Reliability and Validity of a New Fingertip-Shaped Pressure Algometer for Assessing Pressure Pain Thresholds in the Temporomandibular Joint and Masticatory Muscles

Olaf Bernhardt, Dr Med Habil, PD
Assistant Professor
Department of Restorative Dentistry
School of Dentistry
University of Greifswald
Greifswald, Germany

Eric L. Schiffman, DDS, MS
Associate Professor

John O. Look, DDS, PhD
Senior Research Associate

Department of Diagnostic & Biological Sciences
School of Dentistry
University of Minnesota
Minneapolis, Minnesota

Correspondence to:
Dr Olaf Bernhardt
University of Greifswald
Department of Restorative Dentistry
Rotgerberstr. 8
17475 Greifswald, Germany
Fax: +49 3834 867171
E-mail: obernhar@uni-greifswald.de

Aims: *To test in vitro and in vivo the reliability and accuracy of a new algometer, the pressure algometer for palpation (PAP), for measuring pressure pain thresholds (PPTs) and to compare its features with those of a commercially available pressure algometer.* ***Methods:*** *For in vitro accuracy testing, 6 repeated measurements were made at 8 defined test weights from 0.5 to 5 lb. In vivo validity testing compared the PAP to a standard instrument, the hand-held Somedic algometer, at 16 sites including the masticatory muscles, the temporomandibular joints, and the frontalis (as the control site) in 15 temporomandibular disorder (TMD) cases and 15 controls. Intraexaminer reliability was also assessed for both algometers.* ***Results:*** *In vitro reliability was high, with coefficients of variation of < 5% and a single-measurement standard deviation of 2.1 kPa. Accuracy was also high, with PAP measurements correlating with test weights at* r = .99 (P < .001). *Repeated measures reliability in vivo was high, with intraclass correlation estimates of 0.73 to 0.96 for the PAP and 0.78 to 0.99 for the Somedic algometer. PPT values correlated moderately between the 2 devices (*r *ranged from 0.38 to 0.66;* P ≤ .05) *and were consistently higher for the PAP at all sites (*P < .001). *Differences between controls and TMD cases were also significant for both algometers (*P < .006). ***Conclusion:*** *Both the PAP and the Somedic algometer showed high reliability. Concurrent validity was demonstrated by statistically significant correlations between the devices. Both showed equally high capacity for differentiating TMD cases from controls. The PAP yielded significantly higher PPTs than the Somedic algometer.* J OROFAC PAIN 2007;21:29–38

Key words: algometry, pressure pain threshold, reliability, temporomandibular disorders, validity

Evaluation of muscle and joint tenderness by digital palpation is still one of the most important methods for establishing clinical diagnoses of myofascial pain, arthralgia, and osteoarthritis in the study of temporomandibular disorders (TMD). Former and current classification systems for TMD are mainly based on palpation techniques of the masticatory muscles as well as the temporomandibular joint (TMJ).[1–6] Although the reliability of palpation techniques applied to the masticatory muscles and the TMJ has improved in the last few years,[7–9] pressure algometry is a much more reliable method for the detection of pressure pain thresholds (PPTs).[10–15]

Many different techniques for the measurement of PPTs have been proposed during the past decades, and several types of mechanically and electronically operated pressure algometers have been developed.[11,13,16–22] However, the main disadvantage of most of the devices is that they do not simulate the natural palpation technique. They are large handheld devices that do not allow for the palpating finger to be directly placed on the anatomic site of interest. To date, only one fingertip adjustable pressure algometer, the "palpometer," has been tested for PPT measurements in the area of the head.[22] However, the sensor of this device does not have a fingertip-shaped design, and it is not commercially available.

The Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) examination guidelines[2] recommend that extraoral masticatory muscles and the TMJs be palpated using a specified amount of pressure applied by the index finger. Direct measurement and control of the applied pressure by the fingertip could be helpful for determining true fingertip pressure and for calibrating examiners. This would also be useful for clinical and epidemiologic studies. In order to address this need, a new pressure algometer, the pressure algometer for palpation (PAP) was developed. The PAP uses a thin, soft fingertip-shaped sensor that allows the examiner to palpate anatomical structures directly. The examiner is able to locate and feel the targeted structures and thus maintain the natural palpation technique. Further advantages of this new device are the ability to palpate intraoral structures, including the lateral pterygoid area, the tendon of the temporalis, and the posterior aspect of the TMJ inside the external auditory meatus. These sites are not easily accessible with conventional algometers. The aims of the study were to test in vitro and in vivo the reliability and accuracy of the PAP for measuring PPTs and to compare its features with those of a commercially available pressure algometer.

Materials and Methods

Subjects

Fifteen TMD patients (14 women and 1 man with a mean age of 33 ± 11.3 years) and 15 control subjects (14 women and 1 man with a mean age of 38 ± 10.8 years) took part in the study. Controls were selected to approximate the sex and age distributions of the cases. All participants had to be 18 years of age or older but less than 70 years. The cases were recruited from the TMD and Orofacial Pain Clinic, a tertiary care center at the University of Minnesota School of Dentistry, and from advertisements in the University of Minnesota's newspaper. This study was approved by the institutional review board (IRB) of the University of Minnesota for studies with human subjects, and all subjects gave their written consent to participate in the study. They then completed the RDC/TMD history questionnaire and underwent a clinical examination using the RDC/TMD examination protocol.[2] The examination included palpation of the masticatory muscles and the TMJs, range of mandibular motion measurements, and assessment of joint noises. These examinations were performed by an experienced orofacial pain dentist (ELS) with acceptable reliability for diagnosing myofascial pain and TMJ arthralgia.[23] The 2 examiners carrying out the algometry were not blinded to the subjects' TMD status (case versus control), but they were blinded to the measurement values obtained with the other PPT algometer (Somedic). The TMD patients were required to have a diagnosis of myofascial pain and/or arthralgia according to the RDC/TMD diagnostic classification system.[2] In addition, they were required to report that palpation duplicated their jaw pain complaints. Controls had to be free of pain symptoms in their masticatory muscles and TMJs during the prior 6 months, ie, no occurrence of jaw muscle or TMJ pain. Furthermore, they had to have a lifetime history of no limitation on opening due to locking or catching of the TMJs and no headache in the temporal area affected by the jaw movement, function, or parafunction in the last year. Any pain produced during clinical examination could not replicate pain that was familiar to the control subjects. No participants had used analgesics except acetaminophen for at least 3 days prior to the time of the testing. Participants who fulfilled these criteria were included in the study in the order they appeared at the clinic in response to the media announcements or as TMD patients requesting treatment. Some of the participants were employees of the School of Dentistry, but no staff from the TMD and Orofacial Pain Clinic participated as subjects.

The PAP sensor (ConTacts C-500 Tactile Sensor; Pressure Profile Systems) fits on the finger and has the shape of a fingertip; it is flexible and soft. It conforms to the anatomy of different finger tips and is thin so as not to obstruct the examiner's tactile sensitivity during the location and palpation of targeted anatomic sites. The pressure recording is based on capacitance measure. The device operates by means of an electrical charge stored

between 2 electrodes separated by an air gap. As the electrodes are moved closer to or farther from one another, the air gap changes and likewise the capacitance. The effective size of the sensor is the approximate area of a finger pad (1 cm^2) but, depending on the size of the finger pad of the examiner's finger, the amount of surface area in contact with the subject can vary. The sensor is attached to the examiner's finger with the aid of a finger cot (Nitrile Anti-Static Fingercots; QRP) and is connected to a measurement system (Fig 1). It includes a scale that shows the applied pressure in kPa. The device also has the capacity to apply pressure with a constant rate increase of 20, 30, 40, and 50 kPa/s, but this rate is not displayed at the same time as the PPT measurements. For the final production model of the PAP, both scales will be displayed simultaneously as for the Somedic device. For both the PAP and Somedic devices, the PPT is recorded at the instant that the subject pushes the control button. An electronic signal immediately stops the reading, and the actual pressure is indicated in the display. The examiner then withdraws the device. The PAP was calibrated by applying known weights to the sensors and measuring the voltage generated by the amplifier's circuits. Testing and controlling of the measurement accuracy of the device was performed using a balance scale (Pelouce, Model Z5) covered with a layer of foam rubber to represent human skin.

Six repeated measurements were taken at 8 different defined test weights from 0.5 to 5 lb., and the displayed pressure values were recorded. Regression analysis was performed, and mean pressure values with (standard deviations), coefficients of variation, and the standard deviation of a single measurement were calculated to estimate reliability and accuracy in vitro.

Procedures In Vivo

PPTs were assessed by 2 experienced examiners on all participants. One examiner used the newly introduced fingertip algometer, while the other used the Somedic algometer. The Somedic algometer consists of a gun-shaped handle with a pressure strain gauge at the tip. This device can be equipped with flat, round rubber tips that are available in 3 sizes. The rubber tip used for this study covered a surface of 1 cm^2.

PPT measurements were performed at 8 sites marked bilaterally on the head of the subjects with a surgical marker.

Anatomic localization of the sites was determined as follows:

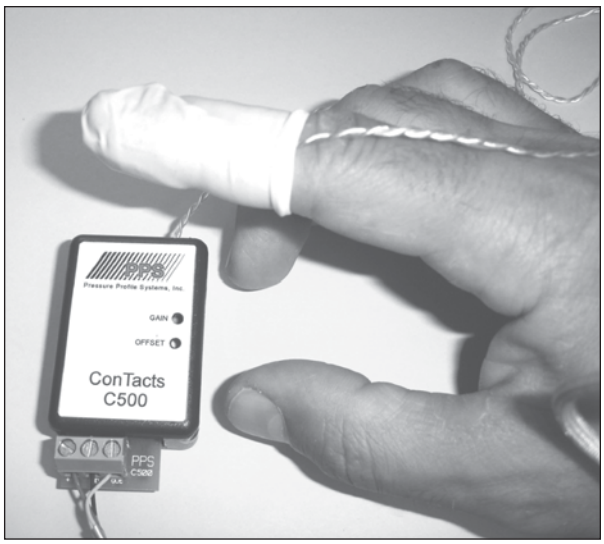

Fig 1 The sensor "ConTacts C-500" of the PAP attached to the index finger.

- Control site:
  - The *frontalis site* was located at the center of the forehead between the eyebrow and the hairline, vertically superior to the pupil.
- Extraoral masticatory muscle sites:
  - The *posterior temporalis site* was located 2 cm above the highest point of the ear.
  - The *middle temporalis site* was an area directly superior to the TMJ in the closed mouth position, at the same horizontal location as anterior temporalis site.
  - The *anterior temporalis site* was an area 1 cm posterior to the bony anterior border of the temporal fossa, located via the depression immediately lateral to the eye and immediately above the zygomatic process.
  - The *masseter origin site* was located 1 cm immediately anterior to the lateral pole of the TMJ in closed position and immediately below the zygomatic arch.
  - The *body of the masseter body site* was the area of greatest expansion during the contraction of the masseter.
  - The *masseter insertion site* was located 1 cm anterior and superior to the angle of the mandible.
- Joint site
  - The *lateral TMJ site* was the lateral pole of the condyle, located by finger palpation during slight opening and closing and/or protrusive movements of the jaw.

Table 1 Mean Pressure Values (± SD) for the PAP and Coefficients of Variation, According to Test Weight

Test weight (lb)	No. of measurements	Mean pressure (kPa)	SD	Coefficient of variation (%)
0.5	6	21.0	0.9	4.3
1.0	6	44.8	0.8	1.7
1.5	6	73.2	1.2	1.6
2.0	6	92.0	1.9	2.1
2.25	6	103.0	3.2	3.1
3.0	6	134.8	2.5	1.8
4.0	6	178.0	2.1	1.2
5.0	6	221.5	2.6	1.2

SD = Standard deviation.

The order in which the algometers were employed was selected using a random number table. The right side was tested first in all patients. All measurements with the PAP were made by 1 of the investigators (OB) using the right index finger for all measurement sites, and all measurements with the Somedic were made by another investigator (ELS), who is also right-handed.

Measurements of PPT were performed with gradually increasing pressures of about 30 kPa/s for both algometers. For the measurements, the subjects were placed in a supine position and were told to keep their teeth apart during palpation of their masticatory muscles and TMJs. The examiner was seated behind the subject's head. Each PPT measurement was taken twice, one immediately after the other. There was a 15-minute break between both the initial clinical examination and the first algometry measurement, and between the first algometry measurement and the second (with a different instrument used in each measurement session). For the intraexaminer reliability analysis, the PPT measurements were repeated for both devices on 10 of the 30 subjects (5 controls and 5 cases) following another 15-minute break.

Data Summaries and Statistical Analysis

The data for each measurement site represented the average of 2 repeated measures. This method has also been used by previous investigators.[24] For the comparison between controls and TMD cases, the reported value for the frontalis was the mean of the left and right sites; similarly, the mean for the TMJ was the average measurement for the left and right joints. The summary values for the temporalis and masseter muscles were each computed from the mean of 3 sites within each muscle and then averaged over the left and right sides. Differences between TMD cases and controls regarding age, education level, and marital status were examined with the Mann-Whitney test. For the reliability analysis, the intraclass coefficient (ICC) was calculated for each site between the first and the second measurement for both devices. The ICC values were classified as follows: < 0.4 = poor reliability, 0.4 to 0.75 = fair to good reliability, and > 0.75 = excellent reliability.[25] For the comparison of the 2 algometers, a paired *t* test was applied. In order to examine the level of correlation between the 2 devices, Pearson's correlation coefficients were calculated for each measurement site. For comparing TMD cases and controls, the independent sample *t* test was used. The *P* value for statistical significance was set at < .05. All calculations were performed with SPSS 11.0.2. for Macintosh.

Table 2 Reliability for Repeated Measurements with the PAP and the Somedic Algometer for the Investigated Sites

	PAP			Somedic		
		95% CI			95% CI	
Site	ICC	Lower	Upper	ICC	Lower	Upper
Right side						
Frontalis	0.73	0.22	0.92	0.82	0.44	0.95
Temporalis						
Posterior	0.74	0.46	0.93	0.78	0.33	0.94
Middle	0.73	0.24	0.93	0.92	0.71	0.97
Anterior	0.81	0.41	0.95	0.98	0.93	0.99
Masseter						
Origin	0.74	0.26	0.93	0.93	0.77	0.98
Body	0.76	0.29	0.93	0.82	0.44	0.95
Insertion	0.77	0.31	0.94	0.89	0.62	0.97
Lateral TMJ	0.80	0.38	0.95	0.93	0.73	0.98
Left side						
Frontalis	0.87	0.58	0.97	0.87	0.55	0.96
Temporalis						
Posterior	0.87	0.55	0.96	0.86	0.55	0.96
Middle	0.82	0.43	0.95	0.86	0.54	0.96
Anterior	0.96	0.85	0.99	0.94	0.79	0.98
Masseter						
Origin	0.85	0.51	0.96	0.86	0.54	0.96
Body	0.92	0.72	0.98	0.92	0.74	0.98
Insertion	0.96	0.85	0.99	0.80	0.38	0.95
Lateral TMJ	0.93	0.75	0.98	0.96	0.86	0.99

ICC = Intraclass coefficient.

Results

The in vitro accuracy of the PAP was demonstrated by the high linear correlation between the applied weight and the recorded pressure ($r = 0.99$, $P < .001$). In vitro reliability of the PAP was established based on 3 observations: The standard deviations of the mean pressure values were extremely low for all test weights, the coefficient of variation of the pressure measurements was below 5% for every weight (Table 1), and the standard deviation of a single measurement for this test series was only 2.1 kPa.

For the in vivo results, there was no statistical difference between the TMD cases and the controls regarding age, race, education level, marital status or income (Mann-Whitney test, $P > 0.1$). The distribution of TMD diagnoses among the cases included 9 subjects with myofascial pain and bilateral arthralgia, 3 with myofascial pain and unilateral arthralgia, 2 with myofascial pain only, and 1 with unilateral arthralgia.

Reliability analyses of repeated PPT measurements were excellent (ICC > 0.75) for almost all measurement sites evaluated for both algometers. Table 2 indicates that 12 of 16 sites evaluated with the PAP showed excellent reliability (> 0.75); the remaining 4 sites had good reliability (≥ 0.73). The PAP showed slightly higher ICC values for the left side compared to the right one.

Differences between the PPTs of the 2 devices were consistent and highly significant ($P < .001$) for all measurement sites, with mean differences ranging from 51.2 to 99.5 kPa (Table 3). There was a significant correlation between the two devices at all measurement sites with values ranging between 0.38 and 0.66. The correlation coefficients for the left side were slightly lower than those for the right side. However, correlation between the 2 devices was highly significant for all sites except for the frontalis and middle temporalis, where correlation was significant but not highly significant.

Table 3 Paired Differences in kPa and Correlation Coefficients Between the PAP and the Somedic Algometer for All Test Sites (n = 30)

Site	Mean	SD	95% CI Lower	95% CI Upper	*P*	Correlation
Right side						
Frontalis	75.0	60.1	52.5	97.4	< .001	0.64**
Temporalis						
Posterior	64.2	89.3	30.8	97.6	< .001	0.49**
Middle	78.8	62.8	55.4	102.2	< .001	0.64**
Anterior	71.6	66.6	46.8	96.5	< .001	0.59**
Masseter						
Origin	61.3	61.7	38.3	84.3	< .001	0.57**
Body	54.6	54.0	34.5	74.8	< .001	0.58**
Insertion	57.8	62.3	34.6	81.1	< .001	0.50**
Lateral TMJ (closed)	65.8	48.4	47.7	83.8	< .001	0.66**
Left side						
Frontalis	93.9	71.5	67.2	120.6	< .001	0.42*
Temporalis						
Posterior	99.5	86.6	67.2	131.8	< .001	0.53**
Middle	92.7	80.1	62.8	122.6	< .001	0.38*
Anterior	66.9	63.7	43.1	90.7	< .001	0.56**
Masseter						
Origin	61.9	59.2	39.8	84.0	< .001	0.61**
Body	51.2	61.6	28.3	74.2	< .001	0.56**
Insertion	55.8	68.3	30.3	81.3	< .001	0.47**
Lateral TMJ	69.7	59.4	47.5	91.9	< .001	0.64**

**$P \leq .01$, *$P \leq .05$ (2-tailed).

Table 4 Comparison of PPTs in kPa Between TMD Cases and Controls for the Summarized Test Sites for the PAP and the Somedic Algometer

Site	Cases (n = 15) Mean	Cases (n = 15) SD	Controls (n = 15) Mean	Controls (n = 15) SD	*P*
PAP					
Frontalis	215.6	32.6	303.8	51.4	< .001
Temporalis	222.7	43.3	298.9	57.8	< .001
Masseter	169.5	36.7	241.4	63.2	< .001
Lateral TMJ	165.0	39.6	242.7	68.3	< .001
Somedic					
Frontalis	139.3	40.2	211.3	67.2	< .002
Temporalis	144.4	59.6	219.0	76.1	< .006
Masseter	115.5	39.2	179.5	55.9	< .001
Lateral TMJ	106.7	32.2	165.5	51.4	< .001

Figures 2 to 5 display medians, interquartile ranges and outliers of the summarized measurement site values of controls and TMD cases for both algometers. Differences in PPTs between controls and TMD cases were also statistically significant (Table 4) for both algometers in all 4 areas evaluated (frontalis, temporalis, masseter, and TMJ). The temporalis and frontalis sites showed even higher significance levels for the PAP compared to the Somedic algometer.

Based on the mean values of the PPT measurements, the PAP delivered about 50% higher PPT values for the cases compared to the Somedic, and about 40% higher values for the controls. These values were consistent for all measurement sites.

Discussion

The introduction of a new measurement device requires scientific evidence of its reliability and validity. The in vitro test of the PAP revealed a measurement accuracy as good as the previously developed fingertip algometer.[22] However, the

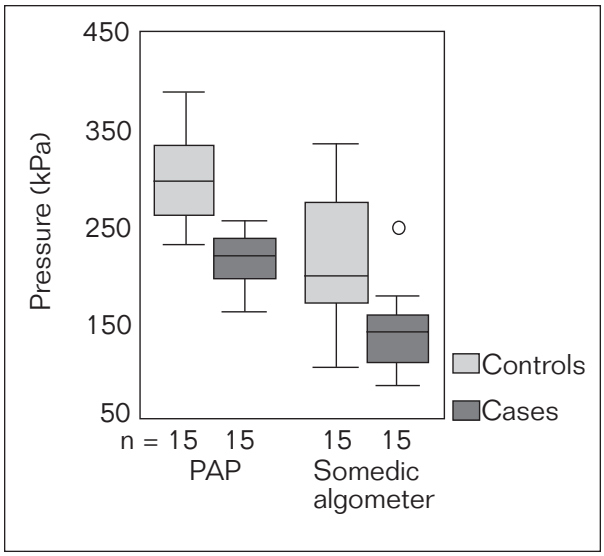

Fig 2 Medians, interquartile ranges, and outliers of the averaged frontalis site for both algometers. The difference between cases and controls was significant for both the PAP ($P < .001$) and the Somedic ($P < .002$).

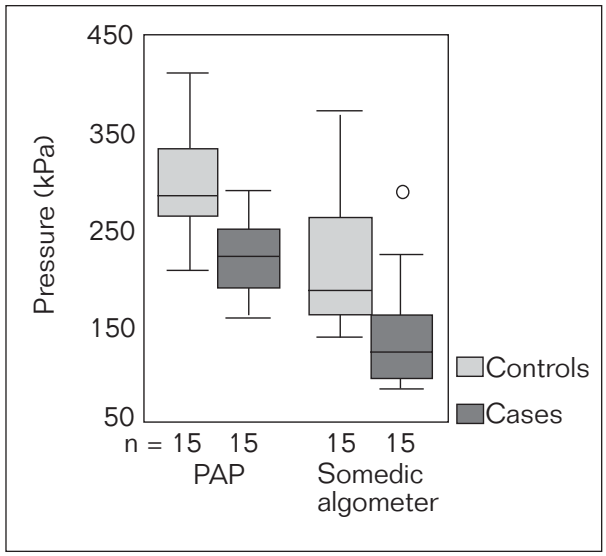

Fig 3 Medians, interquartile ranges, and outliers of the averaged temporalis site for both algometers. The difference between cases and controls was significant for both the PAP ($P < .001$) and the Somedic ($P < .006$).

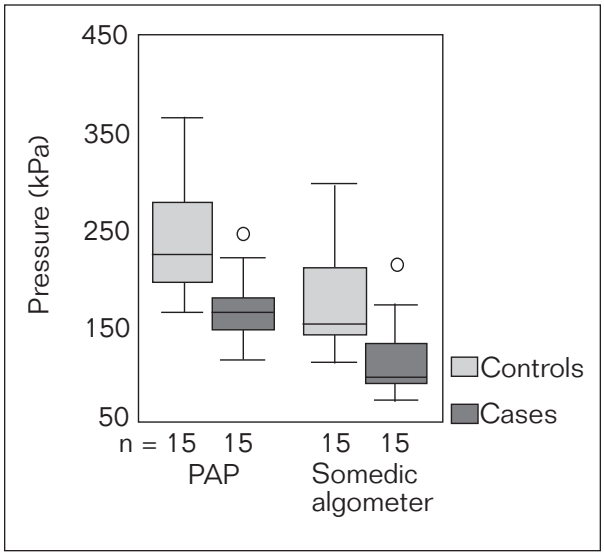

Fig 4 Medians, interquartile ranges, and outliers of the averaged masseter site for both algometers. The difference between cases and controls was significant for both the PAP ($P < .001$) and the Somedic ($P < .001$).

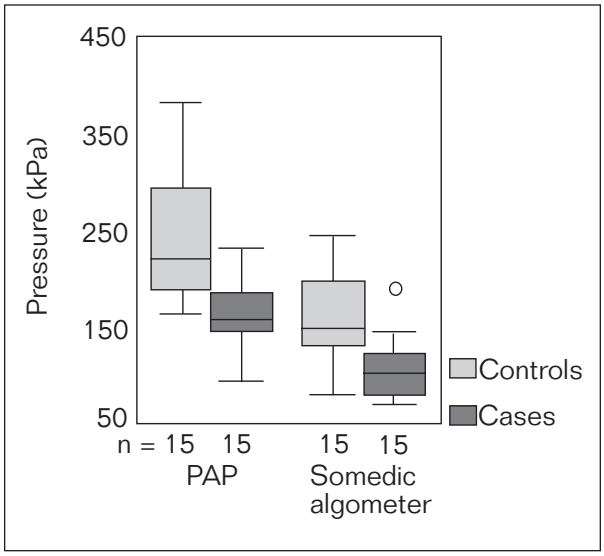

Fig 5 Medians, interquartile ranges, and outliers of the averaged TMJ site for both algometers. The difference between cases and controls was significant for both the PAP ($P < .001$) and the Somedic ($P < .001$).

advantage of the PAP is its direct display of the applied pressure in kPa and its ability to measure pressures applied to the entire contact surface of the palpating fingertip. The palpometer tested by Bendtsen and colleagues displayed the output in arbitrary units, and another algometer was used to relate the arbitrary units to actual force.[22] This might be 1 of the reasons why this device did not come into widespread use. The PAP does not require a second algometer for calibration of the device. The pressure is displayed directly in kPa.

Although the time needed for measurements was not formally tested, measurement with the PAP did not seem to be more time consuming than with the Somedic system. As shown from the consistency of the control measurements, recalibration of the PAP was not necessary between measurement of the subjects. Only a resetting of the display to zero was required.

Reliability and validity of the new device were tested in vivo, in comparison to the widely used and validated Somedic algometer.[26,27] The ICCs for the intraexaminer comparison of PPTs of the masticatory muscles and the TMJ showed good to excellent reliability for the Somedic algometer, as previously reported.[11,18,24,27] The same reliability was observed for the PAP. Furthermore, Antonaci and colleagues[15] achieved the same excellent intraexaminer reliability (ICC between 0.75 and 0.91 for several muscle sites) with a handheld algometer that had a flat rubber-covered tip like that of the Somedic algometer used in the study. However, their interexaminer reliability was not as high.[15]

Minor side differences were observed with the PAP, showing slightly higher reliability for PPT measurements of the subject's left side. This phenomenon was not seen in the ICC values for the Somedic algometer and has not been reported in other studies. Although the investigator was trained to apply his right index finger with the sensor to the skin in a consistent manner, the angle at which the finger of the investigator, who was right-handed, was applied might have influenced the pressure reading. Furthermore, all measurements started at the subject's right side followed by the left, and this could also have influenced the results.

In several studies of the reproducibility and validity of PPT measurements, algometers have been compared to fingertip palpation techniques.[13,18,28] Other studies have compared measurements at ipsilateral sites with those at contralateral control sites using the same algometer.[14,27,29] Some authors have also compared PPTs of patients with those of nonpatients and found gender differences regarding PPTs.[18,27] Direct comparison of 2 algometers for PPT measurement in a sample of TMD patients has only been reported once before.[30] However, these authors used only different tips for the same algometer, and they evaluated PPTs of only the posterior aspect of the TMJ.

Some studies have proposed methods to control for variables that can influence the measurements of PPTs. These methods include applying pressure at a constant rate increase ranging from 20 to 50 kPa/s and having the subjects keep their teeth apart during the examination.[10,23,24,27,31–34] The current study incorporated these methods into its study design. Finally, although not done in this study, the PAP alone, in contrast to the Somedic algometer, allows for assessment of intraoral structures, including the pterygoid muscles and the tendon of the temporalis.

PPT values measured with the PAP were significantly higher compared to the Somedic algometer. This result was consistent for all examined muscle and joint sites. The reason for the higher PPTs being observed with the PAP sensor could be due to the softer fingertip surface that adjusts better to tissue structures than the round, flat, and relatively sharp-edged tip of the Somedic algometer. Similar results were found when fingertip palpation was compared with an algometer that had a flat and round tip like the Somedic algometer.[28] In this study,[28] fingertip palpation and algometry was applied to all subjects with the same pressure. However, the subjects reported more extreme pain word descriptors for the Somedic algometer. The authors concluded that 1 possible explanation was that the harder and less resilient tip may have provided increased loading levels per square centimeter (especially at the edges if the tip were not perfectly perpendicular to the surface of the skin) compared to the examiner's fingertip pad. Since the diagnosis of tenderness of the masticatory muscles and the TMJ is based on a specified palpation pressure, it is important that the pain response would be only to the pressure and not to a function of variation in loading dependent on the sensor tip placement or the design.

Compared to the Somedic algometer, the PAP delivered PPT values that were about 50% higher for the TMD cases and about 40% higher for the controls. There might be several reasons for the 10% difference between cases and TMD controls.

First, the curve of the measurement scale of the PAP might be less linear for very high values. Second, the difference in observed pain thresholds is likely a function of the difference in pressure deformation of the contact surfaces of the algometers. As for all digital palpation techniques, the surface of the fingertip with the sensor flattens and enlarges at the higher pressures. The present data indicate that the pain threshold was more quickly reached when the harder tip of the Somedic algometer was used. It is reasonable to predict that this effect would be less in controls with their lower pain susceptibility, and this is what the present data seem also to suggest.

Pearson's correlation coefficients were applied for direct comparison of the 2 devices, since a linear relation between them had to be assumed. The correlation coefficients indicated a moderate relationship between the 2 devices for all measurement sites. Higher values could not be expected, since slightly higher coefficients were achieved only in a direct correlation of the left and right sides for each algometer (data not shown). The correlation

coefficients were higher for some sites and lower for others. There is no specific explanation for why the left middle temporalis and the left frontalis had lower correlation coefficients compared with the corresponding right sites. One reason might be that the examiners measured more consistent values on the right site of the patient, since both examiners were right handed. Values of the right and left measurements were not summed before the correlation coefficients were calculated. Furthermore, Bland and Altman plots were drawn for all sites. In these plots, the differences between the values measured with the 2 devices were plotted against the averages of the measurements to assess for systematic error. None of the plots showed evidence of any systematic bias (plots not presented).

As noted, the examiners were blinded to each other's measurements but were aware of the case versus control status of the subjects. The absence of systematic error with the direct comparison of the 2 devices suggests that the examiners' awareness of subject status did not bias the measurements.

For all measurements, the sensor was held in place with a finger cot. This method assured the best handling of the device, not only to stabilize the sensor over the fingertip, but also to keep the electrical wire leads from interfering with the examination. For PPT measurements, the finger cot seems sufficient because only the examiner's fingertip comes into contact with the patient. Although not tested, latex gloves would also provide a safe fixation of the sensor at the fingertip. However, putting on the gloves with the sensor would certainly be more difficult compared to the finger cot. It would be easier to first stabilize the sensor with the finger cot, and then place the latex glove.

According to the RDC/TMD, extraoral palpation is to be carried out with the last phalanx of the index finger with a pressure of 2 lbs (89 kPa) to masticatory muscles and with 1 lb (44 kPa) to the TMJ and intraoral muscles for the determination of muscle and joint tenderness.[2] The Somedic algometer yielded mean PPTs in TMD cases for the examined muscles of 116 to 144 kPa and a mean PPT of 107 kPa for the TMJ. Other studies using the Somedic algometer have reported mean values of between 96 and 108 kPa for the masseter and temporalis muscles in myofascial pain patients and between 144 and 146 kPa for the TMJ in arthralgia patients.[27,33] However, PPTs in TMD cases established with the fingertip algometer were much higher. Thus, the pressures of 1 and 2 lbs specified in the RDC/TMD may be questioned; these pressures may not be sufficient for differentiation between painful and nonpainful tissues, as has already been reported.[23] Other authors have used higher standard pressures for fingertip palpation procedures.[28]

For both algometers, PPTs were significantly lower for TMD cases than for the control subjects, as in earlier studies.[14,27,33] For the masseter and TMJ sites, differences between PPTs in cases and controls reached the same significance with both algometers. For the temporalis and frontalis sites, differences between cases and controls showed an even higher significance level for the PAP.

The use of pressure algometry for establishing a diagnosis in painful TMD patients may be rather limited due to relatively high standard deviations associated with the PPT mean values in vivo (Table 3). Also, Farella and associates estimated a sensitivity of 0.67 and a specificity of 0.85 for the Somedic algometer; this level of sensitivity appears to be too low for a diagnostic instrument.[33] Nonetheless, both the PAP and the Somedic algometer are appropriate for assessing PPTs for clinical and epidemiologic studies.

Conclusions

The 3 parameters used in this study, standard deviation of the mean pressure values, coefficients of variation, and the standard deviation of a single measurement, all indicated a high measurement reliability of the PAP in vitro. Testing of the fingertip algometer PAP in comparison to the Somedic algometer revealed a high reliability of both instruments. The concurrent validity of the PAP was supported by its statistically significant correlation with the Somedic algometer at all test sites. Validity of both algometers was demonstrated by their ability to differentiate between TMD cases and controls. This study also demonstrated that standard fingertip pressure leads to significantly higher PPTs than the use of an algometer with a flat rubber tip surface. The main advantage of the PAP over the Somedic algometer is that it has a soft surface and fingertip-shaped form, which allows direct fingertip palpation of tissues and structures. However, further studies with the PAP are necessary to test its reliability and measurement accuracy with larger sample sizes and its stability after long-term use.

Acknowledgments

This study was supported by funds from the University of Minnesota, School of Dentistry, Divisions of TMD and Orofacial Pain, and by the Alfried Krupp von Bohlen and Halbach Foundation, Essen, Germany. The authors would also like to thank Amanda Jackson for her assistance with coordinating this study.

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