Function of Temporal and Masseter Muscles in Individuals with Dual Bite

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Dual bite is defined as an occlusion with an abnormally long anteroposterior difference between the retruded and intercuspal positions of the mandible. The average "normal" distance is 1 mm or less in children and adults with a range of variation from 0 to 2 mm.[7] If the distance is more than 2 mm, the occlusion is classified as a dual bite. The patient has then two occlusal positions he can easily use and in which the upper and lower teeth fit well together. The most anterior of these positions is the intercuspal position of the mandible and the most posterior is close to or coincident with the retruded position of the mandible.

Uncertainty exists as to whether or not dual bite predisposes for functional disturbances of the masticatory system and which of the two mandibular positions should be considered the optimal intermaxillary relationship. The first aspect, the prevalence of symptoms of mandibular dysfunction, has been accounted for in a previous report on a series of subjects with dual bite.[4] A morphological description of the dentition and the face of the subjects was also given in that report.

The aim of the present investigation was to elucidate the second question, which of the two mandibular positions is the optimal one, by electromyographic examination of some of the muscles of mastication during natural functions of the masticatory system. By comparing the muscle activity of subjects with dual bite with that of normal individuals, any aberrations in activity are revealed and hence the function of the masticatory system in various mandibular positions and during various activities.

MATERIAL AND METHODS

The subjects comprised two groups, one with dual bite and one control.

The dual bite group consisted of 7 males and 5 females aged 11-60 years. The median age was 17 years. The patients have been described with respect to morphology of the dentition and the face, function of the masticatory system, and symptoms of mandibular dysfunction in an earlier report.[4] Dual bite was diagnosed by clinical functional examination. The anteroposterior distance between the retruded and the intercuspal positions of the mandible was 2.5-5 mm with a median value of 4.0 mm. The clinically recorded distance between the two mandibular positions was verified by measurement in a gnathothesiometer and on profile and temporomandibular joint radiographs.[4]

The control group consisted of dental students, 6 men and 6 women aged between 22 and 27 years. The median age was 23 years. The number of teeth varied between 25 and 30. The missing teeth, third molars excluded, were either extracted on orthodontic indications or congenitally absent. The control subjects had clinically normal occlusion. The overbite was 1.5-5 mm and the overjet 1-5 mm. Some subjects had minor crowding or occlusal deviations. None of the control subjects reported any subjective symptoms of functional disturbances of the masticatory system and on clinical examination none had cuspal interference but two had minor symptoms of mandibular dysfunction (mainly tender masticatory

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muscles on palpation). The anteroposterior distance between the retruded and the intercuspal positions was 0-1 mm (median distance 0.5 mm).

Electromyography

An electromyograph with four direct channels (DISA 14 A 30) and two double mean voltage channels (DISA 14 C 20) connected to a six-channel ink jetwriter (Mingograph 800) was used. The writer (Frequency 0-1200 Hz) was fed with paper at a speed of 5 cm/sec during recording of activity in the postural position of the mandible and during maximal bite, and 10 cm/sec during recording of chewing and swallowing activity. Activity below 20 Hz was filtered off.

The activity in the anterior and posterior portions of the temporal muscle and in the masseter muscle was recorded bilaterally with bipolar hook electrodes placed intracutaneously.[1] The electrodes were positioned as described earlier with the placement of the masseter electrodes modified to a 5 mm more superior position.[9]

The following EMG recordings were made in the order given: 1) the postural position of the mandible, 2) during chewing and swallowing bread and apple, 3) during unilateral chewing of chewing gum, right and left sides, 4) during swallowing water, 5) during maximal bite in the intercuspal position and in the retruded position, and 6) repetition of recording No. 1.

Since only four direct channels were available for 6 muscles, the sequence of recordings was repeated, each time with the right anterior temporal muscle as the reference muscle. The calibration was 50 μV/div. in the recording of postural activity and 200 μV/div. in all other recordings.

In test No. 2 the subject was given a piece of bread with butter and fresh apple, respectively, and requested to chew and swallow without waiting for further instructions. In test No. 3 the subject was given a piece of chewing gum and asked to chew it until soft. Recordings were then made when the subject chewed on the right and left sides, respectively. In test No. 4 the subject was given a spoonful of water (5 ml) and instructed to swallow on command. Maximal bite in the retruded position was not recorded in the control group. In the dual bite group *two* different recordings of biting in the retruded position were done. In one, the subject was asked to retrude the mandible actively as far as possible and simultaneously bite in that position. A second recording of maximal bite was then done when the investigator pressed the mandible back into the retruded position and the subject simultaneously bit in that position.

Analysis of the EMG recordings comprised:

1) The characteristic mean voltage amplitude in the postural position and during maximal bite.

2) The number of chewing cycles necessary to triturate the test media (bread and apple) and the duration of the act of chewing (from the beginning of chewing until swallowing).

3) The maximal mean voltage amplitude and duration of activity during the closing phase of the chewing cycle and during swallowing. Every third chewing cycle was measured.

4) The onset of activity and time for maximal mean voltage amplitude in the posterior temporal muscle and in the masseter muscle in relation to the onset of activity and time for maximal mean voltage amplitude in the right anterior temporal muscle. Every third chewing cycle was measured.

Since muscle activity during the functions studied has been shown to be symmetric,[9,11] the activity in the right

TABLE I

Median and range, in μV, for the mean voltage amplitude in the postural position of the mandible. n = 12 in each group.

	Anterior temporal		Posterior temporal		Masseter	
Group	Median	Range	Median	Range	Median	Range
Dual bite	0.8	0.0-5.3	2.9	0.5-18.6	0.0	0.0-1.2
Control	1.9	1.3-7.6	6.5	1.2-13.8	0.4	0.0-0.7
Sig. diff.	**		—		—	

** = $0.001 < P < 0.01$

and left muscles was pooled. The same was done for the two recordings of the postural activity.

Statistical methods

Differences between distributions were tested with Wilcoxon matched-pairs signed ranks test and Mann-Whitney's U-test.[16] Interdependence between variables was tested by rank-correlation according to Spearman.

Results

Postural activity

The distribution of postural activity was the same in the group with dual bite and in the control group, i.e., the activity was highest in the posterior portion of the temporal muscle and lowest in the masseter muscle (Table I). There was no difference between the groups in postural activity in the posterior temporal muscle and in the masseter muscle, while the activity in the anterior temporal muscle was significantly lower in the group with dual bite.

Activity during maximal bite

There was no significant difference between the two groups in activity during maximal bite in the intercuspal position (Table II).

The distribution was the same in the two groups, i.e., highest in the anterior temporal portion and lowest in the posterior temporal portion.

There was no difference in activity between biting in the retruded position with and without investigator control. The activity in the anterior temporal portion did not differ significantly when biting was done in the intercuspal position and in the retruded position. The activity in the posterior temporal portion, however, was higher ($P < 0.001$), and in the masseter muscle lower ($0.001 < P < 0.01$) during biting in the retruded position (Table II). The distribution of muscle activity during maximal bite was thus different in the retruded position and in the intercuspal position.

TABLE II

Median and range, in μV, for the mean voltage amplitude during maximal bite in the intercuspal position (IP) and in the retruded position (RP) of the mandible with and without stabilization of the mandible by the investigator. n = 12 in each group.

	Anterior temporal		Posterior temporal		Masseter	
Maximal bite in IP	Median	Range	Median	Range	Median	Range
Dual bite	141.5	14-269	49.5	2-244	117.0	60-204
Control group	195.0	99-320	102.5	76-344	122.0	35-275
Sig. diff.	—		—		—	
Maximal bite in RP						
Dual bite	183.3	112-345	126.0	61-317	47.8	8-146
Maximal bite in RP with investigator control						
Dual bite	181.0	133-323	130.3	73-239	35.0	5-168

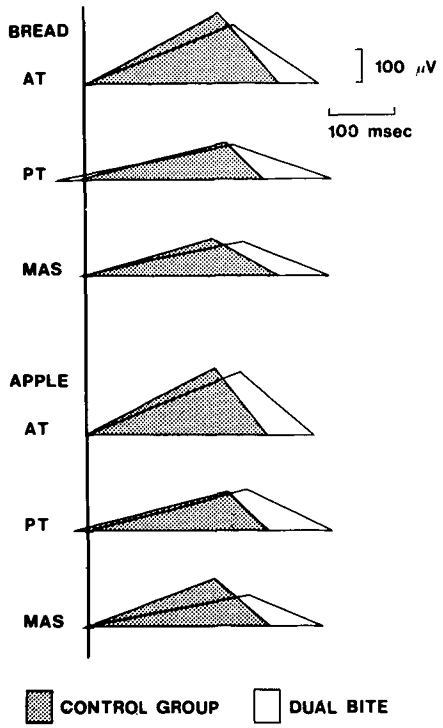

Fig. 1 Average mean voltage activity during the closing phase of the chewing cycle. Chewing of bread and apple. The vertical line denotes onset of activity in the anterior temporal muscle. Note longer duration of activity in the dual bite group.

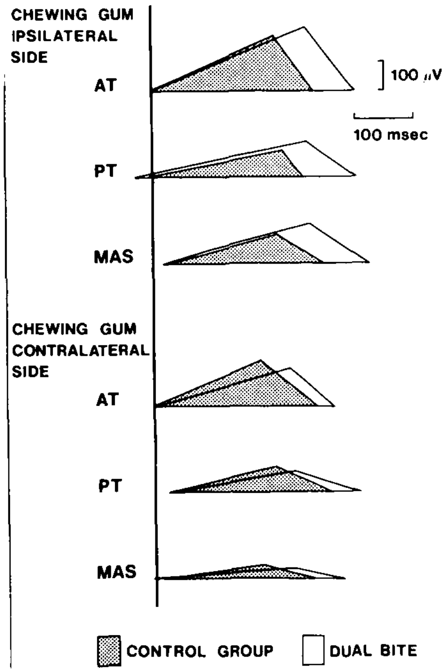

Fig. 2 Average mean voltage activity during the closing phase of the chewing cycle. Unilateral chewing of gum.

Chewing activity

There was no significant difference between the group with dual bite and the control group in the number of chewing cycles used to triturate bread or apple or in the duration of the act of chewing.

There was no significant difference between the two groups in amplitude during chewing for any of the test media.

The distribution of amplitude between the three muscles was the same in both groups during chewing of bread and apple and on the ipsilateral side during gumchewing, i.e., the amplitude was significantly higher in the anterior temporal portion than in the other two muscles while there was no difference between the posterior temporal portion and the masseter muscle (Figs. 1, 2). The amplitude on the contralateral side during gumchewing differed significantly between all three muscles in the control group while in the dual bite group there was a difference only between the anterior temporal and masseter muscles.

The duration of the muscle activity during chewing was almost always longer in the group with dual bite than in the control group (Table III).

The onset of activity during the closing phase of the chewing cycle in the masseter muscle did not differ significantly between the two groups. The onset of activity in the posterior temporal portion, on the other hand, was earlier in the dual bite group during chewing of bread (Table IV). The same tend-

TABLE III

Median and range, in msec., for duration of muscle activity during the closing phase of the chewing cycle.

	Anterior temporal			Posterior temporal			Masseter		
	n	Median	Range	n	Median	Range	n	Median	Range
Bread									
Dual bite	12	357.5	285-555	10	425.0	300-625	12	382.5	280-595
Control group	12	297.5	250-355	12	285.0	190-365	12	295.0	235-370
Sig. diff.		*			**			**	
Apple									
Dual bite	12	345.0	280-650	9	375.0	250-585	12	370.0	275-650
Control group	12	280.0	240-360	12	300.0	220-345	12	280.0	220-320
Sig. diff.		**			*			**	
Chewing gum Ipsilateral side									
Dual bite	12	352.5	235-710	10	380.0	325-660	12	350.0	230-620
Control group	12	275.0	240-400	12	265.0	205-405	12	267.5	215-345
Sig. diff.		*			**			**	
Chewing gum Contralateral side									
Dual bite	12	310.0	230-740	10	320.0	215-770	12	327.5	270-625
Control group	12	282.5	260-365	12	277.5	240-330	12	252.5	200-410
Sig. diff.		—			—			**	

* = $0.01 < P < 0.05$,
** = $0.001 < P < 0.01$

TABLE IV

Median and range, in msec., for onset of activity in the posterior temporal muscle and in the masseter muscle during the closing phase of the chewing cycle in relation to the onset of activity in the right anterior temporal muscle (reference muscle). A minus sign denotes earlier onset of activity in the test muscle than in the reference muscle.

	Posterior temporal			Masseter		
	n	Median	Range	n	Median	Range
Bread						
Dual bite	10	—47.3	—136-+26	12	— 8.3	— 86-+47
Control group	11	— 7.0	— 53-+53	12	2.3	— 53-+67
Sig. diff.		*			—	
Apple						
Dual bite	9	— 1.5	—140-+31	12	— 9.2	— 73-+20
Control group	12	—21.3	— 45-+70	12	0.0	— 62-+32
Sig. diff.		—			—	
Chewing gum Ipsilateral side						
Dual bite	10	—26.8	—118-+32	12	19.5	— 46-+75
Control group	12	— 5.8	—104-+43	12	26.8	— 47-+46
Sig. diff.		—			—	
Chewing gum Contralateral side						
Dual bite	10	34.0	—138-+81	12	— 4.3	—132-+88
Control group	12	23.8	+ 3-+86	12	17.3	— 63-+55
Sig. diff.		—			—	

* = $0.01 < P < 0.05$

TABLE V

Median and range, in msec., for time to maximal mean voltage amplitude during the closing phase of the chewing cycle in the posterior temporal muscle and in the masseter muscle in relation to the maximal mean voltage amplitude in the right anterior temporal muscle (reference muscle). A minus sign denotes earlier maximal mean voltage amplitude in the test muscle than in the reference muscle. n = 12 in each group.

	Posterior temporal		Masseter	
	Median	Range	Median	Range
Bread				
Dual bite	— 4.8	—93-+68	8.3	—86-+38
Control group	11.5	— 8-+25	—10.8	—42-+13
Sig. diff.	—		—	
Apple				
Dual bite	7.8	—83-+68	8.0	—29-+59
Control group	16.0	—12-+40	— 1.5	—44-+11
Sig. diff.	—		—	
Chewing gum Ipsilateral side				
Dual bite	0.8	—31-+19	7.3	—34-+36
Control group	12.8	— 7-+38	1.8	— 8-+15
Sig. diff.	*		—	
Chewing gum Contralateral side				
Dual bite	7.3	—20-+36	0.0	—142-+66
Control group	23.3	— 9-+43	0.3	—86-+22
Sig. diff.	—		—	

* = $0.01 < P < 0.05$

ency, though not significant, was found on the ipsilateral side during gumchewing.

The maximal mean voltage amplitude during chewing in the posterior temporal muscle also occurred earlier in the dual bite group than in the control group (Table V). The difference was significant only on the ipsilateral side during gumchewing, however.

Swallowing activity

There was no significant difference between the dual bite group and the control group in amplitude during swallowing of bread and apple (Table VI). During swallowing of water, however, the amplitude in the temporal muscle was smaller in the dual bite group.

The duration of the activity during swallowing of bread did not differ significantly between the two groups for any of the muscles. During swallowing of apple and water the duration of the masseter activity was longer in the dual bite group than in the control group ($0.01 < P < 0.05$).

Correlation between muscle activity and relationship between retruded and intercuspal positions

Results from the clinical and radiographic examination of the subjects with dual bite were correlated with the findings from the EMG examination. The following clinical and radiographic variables were used: 1) number of maxillary teeth in occlusion in the retruded and in the intercuspal positions, respectively, 2) the anteroposterior, transverse and vertical differences between the retruded and intercuspal positions as measured at the infradentale in a gnathothesiometer, and 3) the anteroposterior and vertical differences in positions of the mandibular condyles in the retruded and intercuspal positions

TABLE VI

Median and range, in μV, of the maximal mean voltage amplitude during swallowing. n = 12 in each group.

	Anterior temporal		Posterior temporal		Masseter	
	Median	Range	Median	Range	Median	Range
Water						
Dual bite	3.5	0-30	18.5	2-53	6.5	1-41
Control group	14.8	4-134	29.8	16-92	10.8	2-57
Sig. diff.	*		*		—	
Bread						
Dual bite	84.0	10-274	53.5	15-176	39.5	8-168
Control group	131.5	16-338	71.0	19-212	62.8	18-173
Sig. diff.	—		—		—	
Apple						
Dual bite	78.5	0-262	54.0	0-229	31.8	4-193
Control group	109.5	23-327	64.0	19-216	50.3	13-204
Sig. diff.	—		—		—	

* = $0.01 < P < 0.05$

as measured on profile radiographs.

The number of teeth in occlusion in the intercuspal position was not significantly correlated with any of the EMG variables. The number of teeth in occlusion in the retruded position was negatively correlated to the duration of the act of chewing apple (Rho —0.74, $0.01 < P < 0.05$) but positively to the amplitude in the masseter muscle during biting in the retruded position with investigator control (Rho 0.73, $0.01 < P < 0.05$) and in the posterior temporal muscle on the contralateral side during gumchewing (Rho 0.68, $0.01 < P < 0.05$). Subjects with many teeth in occlusion therefore had a short chewing time and strong masseter activity during maximal bite.

The *anteroposterior difference* at the infradentale between the retruded and intercuspal positions was negatively correlated with the onset of activity in the posterior temporal muscle during chewing of bread (Rho —0.71, $0.01 < P < 0.05$). The *anteroposterior differences* in positions of the condyles were negatively correlated to the onset of activity in the posterior temporal muscle during chewing of bread (Rho —0.73, $0.01 < P < 0.05$) and, on the ipsilateral side during gumchewing (Rho —0.76, $0.01 < P < 0.05$). The same tendency was found for the posterior temporal muscle during chewing of apple (Rho —0.66, $0.05 < P < 0.10$). A large anteroposterior difference was therefore associated with an early onset of activity in the posterior temporal muscle during chewing.

The *vertical difference* at the infradentale was correlated with the duration of masseter amplitude during swallowing of bread (Rho 0.68, $0.01 < P < 0.05$) and the masseter amplitude on the contralateral side during gumchewing (Rho 0.60, $0.01 < P < 0.05$).

The *vertical difference* in condylar position was correlated with: postural activity in the anterior temporal muscle (Rho 0.70, $0.01 < P < 0.05$), the duration of activity in the posterior temporal muscle during chewing of apple (Rho 0.69, $0.01 < P < 0.05$), the duration of contralateral activity in the anterior temporal muscle during gumchewing (Rho —0.60, $0.01 < P < 0.05$), the duration of ipsilateral masseter activity during gumchewing (Rho —0.70, $0.01 < P < 0.05$), and the duration of posterior temporal and masseter activity during swallowing of apple (Rho —0.74 and

—0.63, respectively, $0.01 < P < 0.05$).

A *lateral difference* at the infradentale was negatively correlated with the duration in all three muscles during chewing of bread (Rho —0.81 to —0.86, $0.001 < P < 0.01$) and with the duration in the anterior temporal muscle during chewing of apple (Rho —0.71, $0.01 < P < 0.05$), but positively with the amplitude of the anterior temporal and masseter muscles during biting in the retruded position (Rho 0.78, $0.001 < P < 0.01$, and 0.68, $0.01 < P < 0.05$, respectively).

Discussion

The subjects with dual bite seem to be characterized by low postural activity in both portions of the temporal muscle. This is evident both from comparison with the present control group and with other studies in which the same or similar methods have been used.[3,11] The low postural activity of the temporal muscle may possibly be interpreted as indicating a protruded postural position of the mandible, which has been shown to be typical for subjects with a large overjet.[6]

The activity in the anterior temporal muscle was about the same during maximal bite in the intercuspal and retruded positions of the mandible. In the posterior temporal and in the masseter muscles, on the other hand, the activity varied with the position. In comparison with the results of other studies[3,9,10] the activity of the masseter muscle was normal during biting in the intercuspal position but too low in the retruded position. The posterior temporal muscle, on the other hand, showed normal activity during biting in the retruded position but too low activity in the intercuspal position. Judging from the activity during maximal bite, therefore, neither of the two positions is optimal, i.e., neither position gives normal and maximal activity in all three muscles simultaneously. The intercuspal position seems to be a slightly protruded position as judged from the marked drop in activity of the posterior temporal muscle, while the retruded mandibular position seems to be too posterior for maximal activity of the masseter muscle.

The amplitude during chewing did not differ between the two groups and was the same in the present investigation as in other studies using the same or similar methods.[2,8,9,10] The amplitude during chewing thus seems to be normal in the subjects with dual bite. The duration of activity during chewing, however, was longer in the dual bite group than in the controls and also in comparison with other series.[13] This may be due to the instability of the occlusion in the subjects with dual bite or to a different pattern of mandibular movement. In subjects treated surgically for correction of mandibular prognathism, the duration of the muscle activity during chewing was abnormally long after the operation but subsequently improved, possibly as a result of grinding procedures to improve the occlusion.[12] Children with cuspal interference in the retruded position and a lateral crossbite had a longer duration of muscle activity during chewing than children with normal occlusion.[10]

That the pattern of movement of the mandible during chewing is different in the dual bite than in the control group is strongly indicated by the early onset of activity in the posterior temporal muscle in the dual bite group. As has been described by Möller,[14] the mandible on the chewing side is retruded in the first stage of the closing phase of the chewing cycle and subsequently slides forward from a retruded position into the intercuspal. The early onset of activity in the posterior temporal muscle in the dual bite group is compatible with this description of the movement of the mandible. If the distance between the retruded and intercuspal positions is large, as is the case in the subjects with dual bite, then the muscle responsible for retrusion, the posterior temporal portion, must start to contract early. The correlations found between the RP-IP distance and the onset of activity in the posterior temporal muscle are perfectly compatible with this line of reasoning.

The results strongly suggest that the retruded position of the mandible is used during chewing also in subjects with dual bite, thereby corroborating the findings of Schweitzer[15] in his kinesiological studies of mastication in individuals with dual bite. The importance of the retruded position during chewing is further demonstrated by the correlation found between the number of teeth in occlusion in the retruded position and the duration of the act of chewing. A similar correlation for the number of teeth in occlusion in the intercuspal position was lacking.

The amplitude during swallowing of bread and apple was normal in comparison with the control group and other series.[8] During swallowing of water, however, the amplitude was smaller in the dual bite group. This may indicate that the subjects with dual bite swallowed water without tooth contact, since such swallowing has been found to be associated with less muscle activity than swallowing with tooth contact.[13] The reason for swallowing water without tooth contact may be unstable occlusion in line with what was suspected in a series of patients with crossbite and deduced from their muscle activity.[10]

The duration of the muscle activity during swallowing of apple and water was longer in the dual bite group. In analogy with the long duration during chewing this may be a sign of unstable occlusion. Many variables measuring the duration during chewing and swallowing were correlated with the vertical and lateral relation between the retruded and intercuspal positions. This again indicates that the duration of muscle activity is a more sensitive index of muscle function than the amplitude. Duration thus seems to be a sensitive and necessary variable for describing muscle function during chewing and swallowing. This supports the recommendation given by Garnick,[5] based on methodological studies.

The activity during maximal bite did not favour either the intercuspal or the retruded position of the mandible as being the optimal, "correct" position in the subjects with dual bite. Neither of the two positions showed harmonious muscle activity. In the patients with dual bite the retruded position was used during chewing. Treatment should therefore probably be directed toward establishing stable occlusion in or close to the retruded position of the mandible.

Summary

The activity of the anterior and posterior portions of the temporal muscle and of the masseter muscle was studied by electromyography in twelve subjects with dual bite (aged 11-60 years) and in twelve controls.

The muscle activity was recorded in the postural position of the mandible, during maximal bite in the intercuspal and retruded mandibular positions, during chewing and swallowing of bread and apple, during chewing gum and swallowing of water.

The subjects with dual bite had low postural activity of the temporal muscle possibly indicating a protruded postural position of the mandible.

The activity of the posterior temporal muscle was low during maximal bite in the intercuspal position and the same was true for the masseter activity

during biting in the retruded position. Neither of the two mandibular positions examined gave a balanced activity during maximal bite in all three muscles examined.

The duration of the muscle activity in the individual chewing cycles was longer in the subjects with dual bite than in the controls. This was interpreted as being due to instability of the occlusion. The pattern of muscle activity during chewing indicated that the retruded mandibular position was used during chewing. It is therefore probably functionally beneficial to create a stable occlusion in the retruded mandibular position.

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