北醫學報 第二十三卷 第一期 1994年六月
P. 25-34

The Effects of Maximum Centric Clenching on the Velocity of Mandibular Movement.

Ching-Zong Wu

ABSTRACT

Muscle fatigue has been studied fairly extensively by using EMG and power spectral analysis. However, its influence on the velocity of jaw movement is unclear. The purpose of this study is to determine the influence of maximal centric clenching on the velocity of mandibular movement. Eighteen dental students (12 males, 6 females, ages ranged from 21 yrs to 26 yrs) were observed by using Myotronic Kinesiograph K-6 model for the measurement of jaw motion velocity before and immediately after two minutes maximal centric clenching (MVC) (Christensen 1986). Each subject was instructed to open and close as wide and fast as possible. Ten continuous open-close strokes were recorded and processed for evaluating the folowing parameters (1) the maximal opening and closing velocity, (2) the average opening and closing velocity and (3) the maximal velocity of terminal tooth contact. Mean velocity of ten movement strokes was used for comparing the result by pair t-test. Analysis of data indicated that neither the maximal opening and closing velocity nor the average opening and closing velocity was changed (P>0.05). The maximal terminal velocity before tooth contact was not changed either (P>0.05). In conclusion, under the condition of this study the effect of two minutes maximal centric clenching on the alteration of mandibular movement velocity is not influential.

Key words: Centric clenching, Mandibular movement velocity.

Neuromuscular fatigue has been defined as a reduction in the capacity of neuromuscular system to generate force or to perform work[1]. This decreased efficiency can result from central or peripheral reasons but usually involves some failure of the contractile elements and an impairment of the energy supply[2]. Intraoral force tranducers and electromyographic (EMG) evaluations of the integrated muscle activity have been used in many studies to measure the contractile properties of the muscle in masticatory system[3,4,5].

Department of Occlusion, School of Dentistry, Taipei Medical College.
Received for Publication: April 12, 1994

Examination of muscle fatigue usually involves a quantitative comparison between muscle force output and EMG activity. The level of the surface EMG is thought to be a reflection of the number of muscle fiber recruited and their mean firing frequency. When fatigue occurs,this relationship is altered by either electrical failure or contractile failure(1). Electrical failure, or failure of the impulse-propagation mechanism, is present where a parallel decline in both EMG activity and force output occur. Contractile failure or failure of the muscle intrinsic contractile elements, is present when the force declines, but the EMG is unchanged or increases relative to force output(30).

There is still some confusion regarding the characteristics of jaw muscle fatigue. Christensen repeatedly measured the endurance of the jaw -elevating muscles and assumed that subjects stopped clenching because muscle fatigue developed(18). Several others have demonsrtrated a shift of the mean power spectrum to a lower level freguency in these muscle during a sustained contration(16,23). Regardless of the debate of the actural mechanism of this spectral shift, most researchers have suggested that the spectral shift is evidence of neuromuscular fatigue(21).

Unfortunately, little information is available regarding the application of velocity change as a parameter for measuring the effect of muscle fatigue. Chewing velocity varies with the consistence of the food stuff and varies from person to person(7,8). In general, it was found that it ranged from 50 mm to 200 mm per second in a group of normal subjects (8). The purpose of this study is to elucidate (a) the individual variation of the open-close motion velocity. (b) the influence of maximal centric clenching of the alteration of mandibular movement velocity.

MATERIALS & METHODS

Subjects:

Eighteen dental students with mean age of twenty-two years old (range from 21 yrs -26 yrs) participated this study. The subjects consisted of twelve males and six females. Subjects were randomly selected from the dental students at Taipei Medical College. All subjects were in good physical health, free from any acute dental diseases and any orafacial pain during the past six months. Each subject was given a comprehensive oral examination, which included an evaluation of the sign and symptom of the craniomandibular disorders. The consent form was signed after we explained delinerately the possible discomfort caused by the exercise of maximal centric clenching.

Apparatuses:

Myotronic (Myotronic,Seattle,WA. USA) K-6 Diagnostic system was used for recording the mandibular movement velocity. Model EM-2 (Myotronic,Seattle,WA,USA) Electromyography was also applied for monitoring the EMG activities of masticatory muscle.

PROCEDURES

Subjects seated upright in dental chair without head rest i,e, natural head position, and were given a verbal instruction to perform the experiment.

The labial surface of the mandibular incisors and gingiva were dried with cotton gauze and the magnet sensor was sticked horizontally onto the teeth with Urehesive (Squibb Co Ltd) according to the instruction of the operating manual[15].Great care had been taken to make sure that the magnet did not interfere with the closing movement of lower dentition.The magnet was placed on the lingual surface of the mandibular incisor alternatively in case of a deep overbite subject. The sensor array was aligned and the system was set ready for recording the selective parameters according to the guide of operating manual.

The photo I scheme of the K-6 system was used first to trace the trajectory of the jaw open-close motion sagittally and horizontally during opening and closing the mouth. The subject was instructed to open and close the mouth as wide as possible. This was used for the baseline data to check whether he or she would open wide enough at the same magnitude during the subsequent experiment sessions (fig I).

The photo 2 scheme of the K-6 system was used subsequently for recording the jaw movement velocity both in vertical and horizontal plane.The subject was instructed to perform ten continuous open-close jaw motion as fast and wide as possible. Later the subject was asked to make the maximum centric clench (Maximum voluntary tooth clenching -MVC) in the position of maximum intercuspation of the teeth for 120seconds[9,10]. They were instructed to clench as hard as they could,which was verified in the preliminary test[11]. During their clenching exercise, they were asked to point out the area or site where pain or discomfort appeared first around the head and neck area, and it was measured by Visual Analogue Scale[12,13]. The time of pain latency was also recorded by Casio sport watch in microseconds[14]. When the time was running out (120 seconds) they were asked to stop clenching and repeated the ten consecutive open-close jaw motion as fast and wide as possible. The photo 2 scheme would analysing open-close motion into five categories:(I) maximum opening velocity,(II) average opening velocity,(III) maximum closing velocity, (IV) average closing velocity and (V) maximum velocity of terminal tooth contact[15].

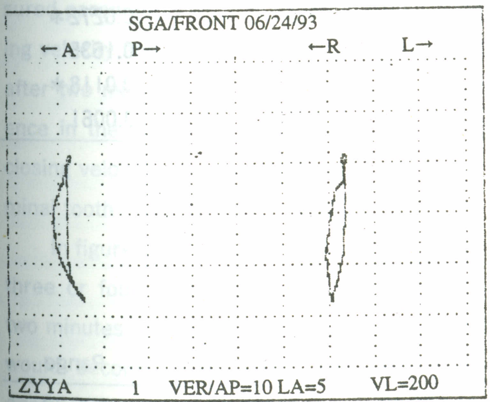

Fig. I Single open-close motion pattern before MVC in saggital and frontal plane (photo I scheme of K-6 system) A: anterior P: posterior R: right L: left

Data Analysis

All the kinesiographic tracking data were stored in disc, and the data were processed by Macintosh personal computer in the program of Excell and Statview. The mean of ten consecutive open-close motion velocity of each category was used for comparison before and immediately after MVC by pair t-test.

RESULTS

There existed a variation of the maximum mandibular open-close movement velocity, which ranged from 120 mm/sec to 443.8 mm/

Table 1. Open-Close motion velocity (mm/sec) before MVC

	Mean	S.D.	Minimum	Maximum	Range
Opmax	290.80	84.39	120.00	443.80	323.80
Opave	131.74	32.38	58.88	192.03	133.05
Clomax	344.80	86.18	184.80	493.60	308.80
Cloave	162.79	39.90	81.01	216.17	135.16
Trermin.	101.51	50.65	17.60	179.20	161.60

Table 2. The velocity difference between opening phase and closing phase

	Opening phase Mean S. D.	Closing Phase Mean S. D.	P value
Maximum Velocity (mm/sec)	290.80 83.39	344.80 86.18	0.0388 *
Average Velocity (mm/sec)	131.74 32.38	162.97 39.90	0.0001 *

* P < 0.05

Table 3. Sex difference of open-colse motion velocity (mm/sec)

	Male	Female	Scheffe-F-Test	Pvalue
Opmax	320.12	232.18	5.49	0.0323 *
Opave	143.29	108.62	5.91	0.0272 *
Clomax	365.12	304.18	2.13	0.1635
Cloave	178.86	131.21	8.08	0.0118 *
Terminal	123.07	58.37	9.97	0.0061

* P < 0.05

Table 4. Open-close velocity (mm/sec) after 2 min of MVC

	Mean	S.D.	Minimum	Maximum	Range
Opmax	260.17	87.03	103.20	400.00	296.80
Opave	121.64	37.38	43.99	180.89	136.90
Clomax	316.32	119.59	128.20	578.90	450.70
Cloave	159.96	52.59	61.33	291.95	230.62
Termin.	111.11	88.58	24.00	404.00	380.00

Table 5. Mean velocity change before and after 2 minutes of MVC.

	Base Data (mm/sec)		2 min. after MVC (mm/sec)		Pvalue
	Mean	S.D.	Mean	S.D.	
opmax	290.80	84.39	260.17	87.03	0.1079 *
opave	131.74	32.38	121.64	37.38	0.1628 *
clomax	344.80	86.18	316.32	119.59	0.2543 *
cloave	162.79	39.90	159.96	52.95	0.7409 *
terminal	101.51	50.65	111.11	88.58	0.5921 *

* $P > 0.05$

sec in the opening phase and from 184.5 mm/sec to 493.6 mm/sec in the closing phase (table 1). This data was similar to that of Bates[17] who stated that the chewing velocity was among 50mm/sec to 200mm/sec. In general, we noted that the opening phase velocity was slower than-that of the closing phase (table 2). There existed the velocity difference between gender (table 3) i.e. that velocity of the male subjects was faster than that of the female ones.

In table 4 we could find the distribution of mandibular open-close motion velocity after two minutes of maximum centric clenching. There were no significant difference among the measured parameters such as in the maximal opening velocity and in the average opening velocity after two minutes of MVC, nor were any difference in the maximum closing velocity average closing velocity and the maximal velocity of terminal tooth contact(table 5, fig. 2).

In figure 3 we noted the unstable initial first three or four open-close motion velocity after two minutes of maximum voluntary clenching. It would become more stable after the fourth open-close motion(fig 3). The overall velocity pattern were not changed after two minutes of MVC. (fig 4, fig.5).

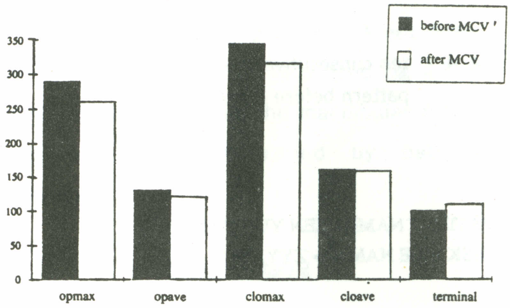

Fig. 2 Histogram of the mean velocity difference before and immediately after 2 min. of MVC.

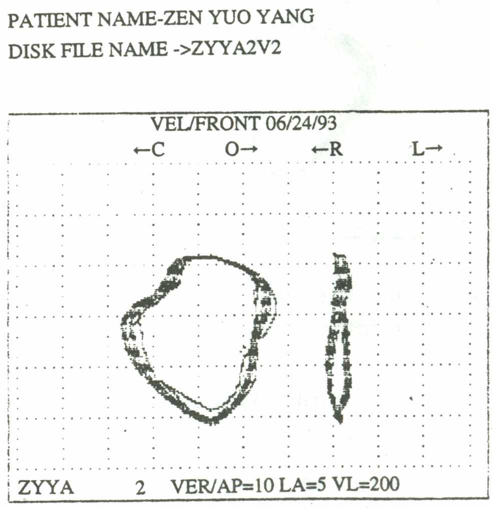

Fig. 3 Unstable initial three or fourth open-close motion velocity after 2 min. of MVC. (Photo 2 shceme of k-6 system) C: closing plase O: opening phase R: right L:left

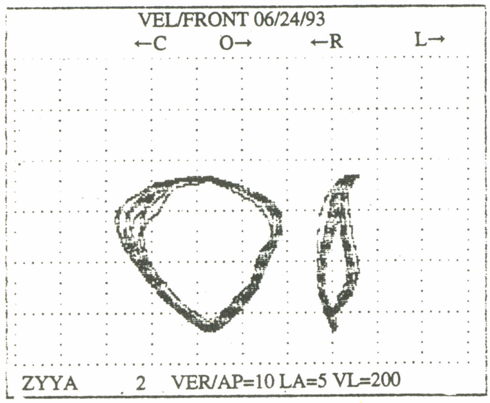

Fig. 4 ten consecutive open-close motion velocity pattern before 2 min of MVC.

PATIENT NAME - ZEN YUO YANG
DISK FILE NAME -> ZYYA2V5

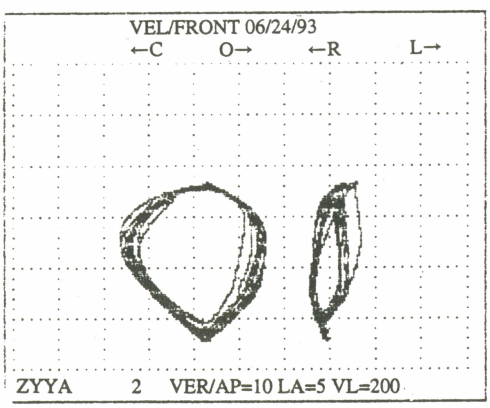

Fig. 5 Ten consecutive open-close motion velocity pattern after 2 min. of MVC.

DISCUSSION

Static contractile activity is divided into three tempory phases: (a) The fatigue threshold, (b) the pain threshold and (c) the pain tolerance[18]. The onset of fatigue seemed to depend on how long the contraction last, i.e. time factor., and possibly also on how high a force level i.e. tension factor for contractile were exercised[19]. Potentiation might have augmentated the contractile activity of the fatigue muscle.[20].

It was reported earlier that at maximum voluntary contractile strength (MVC), maintained isometric contraction of health human mandibular elevator muscle might cause complete exhaustion and intolerable pain in the contracile muscle. The isometric endurance time is about 2 minutes[21] and the muscle fatigue appeared about 30 seconds of isometric contraction[22] In this experiment, two minutes of maximum voluntary clenching was adopted and the subject were asked to make maximum effort to clench their teeth as could as possible and this was confirmed in the study[10,18,25]. 120 seconds of maximum vloluntary contraction did make the most of the subject feel discomfort or pain in temporal area[10,18].

Power spectrum analysis has confirmed that the rate of frequency shift to lower frequency might be a valuable parameter to quantify the masseter muscles which were susceptible to fatigue[23].

Different posture have been acclaimed to have the effect on the muscle tonicity i. e. the different rest position will influence the electromyographic activity of masticatory muscle[9,24]. In our preliminary study there was no difference of open-close velocity change at supine or at upright position with or without head supported[11]. In this study we asked the subject to seated upright without head rest as it was used in the pilot study

In this study, we find a tendency that an unstable open-close motion velocity and kinesiographic change during the initial first 3 motion after 120 seconds of MVC (fig.3). Similar phenomena had been found that an unstable initial velocity in the kinesiographic tracing during the chewing strokes[26]. Under the condition of this study we used the mean velocity of the first ten consecutive open-close motion instead of the individual one for later comparison.

In this study we could not find any discernible change of mandibular movement velocity after two minutes of centric clenching. There exists three possible reasons: as Asmussen stated that psychologic influence of willpower on the cortical motor commands[27]. Although we have used the EMG for monitoring the maximum contraction effort of the subject, there could exist the influence of willpower on the contraction. The behavior of the subject and their perception to pain were two limiting factors to abstrain the subject from continuing exerting their clenching force.

Another possible reason is that the pain caused by centric clenching will forbide the subject from making maximum effort to clenching their teeth. Pain has been described as a major limiting factor in health subjects[28,29,30]. As Rodhard explained this contration induced pain stating it is well-accepted that excessive muscle work can be painful, probably from the accumulation of a toxic metabolite during muscle contraction[31]. In fact, Moller[32] has shown that intramuscular blood flow during a sustained contraction does not increase as expected, and he speculated that relative ischemia obstruction of a supply vessles. The third reason is that mandibular movement was goverened by pattern generator[33]. It will not be affected by two minutes of MVC.

Although the velocity change was not significant after two minutes of MVC, we did find an interesting fact that the standard deviation of each measured parameter both in opening phase and closing phase were increased to a significant level(table 5). It mean that there existed a greater velocity change after two minutes of centric clenching expecially in the first three open-close phases (fig 3), this phenomenon might be the result of mandibular movement adaptation. Similar result was found in the study of Dr. Shiau.[26]. Further study is needed to verify this veiwpoint.

Mandibular velocity pattern was not changed after two minutes of MCV (see fig 4,5).It might also indicated that the mandibular movement pattern is goverened by pattern generator[33]

CONCLUSION

1. There existed a great variation of mandibular open-close motion velocity among the test subjects.

2. Two minutes of maximum centric clenching will not change the mandibular movement velocity.

ACKNOWLEDGEMENTS

1. I am grateful to Drs. Shiau YY,Wang RS and Chou SL for giving me the benefical suggestion during the experiment and reading the manuscript.

2. Thank for the grants from Taipei Medical college research committee. TMC 81d -114.

REFERENCES

1. Bigland-Ritchie B, Donovan EF, Roussor CS: Conduction velocity and power spectrum

analysis in fatigue of sustained maximal efforts. J Apply Physiology 51; 1300-1305, 1981.

2. Edwards RHT: Human muscle function and fatigue. In Human muscle fatigue: physiologic mechanisms (Ciba foundation) pp.1-18. Pitman medical, London,1981.
3. Rugh J, Solberg W: The measurement of forces. Behavior research method and instrumentation. 4; 125,1972.
4. Carlsson GE: Bite force and chewing efficiency. In Kawamura Y. ed. Frontiers of oral physiology 1;265,1974
5. Stenber D, Van Devries: Resistence of jaw-closing muscles to fatigue during repetitive maximal voluntary clenching efforts in man. Arch Oral Biol 23;697-701, 1978.
6. Gibbs CH, Lundeen HC: Jaw movements and forces during chewing and swallowing and their clinical significance. In Advances in Occlusion. edit by Lundeen HC et al. John Wright.PSG Inc.1982.
7. Ahlgren J: Masticatory mpvements in man. In Anderson, D.J. and Mathews, B. (Eds), Mastication, John Wright,Bristol. pp.119-127,1977.
8. Hannan AG, De Cou R E,Scott J D: The relationship between dental occlusion,muscle activity and associated jaw movement in man. Arch Oral Biol 22;25-32,1977.
9. Christensen L V: Pains from the jaw muscle in children and adults. In Orthodontics, state of the art - Essence of science pp.28-47 C.V.Mosby. 1986.
10. Chou SL The investigation of pain provoked by experimental clenching at retruded contact position. Bulletin of Taipei Medical College 17;73-87, 1988.
11. Wu CZ: The effect of head posture on the maximal mandibular movement velocity. Chinese Dental J 12; 51. # 044. abstract of the 16th annual session Association of Dental Research Sciences.1993.
12. Huskisson EC: Visual analogue scale. In pain measurement and assesment. Melzack R. pp.23-37. Raven, New York. 1983.
13. Heft HW, Parker SR: Visual analogue scale (VAS) of pain ratio or interval scales. J Dent Res 65; 307 (abstr. 1241). 1986.
14. Casio: HS-10 W /HS-20. Casio computer Co. Ltd. Japan.
15. Manual: K-6 Diagnostic system user's guide Version 3.3 GS. Myotronics, Seattle WA. USA.
16. Palla S,Ash MM: Power spectral analysis of the surface electromyogram of human jaw muscles during fatigue. Arch Oral Biol 26; 254, 1981.
17. Bates J F, Stafford GO, Harrison A : Masticatory function -A review of literiature: Speed of movement of the mandible. Rate of chewing and force developed in chewing. J Oral Rehab 2;349-361,1975.
18. Christensen L V: Jaw muscle fatigue and pains induced by experimental tooth clenching. J Oral Rehab 8; 27,1981.
19. Christensen LV, Mohamed SE, Harrison JD: Delayed onset of masseter muscle pain in experimental tooth clenching. J Prosth Dent 48;579-584,1982.
20. Kernell D, Monster A W: Motoneurone properties and motor fatigue Experimental. Brain Res 46; 197,1982.
21. Jow R W, Clark G T: Endurance and recorvery from a sustained isometric contracction in human jaw-elevating muscles. Arch Oral Biol 34;857-860, 1989.
22. Christensen LV, Mohamed SE: Contractile

activity of the masseter muscle in experimental clenching. J Oral Rehab 11; 191-197, 1984.

23. Naeije M: Correlation between surface electromyogram and the susceptibility to fatigue of the human masseter muscle. Arch Oral Biol 29; 865-870, 1984.
24. Moller E: Evidence that the rest position is subject to servocontrol. In Anderson DJ and Mathews B. (Eds): Mastication. John Wright, Bristol. pp. 72-80,1976.
25. Wu CZ: The effect of time frame on the maximal mandibular movement velocity. unpublished data.
26. Shiau Y Y, Ash M M: Immediate and delayed effects of working interferences on EMG and jaw movement. In EMG and Jaw reflex in man. Leuven University press. pp.311-326, 1988.
27. Asmussen E: Muscle fatigue. Medicine and Science in Sports. 11;313, 1979.
28. Moyers D E, McCall W D Jr: Head pain as a result of experimental ischemic exercise of the temporalis muscle. Headache 23; 113-116, 1983.
29. Clark G T, Beemsterboer P L, Jacobson R: The effect of sustained submaximal clenching on maximal bite force in myofascial pain dysfunction patients. J Oral Rehab 11;387-391, 1984.
30. Clark G T, Carter M G: Electromyographic study of human jaw-closing muscle endurance, fatigue and recovering at various isometric force level. Arch Oral Biol 30; 563-569, 1985.
31. Rodhard S: Pain associated with muscle contraction. Headache 10; 105-115, 1970.
32. Moller E: The myogenic factor in headache and facial pain. In Oral-Facial sensory and motor function. Edit by Kawamura Y. and Dubner, R. pp.225-239. Quintessence, Chicago IL. 1981.
33. Lund J P: Evidence for a central pattern generator regulating chewing cycle. In Anderson DJ.and Mathews B.(ed). Mastication, John Wright, Bristol. pp.204-212. 1976.

中心咬牙對下顎運動速度的影響

吳慶榕

肌電圖與能量光譜分析曾被廣泛用來探討肌肉的疲勞效應。但肌肉疲勞對下顎運動速度的影響則不是很清楚。本研究的目的即在探討最大中心咬牙對下顎運動速度的影響。十八位牙科學生(十二位男性，六位女性，其平均年齡介于二十一歲至二十六歲間)參與此實驗。利用下顎運動描繪器(K-6)來測量受測者在約二分鐘最大中心咬牙前後的下顎運動速度變化。每位受測者被要求盡其可能作最大及最快的下顎運動。我們記錄連續十次的開閉口運動速度來分析下列參數(1)最大開口及閉口速度。(2)平均開口及閉口速度(3)牙齒接觸前的最大速度。十次運動速度的平均值利用統計方法分析咬牙前後的運動速度變化。實驗結果分析顯示經過二分鐘最大中心咬牙後其下顎最大及平均開閉口速度均不受中心咬牙影響(P＞0.05)。牙齒接觸前的最大閉口速度亦不受中心咬牙後的影響(P＞0.05)。結論：在此實驗條件下，二分鐘的最大中心咬牙似乎不影響下顎速度的改變。

關鍵字：中心咬牙，下顎運動速度。

台北醫學院牙醫學系
民國八十三年四月十二日受理