· Advances in Medical Sciences · Vol. 53(2) · 2008 · pp 316-320 · DOI: 10.2478/v10039-008-0049-1

The effect of mastication on occlusal parameters in healthy volunteers

Sierpinska T*, Golebiewska M, Lapuc M

Department of Prosthodontics, Medical University of Bialystok, Bialystok, Poland

* CORRESPONDING AUTHOR:
Department of Prosthodontics,
Medical University of Bialystok
M. Sklodowska-Curie Str. 24a
15-276 Bialystok, Poland
tel.: 48 85 7468349
e-mail: teresasierpinska@net.bialystok.pl (Teresa Sierpinska)

Received 24.07.2008
Accepted 08.10.2008
Advances in Medical Sciences
Vol. 53(2) · 2008 · pp 316-320
DOI: 10.2478/v10039-008-0049-1

ABSTRACT

Purpose: To assess possible associations between occlusal parameters and comminution of solid food during chewing in a group of completely dentate subjects.
Materials and methods: Twenty-five completely dentate volunteers (28 teeth, 14 functional dental units) aged 24-50 yrs, without any complaints of the stomatognathic system participated in this study.
An Optosil test was used to estimate masticatory efficiency for 20 and 80 cycles of chewing. An occlusal analysis, using the T-Scan II System, was performed to assess the following occlusal parameters: the distribution of occlusal contacts, the time of occlusion, the chewing platform area before chewing and after 20 and 80 cycles of chewing.
Results: The parameters, that were taken into account: i. X50 for 20 and 80 cycles of chewing, ii. the occlusion time, iii. the occlusal contact area. The occlusion time decreased after 20 and 80 chewing cycles (mean TO_0=0.28±0.07 *vs* TO_{20}=0.21±0.05 s *vs* TO_{80}=0.18±0.05 s, respectively). The mean value of the chewing platform area was 125.12±46.5 mm^2.
Conclusion: Prolongation of chewing produces, shortening of the occlusion time while the chewing platform area remains at the same level independent of the number of chewing cycles.

Key words: masticatory efficiency, Optosil test, T-Scan analysis

INTRODUCTION

The aim of mastication is to comminute food and to increase the surface area of the food being exposed to digestive juices [1]. Factors associated with masticatory efficiency include bite force, occlusal contact area, body size, severity of malocclusion, tactile sensitivity, oral motor function and loss of postcanine teeth [2-9]. The critical issue of the functional connection in the masticatory system is the influence of occlusal conditions on masticatory function. The above associations relate to the configuration of occlusal surface and the number of tooth contacts. Published studies demonstrate a significant relationship between occlusal force and masticatory performance [1,10]. Both in healthy subjects and in patients undergoing prosthetic treatment, significant associations between occlusal forces and facial morphology have been found [11]. However, there is limited information in the literature regarding the effects of the chewing process on occlusion.

The purpose of this study was to assess the changes of the occlusal parameters during chewing of solid test food in completely dentate adult subjects. We hypothesized that the occlusal contact area and the time of occlusion, which represents the duration from the first tooth contact to the maximum intercuspation were independent of the duration of the masticatory process.

MATERIALS AND METHODS

The study was performed on a group of 25 completely dentate (28 teeth, 14 dental functional units), healthy volunteers, whose occlusion has never been rehabilitated, with I Angle class of occlusion and group function of lateral guidance (contact on several teeth in lateral excursive and protrusive mandibular movements). The study participants were 16 women and 9 men aged 31.6 ± 9.6 yrs (mean ± SD). They did not report any diseases; no major health problems were found, based on their medical records. Subjects were selected during dental examination, which included a comprehensive dental assessment. Subjects with acute or chronic myofacial pain dysfunction syndrome as well as those treated with antidepressants and any agents known to affect muscle tonus were excluded from the study.

All subjects gave written informed consent for their participation, and the protocol was approved by the University's Institutional Review Board.

A computer-based assessment of occlusal conditions in centric relation was carried out on the participants using T-Scan II equipment (Tekscan, Inc., Boston, MA, USA). Subsequently, portions of test material (each containing 17 Optosil cubes of the standardized dimension of 5.6 mm) were administered to participants who were asked to perform 20 cycles of chewing. After completing this stage of the examination (i.e. removal of masticated material and oral cavity rinsed), occlusal conditions were recorded. Next, 80 masticatory cycles with a new portion of Optosil (the same size) were performed by participants. The occlusal conditions were then re-evaluated immediately after the removal of the used material, followed by a mouth rinse.

Assessment of masticatory efficiency with the Optosil test

The masticatory efficiency was measured using the Optosil test for 20 (short chewing) and 80 (long chewing) cycles of mastication. Chewed test food after drying was sieved through a stack of 10 sieves with the aperture between 5.5 and 0.5 mm. The distribution of particle sizes by weight of the comminuted test food was described according to a Rosin-Rammler equation [12,13].

$$Q_w(x)=1-2^{-(X/X_{50})^b}$$

$Q_w(X)$: - the weight percentage of particles with a size smaller than X.

X (mm): - aperture of sieve.

X_{50} (mm): – aperture of theoretical sieve through which 50% of the particles by weight can pass.

b: – a variable indicating the broadness of the distribution ($0<b<\infty$)

Assessment of occlusal parameters with T-Scan analysis

The T-Scan was used to estimate the quantification of occlusal contact data. The system consisted of a sensor and a support, the handle assembly, the processing unit, software and a built in printer. When the patient pressed firmly on the sensor, the subsequent reduction in electric resistance was translated into an image on the screen [14-18]. This allowed an operator to record occlusal parameters: the occlusion time, defined as the time from the first contact of teeth to the maximal intercuspation, and the occlusal contact area.

Statistical analysis

The data were reported as means and standard deviations. Kolmogorov–Smirnov`s one-sample test for testing the distribution of the variables for normality was used. Student's test and the U-Mann-Whitney test were used to establish a relationship between parameters according to their distribution. Statistical package Statistica 6.0 (StatSoft Inc. Tulsa, USA) was used for statistical calculations. The differences with $P<0.05$ were considered statistically significant.

RESULTS

Based on the examination, the following parameters were taken into account: i. X_{50} for 20 and 80 cycles of chewing by means of an aperture of a theoretical sieve through which half of the weight could pass as the expression of food comminution ability ii. the occlusion time, defined as the time from the first contact of teeth to maximal intercuspation, iii. the occlusal contact area which was calculated by multiplication of the number of tooth contact recorded by the T-Scan sensor by the size of a single pixel (1.6 mm^2) reflecting occlusal conditions.

The parameters were analyzed in relation to the gender and age of the participants. A negative correlation was found between occlusion time and the volunteers' age. There was no gender-related difference in the time of occlusion associated with chewing. The time of occlusion after chewing depended on initial occlusion time. This result was confirmed independently on a number of chewing strokes (Tab. 1). The time of occlusion decreased significantly with an increase in the number of chewing cycles. The longer the chewing lasted, the shorter was the occlusion time. Such an association was not observed in the size of the chewing platform area. Mastication parameters were not associated with the quality of occlusal surface. However, X_{50} values were significantly different, higher in men compared to women ($p<0.05$) regardless of the number of chewing strokes. This difference did not refer to the remaining examined features while those values were similar in men and in women. Men showed a tendency to a greater chewing platform area size in comparison with women (Tab. 2).

DISCUSSION

The studied subjects were recruited by selecting people whose occlusion had never been rehabilitated. This was performed in order to exclude any potential disturbances in occlusion.

Recently, objective masticatory function tests have been introduced offering a possibility of a quantitative assessment of masticatory efficiency by measuring the comminution of food particles. The latter process is a final result of mastication for a given number of strokes. These tests are claimed to be independent of other mastication components that are usually poorly controlled [7,19,20,21].

Table 1. **Correlations between occlusion time and masticatory parameters in 25 healthy adult subjects.**

	Age	*X_{50}20*	*X_{50}80*	*TO/0*	*P/0*	*TO/20*	*P/20*	*TO/80*
X_{50}20	R=0.1203 P=0.5							
X_{50}80	R=0.1876 P=0.369	R=0.8363 P<0.001						
TO/0	R=-0.361 P=0.076	R=-0.074 P=0.725	R=-0.129 P=0.539					
P/0	R=0.1863 P=0.373	R=0.0485 P=0.818	R=0.0868 P=0.68	R=0.12 P=0.568				
TO/20	**R=-0.5489** **P<0.05**	R=-0.0093 P=0.965	R=-0.066 P=0.754	**R=0.5997** **P<0.05**	R=0.1353 P=0.519			
P/20	R=0.1692 P=0.419	R=0.0689 P=0.744	R=0.0971 P=0.644	R=0.1544 P=0.461	R=0.9942 P=0.000	R=0.1901 P=0.363		
TO/80	**R=-0.5889** **P<0.05**	R=0.1389 P=0.5808	R=-0.0134 P=0.949	**R=0.5389** **P<0.05**	R=-0.0471 P=0.823	**R=0.8690** **P<0.001**	R=-0.0096 P=0.964	
P/80	R=0.1643 P=0.443	R=0.0661 P=0.254	R=0.0929 P=0.659	R=0.1296 P=0.537	R=0.9969 P<0.001	R=0.1620 P=0.429	R=0.9926 P<0.001	R=-0.0100 P=0.962

P/0, P/20, P/80 - chewing platform area - number of pixels multiplied by 1.6 mm^2 (the size of pixel) before occlusal registration, after 20 chewing strokes, after 80 strokes of chewing (mm^2)
X_{50} - the aperture of a theoretical sieve (mm) through which half of the weight could pass (Optosil test) after 20 strokes of chewing and after 80 cycles of chewing (mm)
TO/0, TO/20, TO/80 - occlusion time – the time (s) from the first tooth contact to intercuspal position (T-Scan II analysis) before chewing, after cycles and after 80 strokes of chewing (s)
R - coefficient of correlation

Table 2. **Mean values (± SD) for parameters of chewing and occlusion in studied female and male subjects.**

	Total n=25	*Female n=16*	*Male n=9*	*P=*
Age	31.6± 9.6	32.2±10.5	30.67±8.38	0.71
X_{50}20	5.0387±0.3462	5.1426±0.2755	4.8539±0.3965	**0.04**
X_{50}80	3.5893±1.1389	3.9707±0.9572	2.9112±1.1684	**0.02**
TO/0	0.2759±0.0689	0.2768±0.0724	0.2743±0.0665	0.93
P/0	125.12±46.5	113,19±39.08	146.33±53.22	*0.08*
TO/20	0.2129±0.051	0.2116±0.05411	0.2152±0.0482	0.86
P/20	124.16±47.45	112.44±38.57	145±56.58	*0.10*
TO/80	0.1805±0.0519	0.1859±0.0553	0.1710±0.0468	0.50
P/80	123.96±46.59	113±39.92	143.44±53.44	*0.11*

P - chewing platform area - number of pixels multiplied by 1.6 mm^2 (the size of pixel) (mm^2)
X_{50} - the aperture of a theoretical sieve (mm) through which half of the weight could pass (Optosil test) (mm)
TO - occlusion time – the time (s) from the first tooth contact to intercuspal position (T-Scan II analysis) (s)
0, 20, 80 – number of chewing cycles

To assess the masticatory efficiency, we chose the test based on chewing artificial food - silicon-rubber mass (Optosil). This method allowed us a quantitative assessment of artificial food particle comminution as a function of the number of chewing strokes using a standardised sieving method. Evidence exists that the ability of food comminution is greater in men compared to women. Similar results are reported by other researchers [22]. However, the influence of the size of chewing platform area on masticatory efficiency was not confirmed, though differences in the movement of the jaw may have a greater influence on chewing efficiency than the occlusal contact area [6].

The T-Scan system proved to be a reliable method for the analysis and evaluation of occlusal contact distribution in maximum intercuspation (14,15). The use of the method in our research appeared appropriate. The possibility of determining the occlusion and disclusion times allowed us to evaluate the role of jaw movements in food comminution. Although the small sample size of this study limits inferences that could be made, our finding suggests that the time of occlusion decreases due to prolonged mastication.

The chewing process remains under the control of the central pattern generator located in the brain stem but is also influenced by dental and temporomandibular joint (TMJ) morphology. The most important portion of the chewing cycle is the area entering and leaving the intercuspal position where gliding contacts occur [5]. The changes in the threshold of occlusal perception after intense chewing may reflect the influence of receptors other than periodontal, for example those in TMJ and muscles, which are involved in the control of the postural position of the mandible [23]. Humans chew hard coherent food so that the mandibular teeth coming into contact with food open to a height equivalent to that of the food bolus. The changes in movement of the other parts of the mandible are minimized, ensuring efficient mastication [24].

CONCLUSION

Prolongation of chewing is associated with the shortening of the occlusion time, whereas the chewing platform area remains constant irrespective of the number of chewing cycles.

REFERENCES

1. Okiyama S, Ikebe K, Nokubi T. Association between masticatory performance and maximal occlusal force in young men. J Oral Rehabil. 2003 Mar;30(3):278-82.
2. Hatch JP, Shinkai RSA, Sakai S, Rugh JD, Paunovich ED. Determinants of masticatory performance in dentate adults. Arch Oral Biol. 2001 Jul;46(7):641-8.
3. Helkimo E, Carlsson GE, Helkimo M. Chewing efficiency and state of dentition. A methodologic study. Acta Odontol Scand. 1978;36(1):33-41.
4. van der Bilt A, Olthoff LW, Bosman F, Oosterhaven SP. The effect of missing postcanine teeth on chewing performance in man. Arch Oral Biol. 1993 May;38(5):423-9.
5. Yamashita S, Sakai S, Hatch JP, Rugh JD. Relationship between oral function and occlusal support in denture wearers. J Oral Rehabil. 2000 Oct;27(10):881-6.
6. Wilding RJ. The association between chewing efficiency and occlusal contact area in man. Arch Oral Biol. 1993 Jul;38(7):589-96.
7. Kapur KK, Garrett NR, Fischer E. Effects of anaesthesia of human oral structures on masticatory performance and food particle size distribution. Arch Oral Biol. 1990;35(5):397-403.
8. Julien KC, Buschang PH, Throckmorton GS, Dechow PC. Normal masticatory performance in young adults and children. Arch Oral Biol. 1996 Jan;41(1):69-75.
9. Koshino H, Hirai T, Ishijima T, Ikeda Y. Tongue motor skills and masticatory performance in adult dentates, elderly dentates, and complete denture wearers. J Prosthet Dent. 1997 Feb;77(2):147-52.
10. Fontijn-Tekamp FA, Slagter AP, van Der Bilt A, van ‘T Hof MA, Witter DJ, Kalk W, Jansen JA. Biting and chewing in overdentures, full dentures, and natural dentition. J Dent Res. 2000 Jul;79(7):1519-24.
11. Harada K, Kikuchi T, Morshima S, Sato M, Ohkura K, Omura K. Changes in bite force and dentoskeletal morphology in prognathic patients after orthognathic surgery. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2003 Jun;95(6):649-54.
12. van der Bilt A, Olthoff LW, van der Glass HW, van der Weelen K, Bosman F. Mathematical description of the comminution of food during mastication in man. Arch Oral Biol. 1987;32(8):579-86.
13. Slagter A, Bosman F, van der Bilt A. Comminution of two artificial test foods by dentate and edentulous subjects. J Oral Rehabil. 1993 Mar;20(2):159-76.
14. Garcia Cartagena A, Gonzales Sequeros O, Garrido Garcia VC. Analysis of two methods for occlusal contact registration with the T- Scan System. J Oral Rehabil. 1997 Jun;24(6):426-32.
15. Garrido Garcia VC, Garcia Cartagena A, Gonzales Sequeros O. Evaluation of occlusal contacts in maximum intercuspation using the T-Scan II System. J Oral Rehabil. 1997 Dec;24(12):899-903.
16. Kerstein RB, Wright NR. Electromyographic and computer analysis of patients suffering from chronic myofascial pain-dysfunction syndrome before and after treatment with immediate complete anterior guidance development. J Prosthet Dent. 1991 Nov;66(5):677-86.
17. Maness WL, Benjamin M, Podoloff R, Bobick A, Golden RF. Computerized occlusal analysis: a new technology. Quintessence Int. 1987 Apr;18(4):287-92.
18. Mannes WL, Podoloff R. Distribution of occlusal contacts in maximal intercuspation. J Prosthet Dent. 1989 Aug;62(2):238-42. J Prosthet Dent. 1989 Aug;62(2):238-42.
19. Slagter AP, van der Glas HW, Bosman F, Olthoff L. Force-deformation properties of artificial and natural foods for testing chewing efficiency. J Prosthet Dent. 1992 Nov;68(5):790-9.
20. Buschang PH, Throckmorton GS, Travers KH, Johnson G. The effects of bolus size and chewing rate on masticatory performance with artificial test foods. J Oral Rehabil. 1997 Jul;24(7):522-6.
21. Peyron MA, Mishellany A, Woda A. Particle size distribution of food boluses after mastication of six natural foods. J Dent Res. 2004 Jul;83(7):578-82.

22. Salsench J, Martinez-Gomis J, Torrent J, Bizar J, Samsó J, Peraire M. Relationship between duration of unilateral masticatory cycles and the type of lateral dental guidance: a preliminary study. Int J Prosthodont. 2005 Jul-Aug;18(4):339-46.

23. Kiliaridis S, Tzakis MG, Carlsson GE. Short term and long term effects of chewing training on occlusal perception of thickness. Scand J Dent Res. 1990 Apr;98(2):159-66.

24. Miyawaki S, Ohkochi N, Kawakami T, Sugimura M. Effect of food size on the movement of the mandibular first molars and condyles during deliberate unilateral mastication in humans. J Dent Res. 2000 Jul;79(7):1525-31.