

# Self-registration of Mandibular Opening Capacity and Vertical Overbite. A Method Study

**Catharina Hagberg, DDS, PhD**  
Associate Professor  
Mun-H-Center  
Swedish National Orofacial Center for  
Rare Disorders

Department of Orthodontics  
Faculty of Odontology  
University of Gothenburg  
Gothenburg, Sweden

**Correspondence to:**  
Dr Catharina Hagberg  
Mun-H-Center  
Odontologen  
Medicinaregatan 12 A  
S-413 90 Gothenburg  
Sweden  
E-mail: catharina.hagberg@vgregion.se

**Aims:** To evaluate a method for self-registration of maximum mandibular opening capacity by means of a spatula and estimation of vertical overbite from photos. **Methods:** The study group consisted of 50 adults. Each participant received written instructions, photos, a measuring spatula, and a pencil. The first task was to register maximum interincisal distance. The participant opened up his or her mouth as wide as possible, looked in a mirror, and marked the distance on the spatula. The second task was to estimate the vertical overbite in the intercuspal position. A clinician then estimated the type of overbite and measured the maximum interincisal distance and the vertical overbite with a ruler in millimeters. **Results:** The normal overbites showed a mean value of 2.4 mm, and a standard value of 2 mm was set. The deep bites showed a mean value of 5.2 mm, and a standard value of 5 mm was set. The standard overbite value, added to the value measured on the spatula, was compared with the clinical values made by the clinician for maximum mandibular opening. The limits of agreement for 95% of the mean difference were -4.2 mm and 4.4 mm. Six people missed the correct diagnosis for the vertical overbite. **Conclusion:** The self-registration method of measuring maximum mandibular opening capacity seems valid for studying major differences in opening capacity when clinical measurements are not possible to perform. *J OROFAC PAIN* 2003;17:341-346.

**Key words:** craniomandibular disorders, mandibular opening, repeatability for measurements, self-registration, temporomandibular joint, vertical overbite

The maximum mandibular opening is one of the measures used for assessment of mandibular function. A reduced opening capacity could be a sign of temporomandibular joint (TMJ) and/or temporomandibular disorders (TMD).<sup>1-5</sup> A greatly increased opening capacity has at times been found to cause clinical problems such as luxations and traumatic injuries of the TMJ.

Clinical opening measurements are considered to have good reliability.<sup>6-10</sup> In a study by Dworkin et al, excellent interrater reliability was reported for vertical range-of-motion measures.<sup>8</sup> It has been pointed out that a measure of the vertical overbite is essential for a true value of maximal mandibular opening capacity.<sup>6</sup> The value for the vertical overbite is added to the maximum interincisal distance. The mean values reported for maximum mandibular opening, which by definition includes the vertical overbite, vary from study to study. Agerberg reported, for example, a mean value of 58.6 mm for young men and 53.3 mm for young women.<sup>6</sup> When the vertical overbite value was not included, the mean values for maximum interincisal distance were 55.5 mm and 51.0 mm, respectively.<sup>6</sup>



**Fig 1** Instruction photo for measurement of mandibular opening capacity.

In large population-based questionnaire studies on orofacial function, a valid method for self-registration of maximum mandibular opening capacity could be useful when clinical examinations are not possible to accomplish.

The aim of the present investigation was to evaluate a method for self-registration by means of a spatula and estimation of vertical overbite from photos. The self-registration method was designed for later use in a large questionnaire study on dental and orofacial problems in adults with Ehlers-Danlos syndrome (EDS), a connective tissue disorder that has been reported at times to cause increased mobility of the TMJ as well as reduced opening capacity because of degenerative changes.<sup>11-13</sup>

## Materials and Methods

The study group consisted of 50 persons (27 women and 23 men) consecutively visiting a suburban dental clinic in Gothenburg, Sweden. The age range was 20 to 82 years. Both adult patients and adults accompanying their children for dental treatment were asked to participate. None had severe signs of TMD. The minimum age was set at 20 years. The median age for the women was 42

years (range 27 to 82 years). The corresponding value for the men was 46 years (range 20 to 71 years). The participants were not to have any professional dental education. All subjects agreed to participate. The study was approved by the Ethics Committee, University of Gothenberg.

Each participant received written instructions, a measuring spatula, and a pencil in order to perform 2 tasks. The clinician also informed the subjects that the assignment was planned to be part of a questionnaire study and therefore no further instructions or help could be given. The instructions were:

- **Registration of mandibular opening capacity:** Look in a mirror. Open your mouth wide 3 times. Open up again and then put the enclosed measuring spatula between the teeth in your upper and lower jaw right in the front. Put the slot on the spatula against the edge of one of the teeth in the middle of the lower jaw. Draw a distinct horizontal line on the spatula where the lower edge of the opposed central incisors in the upper jaw reaches when you open up as wide as you can without injuring your temporomandibular joints. Look at the photo below (Fig 1). Check in the mirror that you are holding the spatula straight and that your marking is clear.
- **Registration of vertical overbite:** Clench your teeth as tightly as possible. Look in the mirror and see how much your upper front teeth overlap your lower teeth. Look at each photo below and choose the photo that most closely resembles your teeth (Fig 2).

The clinician then compared the participant's vertical overbite with the photos and chose the photo that most closely resembled the participant's teeth. Finally, the participant opened his or her mouth as wide as possible and the clinician measured the distance with a ruler graduated in millimeters. The method was described earlier by Agerberg.<sup>6</sup> The overbite was measured to the nearest millimeter in the intercuspal position. All participants were examined by the same clinician (CH) immediately after the self-registration procedure. They were not informed about the clinical registrations until then.

Using the same ruler used for the clinical measurement, the clinician measured the spatula from the deepest point in the slot to the mark or a line extending from the mark perpendicular to the long axis of the spatula. One week later a second measurement of the spatula was made for a test of repeatability. The measurement was made "blindly," that is, without knowledge of the name of the participant and the previous value.



Fig 2 Instruction photos for assessment of the vertical overbite (deep, normal, open).

### Statistical Analyses

The measurement error for the 2 measurements of the mark on the spatula was calculated as described by Bland and Altman.<sup>14</sup> The within-subject standard deviation  $sw$  was calculated using the formula  $sw^2 = \frac{1}{n} \sum di^2$  where  $di$  is the difference between the 2 observations for subject ( $i$ ) and  $n$  is the number of subjects. The repeatability was calculated according to the formula  $\sqrt{2} \times 1.96 sw$ .<sup>14</sup> Except for the repeatability test, only the first set of measurements of the measuring spatula was used for all statistical analyses.

The limits of agreement between the self-registration method and the clinical measurements were calculated according to the formula  $d - 1.96s$  and  $d + 1.96s$  where  $d$  is the difference between the mean values for each method (mean difference) and  $s$  is the standard deviation of the differences.<sup>15</sup> For each subject, the difference between the 2 measurements was also plotted against the mean of the measurements (the Bland/Altman plot).<sup>15</sup> The  $t$  ratio was used for a matched pairs test of difference between methods.<sup>16</sup>

The overbite values for the “normal overbite” group and the “deep bite” group were compared with an unpaired  $t$  test. Mean values were presented with confidence intervals (CI) with upper and lower 95% confidence limits. The Pearson product moment correlation coefficient ( $r$ ) was used to measure the strength of the linear relationship between 2 variables. The results were considered to be significant for  $P$  values below .05. The statistical program used was JMP.<sup>16</sup>

## Results

### Repeatability for Two Measurements of the Spatula

The measurement error  $sw$  was 0.5 mm. The repeatability was 1.4 mm, indicating that the dif-

ference between the 2 measurements for the same spatula is expected to be less than 1.4 mm for 95% of the pairs of observations.<sup>14</sup>

### Agreement Between the Self-registration and the Clinical Measurement

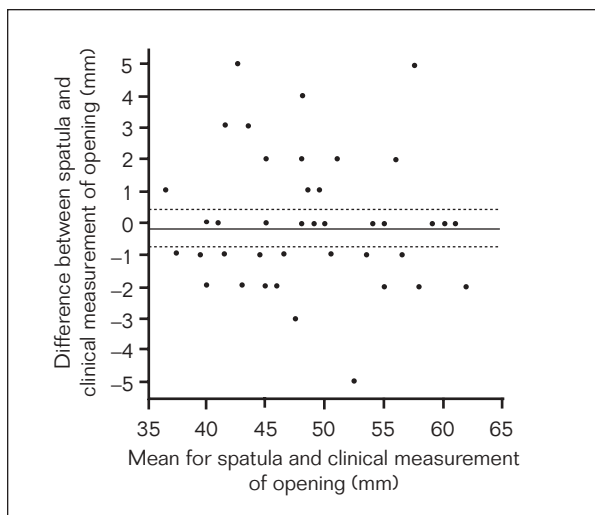
The self-registered maximum interincisal distance had a mean of 48 mm (CI 46–50 mm), and the corresponding clinical measurement made by the clinician had a mean of 48 mm (CI 47–50 mm). The Pearson  $r$  between the 2 sets of values was 0.95. The difference between the measurement on the spatula and the clinical measurement for each subject was plotted as a histogram. The median was zero (range 5 mm to –5 mm). The values appeared acceptably close to a normal distribution ( $d = -0.14$ ;  $s = 2.04$ ).

The limits of agreement for 95% of the differences were –4.1 mm and 3.9 mm. This is a 95% interval of approximately  $\pm 4$  mm for the difference between the mean for the spatula measurement and the mean for the clinical measurement (Fig 3). There was no significant difference between methods according to the  $t$  ratio, which was –0.49 for the matched pairs test of differences ( $P \geq .05$ ).

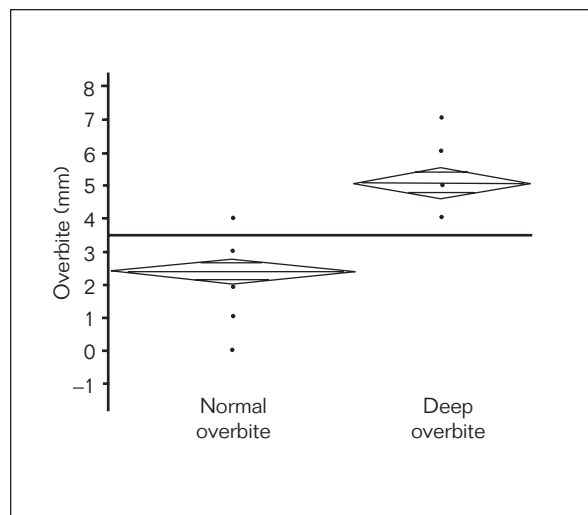
### Vertical Overbite

The vertical overbite was clinically registered as normal in 29 subjects (15 women, 14 men) and deep in 21 subjects (12 women, 9 men).

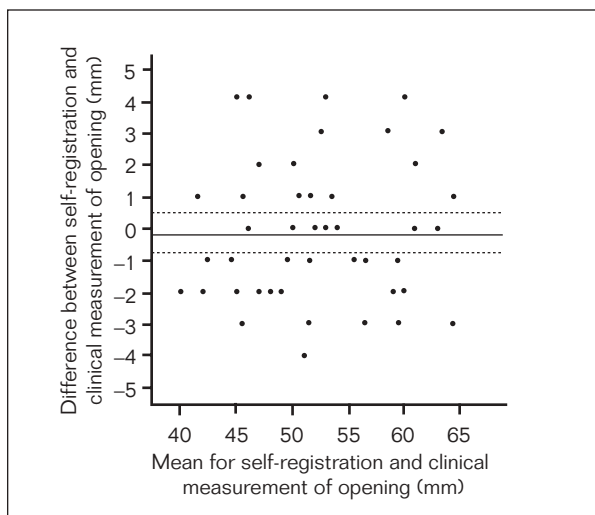
No subject had an open bite. The vertical overbite measured by the clinician had for the normal overbite a mean value of 2.4 mm (CI 2.1–2.8 mm) and for the deep overbite a mean value of 5.2 mm (CI 4.7–5.6 mm) (Fig 4). An unpaired  $t$  test showed a significant difference between values in the normal overbite group and the deep overbite group (Fig 4). It was decided to use a value of 2 mm as a standard value for a normal overbite and 5 mm for a deep overbite when the vertical overbite was assessed from the photos. When the subjects



**Fig 3** Bland/Altman plot for the within-subject difference between spatula measurement and clinical measurement of mandibular opening capacity in millimeters (mm) (y-axis) versus the intra-individual mean value for the same variables (x-axis). N = 50. Ten values coincide and are not separately visible on the plot.



**Fig 4** Means for the measurements of vertical overbite in 2 separate groups assessed by the clinician as normal and deep, respectively. The center lines of the means are group means and the top and bottom of the diamonds form the 95% confidence intervals for the means (N = 50; 21 deep, 29 normal).



**Fig 5** Bland/Altman plot for the within-subject difference between self-registration (spatula value plus estimated value) and the clinical measurement of maximum opening in millimeters (mm) (y-axis) versus the intra-individual mean value for the same variables (x-axis). N = 49. Six values coincide and are not separately visible on the plot.

selected their type of overbite from the photos (Fig 2), 6 people (12%) missed the correct diagnosis.

**Agreement Between the Participants' Self-registered Value and the Corresponding Clinical Value.** Finally, overbite values of either 2 mm or 5 mm,

depending on the choice of photo, were added to the interincisal distance measurement on the spatula. These values were compared with the clinical measurements including both the maximum interincisal distance and the vertical overbite in mm. The mean value calculated for the maximum mandibular opening in the clinical examination was 52 mm (CI 50–54 mm), and the corresponding mean value for the self-registration was also 52 mm (CI 50–54 mm). The Pearson  $r$  was 0.94.

The mean difference ( $d$ ) was  $-0.12$  mm and the standard deviation ( $s$ ) was 2.2 mm. The limits of agreement for 95% of the differences were  $-4.2$  mm and 4.4 mm (Fig 5).<sup>15</sup> The  $t$  ratio was  $-0.39$  for the matched pairs test of differences ( $P \geq .05$ ). One subject was excluded because he had wrongly chosen an open bite when looking at the photos. The separate distributions for males and females were similar for the variables tested and were not further analyzed.

## Discussion

The repeatability for the 2 measurements of the spatula was good in terms of both the measurement error and repeatability. It is believed important that the same person makes all the measurements. Recordings made by the same observer minimize the method error in functional examination of the masticatory system.<sup>17,18</sup>

The method of measuring mandibular range of motion with wooden spatulas is not new. Rivera-Morales et al<sup>19</sup> compared clinical measures of mandibular range of motion and values from a mandibular kinesiograph. A wooden spatula was used but it did not have a slot for placement on the lower incisor edge. The slot is believed important because it stabilizes the spatula and facilitates the self-registration.

In the present study, the correlation was high ( $r > 0.9$ ) between the variables tested. When limits of agreement were calculated it was obvious that there still was a difference between the 2 methods (Figs 3 and 5). The 95% agreement limits of the mean difference between clinical measurements and self-registrations were approximately  $\pm 4$  mm either positive or negative. Provided that these limits for uncertainty can be accepted in an investigation, the self-registration method is useful. It has to be emphasized that maximum opening capacity is only 1 variable among several others needed for studying the masticatory system.<sup>4</sup>

The study was focused on the self-registration method. The mean values registered for maximum interincisal distance and maximum mandibular opening were in line with previous reports<sup>1-6,20</sup> and are not further discussed.

With help from photos, the participants were asked to evaluate the amount of vertical overbite. One reason was that a value only for the maximum interincisal distance would not numerically reflect the full range of movement capacity of the TMJ. A person with an extremely deep bite of 7 mm, for example, has a longer mandibular opening movement up to the maximum, compared to that of a person with a normal vertical overbite of 2 mm. Knowledge of the participant's type of vertical overbite also adds information about morphologic characteristics of the jaws. This could be useful in future questionnaire studies on groups of patients with, for example, connective tissue disorders such as EDS or inherited muscular dystrophy disorders.

The estimated vertical overbite is a potential source of error. Only 6 people missed the correct diagnosis. The small variation of the mean, according to the confidence limits for both the deep overbites and the normal overbites, suggests that the estimation of the vertical overbite is not to be regarded as a major source of error. Extremely deep bites are rare in the adult population. Salonen et al reported a prevalence of deep bite of 4.6% in 699 adults (only those with gingival contact recorded).<sup>21</sup> This self-registration study did not

include any open bites. They are found in only 2.4% of an adult Swedish population.<sup>21</sup>

## Conclusions

It is suggested that the presented self-registration method of measuring maximum mandibular opening is useful. It is not a substitute for a clinical examination, but combined with other relevant data on masticatory function it may be valid for screenings in large population-based studies.

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