.40	2.59	0.42	0.10	0.10		(Sig)

Table V. Comparison of change in overjet (MM) in experimental group and control group.

Group Overjet (in mm)	Pre-Treatment Mean	SD	Post-Treatment Mean	SD	Mean Difference	SD of Mean Difference	T	P
Control	7	0.96	4.71	0.82	-2.28	0.82	9.55	0.001
Experimental	6.64	0.84	6.57	0.75	-0.71	0.27		(HS)

Table VI. Gender comparison of patients before and after treatment in contracted and relaxed states in upper and lower lip in control and experimental groups.

	Experimental group				Control group			
Comparison	Males		Females		Males		Females	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
POLC v/s PLC	0.19	0.16	0.16	0.12	0.01	0.02	0.005	0.01
POLR v/s PLR	0.05	0.06	0.08	0.08	0.00	0.00	0.00	0.02
POUC v/s PUC	0.05	0.05	0.08	0.08	0.00	0.00	0.00	0.02
POUR v/s PUR	0.08	0.11	0.11	0.09	0.05	0.13	0.009	0.02

Table VI shows gender comparison of patients before and after treatment in contracted and relaxed states in the lower lip and contracted and relaxed states in upper lip in experimental group and control group. As the mean value does not have much difference, there is no significance in any of the groups (P >0.5).

DISCUSSION

It is commonly assumed that nasorespiratory function can exert a dramatic effect upon the development of the dentofacial complex. It has been stated that chronic nasal obstruction leads to mouth breathing, which causes altered tongue and mandibular positions. If this occurs during a period of active growth, the outcome is the development of the adenoid facies. Such patients characteristically manifest a vertically long lower third facial height, narrow alar bases, lip incompetence, a long and narrow maxillary arch and a greater than normal mandibular plane angle. These dentofacial traits have repeatedly been attributed to restricted naso respiratory function.

This study evaluated patients with adenotonsil enlargement with all the adenoid characteristics, which were included as variables in ENT and dental performas. Minor related variables were also given in the performas.

Several studies have been conducted to find the effects of chronic absence of active nasal respiration. Schlenker *et al.*[40] has stressed the relationship of oral respiration in orthodontic patients. Shanker *et al.*[41] has conducted study on the dentofacial morphology and upper respiratory function in 8 to 10 year old children. All these studies highlight the effects of mouth breathing. Considering the comparison of ENT variables before and after treatment major features like nasal breathing, rhinitis, snoring and sleep apnea improved in control and experimental group irrespective of the active lipseal therapy and exercises with oral screen given to the experimental group. However proclination and mouth breathing did not improve in the control group. Similarly evaluating the dental performa proclination, lip incompetence, perioral tonicity, and mentalis muscle activity improved in the experimental group, but showed no improvement in the control group.

The fact that the surgical correction of adenoid tonsil enlargement does not correct the mouth breathing habit and proclination of the teeth is still a matter to be discussed. Evaluation of the performas has also shown that these two factors have not improved in control group in spite of surgical treatment.

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Importance of lipseal therapy and exercises with the oral screen is worth mentioning. Rogers[2] has stressed the importance of giving proper systematic exercises after removal of nasal obstruction for proper tone and harmonious development of circum-oral musculature.

Taner-Sarisoy[45] highlighted the importance of functional therapy at early age for favorable changes in profile and lipseal. It is suggested that lip seal therapy and exercises with vestibular or oral screen produces alteration in the functional environment, which induce a chain of adaptive changes in the network of postural system of orofacial complex.

The results obtained after the prescribed lip seal exercises are usually judged clinically. The importance of reduction of overjet plays a crucial role. It is easy to measure the overjet before the treatment period and to compare the values after the treatment period. The present study has measured the pre and post treatments overjet values in both experimental group and the control group. Overjet has reduced significantly in the experimental group when compared to control group, which can be attributed to the regular lipseal therapy and exercises with oral screen.

Imaging with ultrasound is widely used for the prenatal measurement of structures such as fetal eyes[21] and for the early detection of malformation such as cyclopia.[13,14,25] Cleft lip imaging of muscle dimension has been shown to be possible by Alexander and Vernon.[1] Ikai and Fukunage[18] and Dons *et al*.[11] have used ultrasound to measure the changes in muscle size as a result of weighlifting. Cady, Garderner and Edwards[8] have used ultrasound to detect diseased muscle. Prabhu and Munshi[30] have found definite changes in the thickness of the muscles in relaxed and contracted states in various malocclusion states. They have also found increase in muscle thickness in patients, who were given muscle exercises.

Vinkka-Puhakka *et al*.[48] ultrasonically imaged the circum-oral musculature and showed that the muscle tissue is made up of only a part of the total thickness of the lips and varied among individuals in shape, transonicity (clearness) and thickness. In the present study changes in the muscle thickness in the upper and lower lip in the contracted and relaxed states in the experimental and control group are imaged using ultrasound. Comparisons of muscle thickness in the above groups were made. Paired t test is used to assess the mean difference for the pre-treatment and post treatment between the experimental group and control group. In lower lip and upper lip in contracted as well as relaxed states, muscle thickness invariably showed improvement in the experimental group, but did not show any improvement in the control group. This suggests lip seal exercises and exercises with oral screen are crucial for the development of proper musculature of the circumoral area, which would restore back the normal nasal breathing.

The gender comparison of patients in this study before and after treatment in relaxed and contracted states in upper and lower lip in the experimental and control group were done and there was no significant changes between males and females.

Rogers has found that persistent open bite due to mouth breathing caused by lack of tone of facial muscles, particularly the *orbicularis oris*, has improved after proper systematic exercises. So this fact is very relevant in the present study, which also shows that there is increase in muscle thickness after circum oral muscle exercises within the prescribed period thus highlighting the importance of incorporation of such exercises as part of treatment after adenotonsillectomy.

ENT surgeons, who treat children with adenotonsil enlargement, should make it a point that they refer the case to the pediatric dentists as soon as the patients report back to them after surgical healing period. This would help the pediatric dentists to start the lip seal therapy and exercises with oral screen as early as possible to restore the normal nasal breathing and help in normal development of face and to make the child grow up as a more confident person.

CONCLUSIONS

1. Muscle thickness within the circumoral region is imaged and can be measured ultrasonographically in adenotonsilletomized children.
2. Significant changes in the muscle thickness were noticed in the experimental group after the 6 months prescribed lipseal therapy and exercises with oral screen.
3. Significant reduction in overjet was noticed clinically in the experimental group, who were given 6 months prescribed lip seal therapy and exercises with oral screen.
4. Mouth breathers, who had adenotonsil enlargements did not become nasal breathers after surgery, active circum oral exercises only made them nasal breathers.
5. Early incorporation of circumoral exercises should be included as a part of treatment after the surgery in mouth breathers, who were adenotonsillectomized.

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