Tokai J Exp Clin Med., Vol. 30, No. 1, pp. 7-10, 2005

Development of a new mouth opening force test using an indirect cervical traction device

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(Received March 16, 2004; Accepted October 22, 2004)

Background and Aims: There have been few reports of objective jaw opening tests, and such studies have involved devices specifically designed for research. In the present study, in order to conveniently and objectively assess mouth opening movements, we replaced the manual resistance used in Daniels and Worthingham's muscle test (DMT) with an indirect cervical traction device. We examined whether the maximum mouth opening force (MOF) could be reliably quantified using this device.

Methods: The subjects were 12 healthy individuals with a mean age of 28.8 years. The MOF measurement procedure was as follows: 1) the subject sat in the chair, and a head belt was placed under the chin so that a traction force was applied almost parallel to the body axis; 2) the researcher instructed the subject to maintain the maximum mouth opening; 3) as maximum resistance was approached, the rate of increase in the traction force decreased. Maximum opening force was recorded; 4) one measurement was taken per session, for a total of two measurements per subject. Pearson's correlation coefficients were used to assess the reproducibility of MOF values.

Results: The average MOF (mean ± SD) in the first and second tests was 24.2 ± 1.9 and 24.5 ± 2.0 kg. There was an extremely high correlation between first and second measurements (r = 0.969).

Conclusions: The presently described indirect cervical traction device can be used to reliably quantify MOF.

Key words : mouth opening force, jaw opening force, indirect cervical traction device, Daniels and Worthingham's muscle testing.

INTRODUCTION

Daniels and Worthingham's muscle test (DMT) is a clinically convenient test in which jaw opening is classified into four grades; functional (F), weakly functional (WF), non-functional (NF) and absent (0) [4]. However, the assessment in DMT is subjective, and it is difficult to differentiate F, defined as the maximum mouth opening as wide as three stacked fingers, with the mouth remaining open despite of strong manual resistance, from WF, defined as the maximum mouth opening as wide as two stacked fingers, with the mouth remaining open despite some resistance (Fig. 1A). There have been few reports of objective jaw opening tests, and such studies have involved use of devices specifically designed for research [2, 5, 6]. In the present study, in order to conveniently and objectively assess mouth opening movements, we replaced the manual resistance used in DMT with an indirect cervical traction device. We examined whether maximum mouth opening force, namely the amount of force required to maintain maximum mouth

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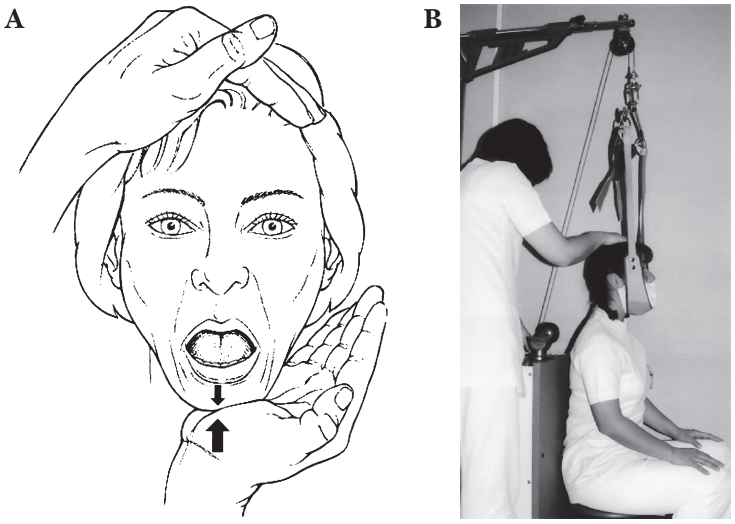

Fig. 1 **A**. Daniels and Worthingham's Muscle Testing for "Jaw opening". **B**. Measuring maximum opening force (MOF) using an indirect cervical traction device.

Table 1 Age, height and weight of subject.

	Men	Women	
Number	6	6	
Age (years)	28.7 ± 1.1	28.8 ± 2.3	NS
Height (cm)	168.2 ± 1.4	158.5 ± 1.8	$p<0.01$
Weight (kg)	67.0 ± 3.5	51.2 ± 2.8	$p<0.01$

An unpaired t-test was used to assess gender differences.
NS, not significant.

opening against force in the mouth closing direction, could be reliably quantified using this device.

SUBJECTS AND METHODS

The subjects were twelve healthy individuals (six men and six women: Table 1) who were able to maintain maximum mouth opening against strong manual force. None of these individuals had temporomandibular joint disorders, such as discomfort, pain, and noise. The average age of the subjects was 28.8 years (range: 23-35 years). The study methods were explained orally to each subject, and informed consent was obtained prior to the study.

The procedure for measuring the maximum mouth opening force was as follows (Fig. 1B): 1) The traction force of the indirect cervical traction device (Tractizer TC-M2) was set at 35 kg; 2) Each subject was instructed to sit down and place the head and neck regions in the neutral position. A belt was placed under the mandible so that a force could be applied in the mouth-closing direction, pulling the mandible approximately vertically; 3) The researcher placed one hand on top of the head of the subject, and while instructing the subject to maintain maximum mouth opening, the researcher pushed the start key. Increases in the traction force (kg) were confirmed using a strain gauge; 4) As the resistance approached maximum, the rate of increase in the traction force decreased. At this stage, the researcher firmly held the subject's head

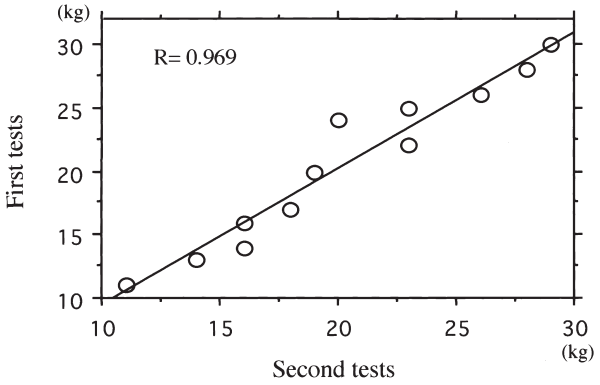

Fig. 2 The reproducibility of maximum opening force (MOF) measurements.

using one hand. When the maximum mouth opening force was reached, the traction force decreased. The maximum value of the mouth opening force was recorded, and the stop key was pressed; 5) One test was performed per session. A total of two tests were performed with each subject within a period of three days.

Maximum mouth opening was also measured as a distance. Each subject was asked to open their mouth as wide as possible, and bimaxillary central incisor distance was measured using calipers in mm.

Statistical analysis: Pearson's correlation coefficients and a paired t-test ($p < 0.05$) were used to assess the reproducibility of maximum mouth opening force ($p < 0.05$). An unpaired t-test was used to assess gender differences ($p < 0.05$).

RESULTS

The length of time that the force in the mouth-closing direction was applied in each session was about ten seconds. None of the subjects experienced temporomandibular joint disorders during the study.

Figure 2 shows the relationship of the maximum mouth opening force between the first and second tests. There was a significantly high degree of correlation between the first and second tests ($r = 0.969$). There was no significant difference in maximum mouth opening force between the first and second tests.

The lowest and highest maximum mouth opening force was 11 and 30 kg, respectively. The average maximum mouth opening force (mean ± SE) was 24.3 ± 1.3 kg for men and 16.4 ± 1.2 kg for women. There was a significant gender difference in the average maximum mouth opening force.

The lowest and highest maximum mouth opening was 28 and 55 mm, respectively. The average maximum mouth opening (mean ± SE) was 41 ± 3 mm for men and 34 ± 2 mm for women. There was no significant gender difference.

DISCUSSION

Techniques in which the mouth opening force is measured in isometric mouth opening movements using an extraoral strain gauge have been reported [2, 5, 6]. In the present study, to objectively and conveniently measure mouth opening force, we replaced the manual resistance used in DMT for jaw opening with an indirect cervical traction device designed for use in a clinical setting. The present results show that the measurements obtained using this device have a high reproducibility, and that the device can be used to reliably quantify maximum mouth-opening force maintaining the isometric maximum mouth opening against the force in the mouth closing direction.

The maximum mouth opening force measured in the present study (1 kg force = 9.81 Newton) was higher than that reported by Sharkey *et al.* (range, 57-410 N; male average, 136 ± 60 N; female average, 90 ± 20 N) [5]. The present technique is based on the break test of DMT, and mouth opening force is indirectly quantified by measuring the external force. In conventional techniques, the

mouth opening force is directly quantified by measuring the external force. Obviously, with previous methods, mouth opening force exerted by subjects in the maximum mouth opening cannot be measured using an outside strain gauge. In one study, the mouth opening position at which the mouth opening force reached maximum was 30 to 80% of the maximum mouth opening [5]. Therefore, the measurements obtained using these methods cannot easily be compared with each other.

Also, using previous methods, it is difficult to establish a mouth opening position at which to measure mouth opening if teeth are missing or denture are used (e.g., determining the mid point of mouth opening). In the present test, mouth opening force is measured at maximum mouth opening, which is the end point of the range of exercise, and the test can be performed conveniently and reproducibly.

The mouth opening force for all subjects of the present study (people in their 20 s and early 30 s) was equivalent to DMT grade F, but the maximum mouth opening force ranged from 11 to 30 kg, and previously reported gender differences were confirmed [5]. These findings suggest that even when the maximum mouth opening force is reduced by half, mouth opening may be assessed as functional, or grade F, by DMT. Also, the maximum mouth opening force was much higher for men than for women. Further investigation is needed to ascertain which level of mouth opening force (kg) is equivalent to grade WF of DMT. Also, there is a need for investigation of correlation between the age and mouth opening force.

The maximum mouth opening for the present subjects ranged from 28 to 55 mm, with no gender difference, and was equivalent to DMT grade WF or F. When assessing functionality of mouth opening, it is important to keep in mind that, even in the absence of trismus, there is a wide range of the maximum mouth opening.

With the present test, mouth opening force was measured while the head and neck region was in the neutral position. However, with all patients, the head tilted backward as mouth opening force approached maximum. This is consistent with a study showing that the head is tilted backward at the maximum mouth opening position, compared with the closed mouth position [3]. As with standard DMT, the head of the subjects was manually held in the present test. In other measurement methods, the head is immobilized using a head cap attached to the analyzer [6] or a four-point hard rubber device [5]. To determine the effects of head immobilization, it will be necessary to clarify the effects of flexion, extension and posture of the head and neck regions on mouth opening force.

CONCLUSION

In the present modification of DMT for jaw opening, an indirect cervical traction device is used to generate force in the mouth closing direction, instead of manual force. The present results show that this device can be used to reliably quantify the maximum mouth opening force, which is the force required to maintain the maximum mouth opening against force generated in the mouth closing direction.

REFERENCES

1) Matthews B: Mastication. In Lavelle CLB (ed), Physiology of the mouth, pp199-242. Bristol: Wright, 1975.
2) Mimura H: Physiological properties of motor Units in the human anterior digastric muscle. J Stomatol Soc Jpn 56: 75-92, 1989. (in Japanese)
3) Muto T and Kanazawa M: Positional change of the hyoid bone at maximal mouth opening. Oral. Surg. Oral Med Oral Pathol 77: 451-455. 1994.
4) Hislop HJ, Montgomery J: Daniels and Worthingham's muscle testing: techniques of manual examination. 7th Ed, W.B. Sunders Company, Philadelphia, Pennsylvania, 2002.
5) Sharkey P, Boyle DK, Orchardson R, McGowan DA: Jaw opening forces in human subjects. Br dent J 156: 89-92, 1984.
6) Yildirim E, DeVincenzo JP: Maximal opening and closing forces exerted by diverse skeletal types. Angle Orthodont 41: 230-235, 1971.