

Occlusal perception and bite force in young subjects with and without dental fillings

Thorvald Kampe, Torgny Haraldson, Helge Hannerz and Gunnar E. Carlsson

Department of Stomatognathic Physiology, Faculty of Odontology, University of Gothenburg, Gothenburg, and Kopparberg County Dental Service Department, Falun, Sweden

Kampe T, Haraldson T, Hannerz H, Carlsson GE. Occlusal perception and bite force in young subjects with and without dental fillings. *Acta Odontol Scand* 1987;45:101-107. Oslo. ISSN 0001-6357.

Interocclusal thickness discrimination (occlusal perception) and bite force was investigated in 29 young adults (16-18 years old). Thirteen individuals had intact dentitions (group I), whereas 16 individuals had minor restorations in posterior teeth (group C). Bite force was tested during 'gentle biting', 'biting as when chewing', and 'maximal clenching'. Endurance tests and bite force discrimination tests were also performed. The best occlusal perception was found in the incisor region in both groups, whereas the occlusal perception was somewhat smaller in the canine and premolar regions. Fifty-four per cent of the subjects in group I and 81% in group C reached certain perceptiveness at the 9- μ m level. There were no statistically significant differences between test locations or groups, however. Group I had a significantly greater bite force in the incisor region during gentle biting than group C. The maximal bite force was on an average 532 N in group I and 516 N in group C. In the endurance tests, group I could withstand the muscle fatigue longer than group C, but the difference was not statistically significant. In the bite force discrimination test both groups showed a similar pattern. Group I showed a closer correlation than group C between recordings in a test of stepwise increase of force and a randomized test of five force levels. Both groups appeared functionally normal in the masticatory system and reacted similarly in the physiologic experiments. However, considering the low age of the subjects in this study, the small samples, and the fact that the subjects in group C had few and usually only small fillings in the posterior teeth, the differences found in this study were discussed in relation to the hypothesis that dental filling therapy may disturb the masticatory system. The findings gave some support for such a hypothesis but more studies on larger materials with more restored teeth would be necessary to achieve more conclusive results. □ *Bite force; dental fillings; mandibular dysfunction; tooth physiology*

Thorvald Kampe, Gnejsvägen 15, S-183 30 Täby, Sweden

The etiology of TMJ dysfunction is now widely held to be multifactorial and complex (1-3). More knowledge about etiologic factors is, however, always essential, as new findings should lead to a better understanding of the cause and development of dysfunction and its therapy.

Pathologic attrition is distinguished by its asymmetrical appearance (4) and may be a consequence of bruxism, especially tooth grinding (5). Dental filling therapy has recently been discussed by Kampe et al. (6-8) as an etiologic factor in occlusal parafunction, such as tooth grinding and/or clenching. Their findings suggest that dental filling therapy can induce changes in the neuromuscular pattern of the masticatory system.

The aims of this study were to analyze measurements of occlusal perception and bite force in subjects with and without dental fillings and to follow up anamnestic and clinical examinations with regard to mandibular dysfunction after 3 years. This paper will concentrate on occlusal perception and bite force.

Materials and methods

Subjects

The material included 29 individuals aged 16-18 years, divided into 2 groups. Group I consisted of 13 subjects with intact dentitions, whereas group C comprised 16 indi-

viduals with mostly minor restorations in posterior teeth. The subjects were first examined at an average age of 14 years, and the results have been described in detail (6, 7). After 3 years, a follow-up study was carried out, using the same methods, with a questionnaire and a clinical examination especially designed for studying symptoms and signs of mandibular dysfunction and details of occlusion. The results of the longitudinal parts of the study are presented separately (9). The tactile sensibility and bite force registrations are described in this paper.

Tactile sensibility

The occlusal perception of thickness was tested by using factory-produced aluminum foils measuring 3×3 mm in thicknesses of 9, 20, and 50 μm . With an 8- μm -thick articulating foil, the occlusal contacts were detected in the region of 45/15 and 43/13 and in the incisor area. A foil was then placed over the contact, and the subject was asked whether he or she felt the test foil. Tests with and without foil were performed in random order.

The results were classified as follows: 5 or less correct answers out of 10 = no perceptiveness; 6–8 correct answers = uncertain perceptiveness; and 9 or 10 correct answers = certain perceptiveness. The tests were continued until certain perceptiveness was reached in each test region. The performance of the test is described in detail elsewhere (10). The method is a modification of that described by Siirilä & Laine (11).

Bite force registrations

The bite force was recorded with equipment described and used earlier (12). The apparatus consisted of a bite fork connected to a recorder and a calculator. The bite force was recorded in the first molar areas bilaterally and in the incisor region at two force levels: gentle biting and biting as when chewing. The maximal bite force was recorded in the subjectively best biting position.

Discrimination between different force levels was tested in the following manner: first, the subjects were informed that the purpose was to divide their bite force into five equal steps, from gentle biting (step 1) to maximal bite force (step 5). In a first test (A) the subjects were then asked to bite with increasing force at these five levels from gentle up to maximal bite force in the incisor region. In a second registration the five force levels were recorded in random order.

The bite force test concluded with an endurance test at 50% of the maximal bite force in the right molar region. The time of endurance was measured in seconds. The area below the endurance force curve was measured with a planimeter. This area (Fig. 1) has been suggested to be a measure of the muscular work during the endurance test (13). The force meter was also used to test the maximal force between the thumb and

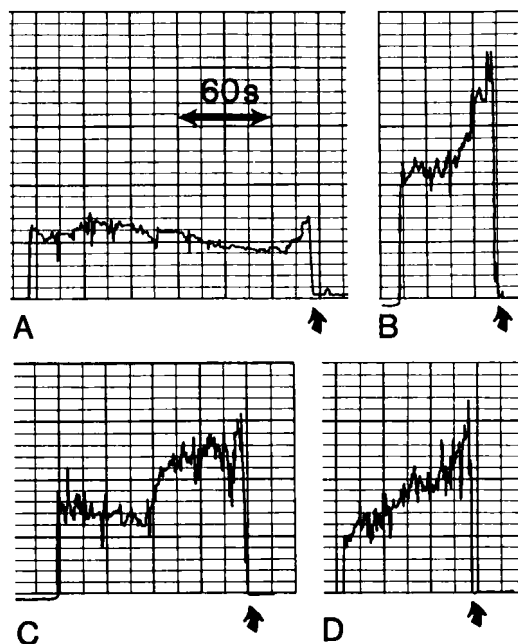


Fig. 1. Examples of recordings of endurance of biting at 50% of maximal force without visual feedback. Arrows indicate the start of the recording. The typical recordings showed a gradual reduction of force, as in B, C, and D. A fairly constant force as in A was rare, and only in one case was there a gradual increase of force. The area between the base line and the recording was measured with a planimeter: A = 780, B = 680, C = 910, and D = 585 mm^2 .

Table 1. Occlusal perception. Figures denote number of subjects with different test thresholds of tactile sensibility in 13 subjects with intact (I) and 16 controls (C) with restored dentitions in different test positions. MD = missing data

	1st premolar region		Canine region		Incisor region	
	I	C	I	C	I	C
9 µm	4	1	5	7	7	13
20 µm	4	8	5	6	3	3
50 µm	3	2	2	2	3	0
n	11	11	12	15	13	16
MD	2	5	1	1	0	0

the forefinger of each hand as described previously (14, 15).

Statistical methods

Differences between distributions were tested with Student's *t* test and Mann-Whitney's U-test (16) or Pitman's permutation test (17). Correlations were analyzed by means of linear correlation (Pearson's *r*) and Spearman's rank correlation test.

Table 2. Bite force. Means (\bar{x}) and standard deviations (SD) of measurements in newtons (N) at 3 force levels in 2 test positions in 13 subjects with intact (I) and 16 controls (C) with restored dentitions. Maximal finger force values are given for comparison

	Gentle biting				Biting as when chewing			
	1st molar region		Incisor region		1st molar region		Incisor region	
	I	C	I	C	I	C	I	C
\bar{x}	19	11	11	5	147	162	65	68
SD	19	12	14	4	127	117	58	39

	Maximal bite force (most comfortable position)		Finger force			
	I	C	Right hand		Left hand	
			I	C	I	C
\bar{x}	532	516	81	69	65	67
SD	189	151	21	23	11	21

Results

Occlusal tactile sensibility

The occlusal perception increased from the more posterior test position to the anterior one (Table 1). The best tactile sensibility was found in the incisor region, where group C had a tendency to better values ($p = 0.05$). Otherwise, there were no statistically significant differences between the groups or test regions. Two-thirds of the subjects (54% and 81% in groups I and C, respectively) reached certain perceptiveness at the 9-µm level in the incisor region, whereas most subjects reached the level of certain perceptiveness at 20 µm in the other test positions. The test of the incisor tactile sensibility had to be performed in an edge-to-edge position in 4 of the intact subjects and in 13 of the controls, owing to incomplete contact in the intercuspal position (IP). At 9 out of 49 test occasions no test could be performed in the more posterior positions because of unacceptable test conditions. They were recorded as missing data (MD in Table 1).

Bite force

The bite force results are presented in Table 2. Bite force was greater in the molar than in the incisor region for both tested submaximal levels. The best biting position selected for the maximal force registration was usually the molar region. During biting, as when chewing, the force exerted in the incisor region was on an average 43% compared with the molar values. A statistically significant difference between the groups was found in the incisor region during gentle biting: group C had lower values than group I ($p < 0.05$). At all force levels tested the registrations differed widely among the subjects, as is shown by the large standard deviations. The maximal finger force was similar to biting as when chewing in the incisor region.

Bite force discrimination tests

The results from the bite force discrimination tests are given in Table 3. There was a stepwise increase of the recorded bite

Table 3. Bite force discrimination. Means (\bar{x}) and standard deviation (SD) of bite force measurements in newtons (N) in accordance with a 5-point scale (1 = gentle; 5 = very strong force) in two tests, A and B. Linear correlations between the two tests are also given. Group I = 13 subjects with intact dentitions; group C = 16 subjects with restored dentitions

Group		Bite force level					Test	
		1	2	3	4	5		
I	\bar{x}	49.9	98.3	135.8	210.1	465.9	A. Continuous increase of force	
	SD	83.5	125.0	131.2	147.9	174.9		
C	\bar{x}	28.9	78.3	185.8	267.5	475.3		
	SD	32.7	64.0	114.4	132.0	159.3		
I	\bar{x}	76.5	144.0	174.0	300.7	498.5		B. Randomized test of force levels
	SD	93.0	116.5	155.2	176.8	196.7		
C	\bar{x}	68.3	142.7	215.9	276.6	455.3		
	SD	52.2	113.3	118.0	158.8	138.9		
I	$r_{A/B}$	0.93***	0.86***	0.94***	0.95***	0.78**		
C	$r_{A/B}$	0.47	0.76***	0.79***	0.73**	0.62**		
I + C	% of level 5	12%	24%	38%	56%	100%		

force in both tests and in both groups. With one exception (group C, maximal level) the recordings were on an average higher in the randomized test than during continuous increase of the force level, but the differences did not reach a significant level. For both tests the difference between level 4 and maximal bite force (level 5) was significantly greater than the other differences in both groups. For a combination of all recordings in both groups the different force levels represented 12%, 24%, 38%, and 56% of the maximal recordings (Table 3). The correlations between the two tests were stronger in the intact groups than in the controls. The difference between the groups was most obvious for level 1, gentle biting.

Endurance test

In both groups, the bite force was significantly reduced at the end of the endurance test compared with the value at the beginning of the test (by 23% in the intact group and 18% in the controls; Table 4). The mean endurance time was longer in the intact group, but the difference between the groups did not reach statistical significance. The exerted forces and the endurance time varied greatly in both groups.

Correlations

The bite force and occlusal perception recordings were correlated to the anamnestic (A_i) and clinical dysfunction (D_i) indices of Helkimo (18) and to reported clicking of the temporomandibular joint (TMJ), as reported elsewhere (9). The maximal forces and endurance test values were in general negatively but not significantly correlated to D_i in both groups. For the combined material the correlation between D_i and the area of the force endurance recording was $r_s = -0.39$ ($p = 0.04$). A significant negative correlation ($r_s = -0.48$; $p = 0.008$) was also found between muscle tenderness and muscle work as reflected by the area of the endurance force recording in the whole material.

Discussion

The purpose of this study was to analyze whether there were any differences in some physiologic factors between subjects with intact dentitions and those with dental fillings. The subjects were part of larger groups previously studied with regard to signs and symptoms of mandibular dysfunction (6, 7). The individuals with intact dentitions had a lower prevalence and degree of dysfunction,

Table 4. Endurance test at 50% of maximal bite force. Means (\bar{x}) and standard deviations (SD) of bite force in newtons (N), area of force recording in mm², and time of endurance in seconds (S) in 13 subjects with intact (I) and 16 controls (C) with restored dentitions

	Force at beginning of test (N)		Force at end of test (N)		Area of force recording (mm ²)		Time of endurance (S)	
	I	C	I	C	I	C	I	C
\bar{x}	263	259	202	213	551	589	81	68
SD	112	92.3	154	115	192	189	44	26

and it was suggested that dental fillings are a possible etiologic factor in mandibular dysfunction. It was proposed that a dental filling could be a subconscious irritation leading to an altered afferent impulse and functional pattern of the masticatory system, including avoidance of contact with the fillings.

The receptors controlling mandibular kinesthesia have been widely discussed in the dental literature (10, 11, 15, 19–24). Joint receptors have been thought to control mandibular kinesthesia and jaw position sense (19, 20), whereas other authors (20, 22) have suggested that mandibular position sense is due to muscle receptors. The sensory-motor mechanism of the jaw, which is responsible for thickness discrimination, is altered by the presence of a myofascial pain-dysfunction condition (24). In this study the controls with repaired dentitions had more signs and symptoms of mandibular dysfunction than the intact group (9), but the occlusal perception was similar in both groups, although there was a tendency to better perception in the controls in the incisor region. The conflicting results of the two studies might be due to different methods or to the fact that there were no subjects with severe dysfunction in this study. In addition, the material was rather small.

The results of the bite force recordings did not show any major differences between the tested groups, but the force was lower in the control group during gentle biting in the incisor region.

The results of the discrimination tests at the different bite force levels showed that

the muscular memory seemed to function better with continuous increase of the force levels than during randomized testing in both groups.

In both groups the values usually decreased slightly during the endurance test in spite of the fact that the selected force level was 50% of maximal force. The controls with more symptoms of mandibular dysfunction, especially more tenderness to muscle palpation (9), reached the time for muscle fatigue earlier than the intact group on average. The negative (but non-significant) correlation between maximal force values and Di in both groups and the significant negative correlation between muscle tenderness and muscle work are in line with a study on bite force in patients with mandibular dysfunction (24). It is of interest in this context that only one subject in group I, compared to eight in group C, was classified as Di II or III (moderate or severe clinical dysfunction).

The results are not conclusive with regard to dental filling therapy as an etiologic factor in mandibular dysfunction. The small differences found for some of the investigated factors between subjects with intact and repaired teeth were not conclusive but might possibly be explained by variations in muscle function. This assumption was verified in a clinical examination of the same group (9), and it was also corroborated in a clinical and psychologic study of a larger sample (8, 25, 26).

Even though the individuals in group C had few and usually only minor occlusal fillings in the posterior teeth, some differences between the groups were found. These dif-

ferences were concentrated to the incisor region, where there was a statistically significant difference concerning gentle biting, with lower values in group C. There were also differences concerning gentle biting in the molar region and bite forces discrimination tests at the same level (1), but they did not reach statistical significance. For interocclusal tactility in the incisor region there was also a tendency to lower values for the subjects in group C. Another difference in the incisor region was that 80% of the individuals in group C, compared with 31% in group I, had to be tested in an edge-to-edge position owing to lack of occlusal contacts in the intercuspal position. These findings together may indicate a higher sensibility in the dentitions among the subjects of group C, especially in the incisor region. Hypothetically, this may be due to adaptive changes caused by the fillings. The masticatory system in a subject with restored dentition might be in a higher state of alertness, with a higher tone in the masticatory muscles and especially in the jaw openers. The finding that the subjects in group C had more muscle tenderness and reached, on an average, the time for muscle fatigue in the endurance test earlier than the subjects of group I is of interest in this context, although the difference was not statistically significant. However, the material in this study was rather small, and more studies on larger material with more restored dentitions would be necessary to test this hypothesis.

Acknowledgements.—This study was supported by grants from the County Council, County of Kopparberg, The Swedish Dental Association, and Dental Practitioners, Inc. (Praktikertjänst AB).

References

- Greene CS, Lerman MD, Satcher HD, Laskin DM. The TMJ pain-dysfunction syndrome: heterogeneity of the patient population. *J Am Dent Assoc* 1969;79:1168–72.
- Rugh JD, Solberg WK. Psychological implications in temporomandibular pain and dysfunction. In: Zarb GA, Carlsson GE, eds. *Temporomandibular joint. Function and dysfunction*. Copenhagen: Munksgaard, 1979;239–68.
- Zarb GA, Speck JE. The treatment of mandibular dysfunction. In: Zarb GA, Carlsson GE, eds. *Temporomandibular joint. Function and dysfunction*. Copenhagen: Munksgaard, 1979;373–96.
- Krogh-Poulsen W. Abrasion og migrasjon. In: Krogh-Poulsen W, Carlsen O, eds. *Bidfunktion/bettfysiologi*. Copenhagen: Munksgaard, 1973;261–72.
- Carlsson GE, Johansson A, Lundqvist S. Occlusal wear. A follow-up study of 18 subjects with extensively worn dentitions. *Acta Odontol Scand* 1985;43:83–90.
- Kampe T, Hannerz H, Ström P. Dental filling therapy as a possible factor regarding mandibular dysfunction. *Acta Odontol Scand* 1983;41:1–9.
- Kampe T, Hannerz H, Ström P. Facet pattern in intact and restored dentitions of young adults. A comparative study. *Acta Odontol Scand* 1984;42:225–33.
- Kampe T, Hannerz H, Ström P. Mandibular dysfunction related to dental filling therapy. A comparative anamnestic and clinical study. *Acta Odontol Scand* 1986;44:113–21.
- Kampe T, Carlsson GE, Hannerz H, Haraldson T. Three-year longitudinal study of mandibular dysfunction in young adults with intact and restored dentitions. *Acta Odontol Scand* 1987;45:25–30.
- Lundqvist S, Haraldson T. Occlusal perception of thickness in patients with bridges on osseointegrated oral implants. *Scand J Dent Res* 1984;92:88–92.
- Siirilä HS, Laine P. The tactile sensibility of the periodontium to slight axial loading of the teeth. *Acta Odontol Scand* 1963;21:415–29.
- Fløystrand F, Kleven E, Øilo G. A novel miniature bite force recorder and its clinical applications. *Acta Odontol Scand* 1982;40:209–14.
- Dahlström L, Haraldson T, Ström D. Endurance tests of the masticatory system on different force levels [Abstract 56]. *Swed Dent J* 1985;9:277.
- Helkimo E, Carlsson GE, Helkimo M. Bite forces and state of dentition. *Acta Odontol Scand* 1977;35:297–303.
- Haraldson T. Functional evaluation of bridges on osseointegrated implants in the edentulous jaw [Thesis]. Gothenburg: Faculty of Odontology, University of Gothenburg, 1979.
- Siegel S. *Nonparametric statistics for behavioral sciences*. New York: McGraw-Hill Book Co., 1956.
- Bradley JW. *Distribution-free statistical tests*. New Jersey: Prentice Hall Inc., 1968;68–86.
- Helkimo M. Studies on function and dysfunction of the masticatory system. II. Index for anamnestic and clinical dysfunction and occlusal state. *Swed Dent J* 1974;67:101–21.
- Thilander B. Innervation of the temporomandibular joint capsule in man. *Trans R Schools Dentistry, Stockholm and Umeå*, No. 7, 1961.
- Ransjö K, Thilander B. Perception of mandibular position sense in cases of temporomandibular joint disorders. *Odontol Tidskr* 1963;71:134–44.
- Christensen LV. Mandibular kinesthesia in fatigue of human jaw muscles. *Scand J Dent Res* 1976;84:320–6.
- Laine P, Siirilä HS. The effect of muscle function in discrimination thickness differences interocclusally

- and the duration of the perceptive memory. *Acta Odontol Scand* 1977;35:147-53.
23. Morimoto T, Kawamura Y. Interdental thickness discrimination and position sense of the mandible. *Oral physiology and occlusion*. New York: Pergamon Press 1978;149-69.
 24. Clark GT, Jacobson R, Beemsterboer PL. Interdental thickness discrimination in myofascial pain dysfunction subjects. *J Oral Rehabil* 1984;11:381-66.
 25. Kampe T, Edman G, Molin C. Personality traits of adolescents with intact and restored dentitions. *Acta Odontol Scand* 1986;44:23-30.
 26. Kampe T, Hannerz H. Functional recording of the masticatory system and malocclusion in adolescents with intact and restored dentitions. A comparative study. *Acta Odontol Scand* 1987;45 (in press).

Received for publication 28 July 1986