

# Comparisons of chewing patterns in patients with bridges supported on osseointegrated implants and subjects with natural dentitions

Torgny Haraldson

Departments of Anatomy and Stomatognathic Physiology,  
University of Gothenburg, Gothenburg, Sweden

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The masticatory muscle activity during chewing was studied by means of electromyography (EMG) in 13 women treated with bridges supported on osseointegrated implants and compared with that in 10 dentate control subjects. The factors studied were the changes of the maximal mean voltage amplitude and the duration and coordination of activity during chewing of peanuts, bread, and apple when comparing the first three with the last three out of ten randomly selected chewing cycles. Patients with implant-supported bridges chewed with approximately the same muscle activity during the whole chewing sequence, whereas the control subjects had a reduced activity at the end of the chewing act. □ *Chewing pattern; oral implants; electromyography; mastication; receptors*

T. Haraldson, Department of Stomatognathic Physiology, Faculty of Odontology, University of Göteborg, Box 33070, S-400 33 Göteborg, Sweden

When electromyographic (EMG) recordings are made of masticatory muscle activity during chewing, the direct impression from the EMG is that the muscle work, as reflected by the electrical activity, decreases at the end of a chewing sequence. However, there is little information in the literature analyzing this condition. In a recent study (6) it was shown that the initial chewing force is related to the consistency of the food and that it increases during chewing. In contrast, it would seem logical if the need for muscle work decreased at the end of a chewing sequence, when the food is more comminuted, and the saliva has made it softer.

Analysis of possible changes during a chewing sequence may also be a test of the neurophysiological capacity of the chewing apparatus to fulfill new functional demands. In earlier studies of masticatory function by means of e.g. EMG, bite force registrations, and chewing efficiency recordings, patients with osseointegrated oral implant bridges (7–10) were claimed to have a masticatory functional capacity equal to or approaching that of patients with a natural but reduced dentition.

The purpose of this study was to analyze by means of EMG changes in the chewing pattern during a chewing sequence, in patients with oral bridges supported on osseointegrated implants (3). Comparisons were made with individuals with a natural dentition of practically the same extent.

## Materials and methods

### *Subjects*

The subjects consisted of 13 women with oral implant bridges (OIB) and 10 women serving as controls. The age of the women with OIB ranged between 42 and 59 years (median age, 56 years). Four women had OIB in both jaws, five in the maxilla, and four in the mandible only. The women with OIB in one jaw had natural teeth or a fixed bridge supported on natural teeth in the other jaw.

The age of the control subjects ranged between 42 and 64 years, with a median age of 56 years. They had either their own teeth or one or more fixed bridges and were

selected with regard to age and the extension of the dentition.

A detailed description of both groups, including oral status, symptoms of mandibular dysfunction, bite force, and muscle activity in the postural position, during biting and during chewing, has been given earlier (9, 10).

### Electromyography

EMG recordings were made with a DISA electromyograph with direct and mean voltage channels connected to a Mingograph writer. Activity was led off bilaterally from the anterior and posterior portions of the temporal muscle and the masseter muscle with bipolar hook electrodes, as described by Haraldson et al. (9). Recordings were made with the mandible in the postural position, during biting and during chewing and swallowing of peanuts, apple, and bread.

From ten randomly selected chewing cycles the first three cycles were compared with the last three. The factors analyzed were

as follows:

1. the maximal mean voltage amplitude,
2. the duration of activity during the closing phase of the chewing cycle, and
3. the onset of activity and time for maximal mean voltage amplitude during the closing phase of the chewing cycle in the posterior portion of the temporal muscle and in the masseter muscle in relation to the corresponding values in the anterior portion of the right temporal muscle.

Since only four direct channels were available, the recordings had to be made twice, each time with the anterior portion of the right temporal muscle as the reference muscle (16).

### Statistics

The recordings on the right and left sides were pooled. Differences between distributions were tested with nonparametric statistical methods and paired Wilcoxon and rank sum tests (19). The level of statistical significance used was  $p < 0.05$ .

Table 1. Median and range of maximal mean voltage amplitude (in  $\mu\text{V}$ ) during the closing phase of the first and last three chewing cycles

Muscle	First three cycles				Last three cycles			
	OIB group		Control group		OIB group		Control group	
	Median	Range	Median	Range	Median	Range	Median	Range
Peanuts								
Ant temporal	142	84-263	182	34-241	141	84-281	135	36-209
Masseter	65	28-113	70	31-138	55	33-117	50	28-113
Post temporal	94	67-143	120	16-165	101	66-145	79	14-146
Apple								
Ant temporal	131	79-245	124	31-265	131	82-268	115	28-257
Masseter	65	32-120	63	31-139	50	27-123	52	27-107
Post temporal	87	59-108	78	19-158	77	54-128	81	18-158
Bread								
Ant temporal	123	78-218	132	89-256	94	82-196	81	24-173
Masseter	53	25-120	66	32-110	36	19-115	43	26-66
Post temporal	90	59-142	89	16-133	83	52-163	79	14-99

## Results

### *Amplitudes during chewing*

The amplitudes during chewing (Table 1) did not differ significantly between the groups for any of the tested muscles, either at the beginning or at the end of the tested chewing sequences.

The differences between the first three and the last three cycles showed different patterns in the two groups. The amplitudes were usually lower in the last three cycles, and the decrease was most pronounced in the control group. These differences were statistically significant for the controls in all muscles tested except for the posterior part of the temporal muscle when chewing apple. No statistically significant changes were found in the OIB group.

The order of activity between the different muscles was identical in the two groups; the highest amplitudes were found in the anterior portion of the temporal muscle and the lowest in the masseter muscle during chewing of all three test foods.

### *Duration of activity*

Duration of activity (Table 2) lasted sig-

nificantly longer in the OIB group than in the control group for all muscles tested with all three test foods and for the first three and for the last three chewing strokes.

The order of the durations of activity between the test muscles during chewing of apple and bread were practically the same in both groups. Only during chewing of apple did the test group have the same duration of activity in the masseter as in the posterior part of the temporal muscle during the last three chewing strokes. During chewing of peanuts there was also a difference in the order of activity regarding the masseter muscle and the posterior part of the temporal muscle of the test group when the first three cycles were compared with the last three.

In two comparisons there were statistically significant differences between the two groups with regard to *time for maximal mean voltage amplitude*: first, in the masseter muscle in the first three chewing cycles during chewing of apple, when the peak of activity took place earlier in the OIB group, and, second, in the posterior part of the temporal muscle, but only during the last three cycles during chewing of apple, when the peak of activity occurred earlier in the OIB group.

Table 2. Median and range of duration of the EMG activity (in msec) during the closing phase of the first three and last three chewing cycles

Muscle	First three cycles				Last three cycles			
	OIB group		Control group		OIB group		Control group	
	Median	Range	Median	Range	Median	Range	Median	Range
<b>Peanuts</b>								
Ant temporal	383	300-635	330	252-406	379	290-581	303	202-356
Masseter	431	180-982	347	155-960	432	202-832	317	105-782
Post temporal	446	155-887	346	232-901	416	251-861	315	180-787
<b>Apple</b>								
Ant temporal	387	313-645	328	246-390	376	269-601	283	250-400
Masseter	429	162-832	334	128-632	446	228-1080	330	150-590
Post temporal	449	188-1032	336	115-701	446	203-932	341	203-532
<b>Bread</b>								
Ant temporal	420	320-560	345	287-378	390	300-580	311	261-356
Masseter	507	290-1210	378	85-711	473	256-820	367	128-632
Post temporal	471	236-936	348	215-635	415	218-681	335	138-529

Table 3. Changes of the maximal mean voltage amplitudes and the durations of the EMG activity when the first three and last three cycles are compared. Values for last three cycles expressed in percentage of first three

Muscle	Test group		Control group	
	Amplitude	Duration	Amplitude	Duration
Peanuts				
Ant				
temporal	100	99	75	92
Masseter	85	100	73	91
Post				
temporal	107	93	66	91
Apple				
Ant				
temporal	100	97	93	86
Masseter	78	104	82	99
Post				
temporal	88	99	104	101
Bread				
Ant				
temporal	77	93	61	90
Masseter	68	93	65	97
Post				
temporal	93	88	88	96

The *start of activity* in the masseter muscle was significantly earlier in the OIB subjects than in the controls when chewing peanuts during the first three cycles.

In addition (Table 3), the changes, mostly reductions, were most pronounced for the calculated amplitudes, whereas the duration of EMG activity was more constant during chewing. The greatest change was found in the control group in the anterior part of the temporal muscle during chewing of bread, when the amplitude decreased in the last three cycles to 61% of the amplitude measured in the first three cycles.

## Discussion

When the first three chewing cycles were compared with the last three cycles, the amplitudes decreased most in the control group. The changes were statistically significant for all muscles tested except for the posterior part of the temporal muscle during chewing of apple. That the amplitudes decreased less in the OIB group could be the effect of a reduced chewing efficiency,

but in an earlier study it was shown that these two groups have a similar chewing efficiency (8). Another possible explanation is that the OIB subjects' chewing pattern results in a higher activity in the elevator muscles throughout the chewing sequence. Nearly all the OIB subjects had worn dentures for a long time, in some cases for 20 years or more. The implant-supported bridges had been worn for a much shorter time—0.5–5.5 years—a period that may be too short to change their earlier denture chewing pattern. The adaptation period after surgical corrections of jaw deformities has been shown to be longer than 6 months (2). Furthermore, some individuals never seem to change their original chewing pattern (4).

The oral tactile sensibility is markedly reduced during chewing compared with conscious biting (18). It may be that patients with implant-supported bridges have a reduced oral tactile sensibility, resulting in a chewing pattern with approximately the same muscle activity during the whole chewing sequence. This reduction could be a result of the reduction or complete lack of periodontal receptors in the OIB group. In

recent studies (5, 11, 14, 15) the importance of other receptors, above all the muscle spindles, in controlling jaw movements has been emphasized. In the study by Fenton & Lundqvist (5) of patients with osseointegrated implant bridges, the occlusal perception was found to be at the same level in the OIB patients as in the subjects with a natural dentition. There might, however, be a difference in occlusal perception in a test situation and in natural chewing.

The duration of EMG activity was for all comparisons longer in the OIB group than among the controls. The decrease from the first three to the last three cycles was more pronounced in the control group. This relationship may also be caused by earlier complete denture wearing of long duration (13).

The findings by Gibbs et al. (6) that the closing forces for hard and soft food at the end of chewing series are nearly equal are partly supported in the present study. The calculated amplitudes for most muscles at the last three cycles are close to those of the first. In the control group the amplitude for the anterior part of the temporal muscle during the last three chewing cycles during chewing of peanuts is, however, higher than in any other muscle except for the same muscle during the first three cycles. These authors (6) also found that the maximal force during pause at IP increased throughout chewing series, from the first chew to swallowing, for hard as well as for soft food. These findings are in contradiction to the present results, in which the muscle activity, as reflected by the mean voltage amplitude, decreased for most muscles tested at the end of the chewing sequence. The suggestion by Gibbs et al. (6) that increase in the force during chewing series appears inherent in the neuromuscular system is thus not supported by the present results.

It is, however, still uncertain to what extent the calculated EMG amplitudes during chewing reflect the forces exerted. That EMG can be used as an indicator of the chewing force during the occlusal phase has been proposed earlier (1). Furthermore, the relationship between EMG and clenching force has been found to be linear up to approximately 80% of the maximal clenching (12).

That the patients with implant-supported bridges have been restored to a functional level corresponding to that in patients with a natural but reduced dentition for most of the functional variables has been shown beyond doubt (5, 8–10). However, the results from this study indicate that the neurophysiological feedback mechanisms during chewing differ between the tested groups. Perhaps a special training program is necessary for the masticatory system and/or individualized bridge design, e.g. soft chewing surfaces, for patients who receive an OIB, especially when they have worn dentures for a long time. Individualized training programs are common in connection with physical therapy during rehabilitation in other branches of medicine (17). As has been said earlier (10), the transition from removable dentures to bridges supported by osseointegrated implants represents a unique change. New functional studies will therefore be undertaken when the implant-supported bridges have been worn for another 2–3 years.

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