Comparison of Techniques for Evaluation of Deep Pain Sensitivity in the Craniofacial Region

Simple Futarmal Kothari, BDS
PhD Fellow
Section of Clinical Oral Physiology
Department of Dentistry
Aarhus University, Aarhus, Denmark

Mohit Kothari, BDS
PhD Fellow
Section of Clinical Oral Physiology
Department of Dentistry
Aarhus University, Aarhus, Denmark

Lene Baad-Hansen, DDS, PhD
Associate Professor
Section of Clinical Oral Physiology
Department of Dentistry
Aarhus University, Aarhus, Denmark

Peter Svensson, DDS, PhD, Dr Odont
Professor
Section of Clinical Oral Physiology
Department of Dentistry
Aarhus University, Aarhus, Denmark, and
Center for Functionally Integrative Neuroscience (CFIN)
MindLab
Aarhus University Hospital
Aarhus Denmark

Correspondence to:
Dr Simple Futarmal Kothari
Section of Clinical Oral Physiology
Department of Dentistry
Aarhus University
Vennelyst Boulevard 9
DK-8000, Aarhus C
Denmark
Fax: +45 8619 5665
Email: simple.futarmal@odontologi.au.dk

Aims: *To determine whether a new palpometer and manual palpation can detect site-to-site differences in human craniofacial pain sensitivity in a similar pattern to that of an electronic pressure algometer and subsequently to compare between-session and within-session variability of palpometer and manual palpation.* ***Methods:*** *Sixteen volunteers participated. Experiment 1 was carried out in two sessions. In session 1, pressure pain thresholds (PPT) were determined with a pressure algometer at nine craniofacial sites. Manual palpation and the palpometer were then applied to all sites, and subjects scored perceived pressure/pain on a 0 to 100 numerical rating scale (NRS). Mean scores were compared using analysis of variance (ANOVA). Ten of the volunteers were recalled for a second session and the same protocol was carried out except for assessment of PPTs to establish between-session variability. In experiment 2, three craniofacial sites were examined using the palpometer and manual palpation. Both techniques were repeated 10 times at each site and coefficient of variation (CV) was compared to determine within-session variability.* ***Results:*** *There were no significant differences in NRS scores evoked by manual palpation or palpometer at any test site between repeated sessions. The CV varied between techniques, with lower within-session variability for the palpometer compared with manual palpation (*P = .*03).* ***Conclusion:*** *The palpometer and manual palpation could detect differences in craniofacial sensitivity in healthy subjects, with no significant differences between repeated sessions. All techniques showed the highest sensitivity at the retromandibular site and the lowest at the temporalis muscle site. The palpometer had lower within-session variability compared with manual palpation.* J OROFAC PAIN 2012;26:225–232

Key words: algometer, numerical rating scale, palpation, palpometer, temporomandibular disorders

Pain from myofascial tissue is perhaps the most common complaint encountered in medical and dental practice.[1] Therefore, evaluation of tenderness and pain by palpation is an important part of myofascial pain research and clinical examination. In fact, the classification of temporomandibular disorders (TMD) is mainly based on palpation techniques of the masticatory muscles and temporomandibular joints (TMJs).[2–4] A precise quantification of tenderness and pain is, however, difficult.[5] The degree of tenderness elicited by palpation is determined by several factors, among which the pressure intensity exerted by the observer is probably the most important one. The palpation pressure cannot easily be measured or standardized within or between observers and is therefore a potential problem.[1] To overcome this problem, the reliability of palpation techniques applied to the masticatory muscles and the TMJ has been improved to a greater extent with the development

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Fig 1a A new palpometer with circular metal stamp with a probe area of 1 cm².

Fig 1b The circular metal stamp in contact with the spring coil, which is calibrated to either 0.5, 1.0, or 2.0 kg.

of many new techniques.[6,7] Although manual palpation is the most common method to assess deep pain sensitivity in muscles and joints in the clinical examination of various TMD and other musculoskeletal pain conditions, such as tension-type headache and fibromyalgia,[6,8] it also has limitations that can influence the outcome; these include patient bias, examiner expectancies, instructions, different examination techniques, and psychologic state.[9] Many techniques other than manual palpation have been proposed for the assessment of deep pain sensitivity, eg, numerous electronically and mechanically operated algometers.[10–14] The main disadvantages with the available pressure algometers are difficulty in handling the instrument, costs, design, and amount of time needed to perform the diagnostic method by the examiner.

In a previous study, a new purely mechanical device, termed the palpometer, was introduced as a new technique for evaluation of differences in craniofacial sensitivity in relation to manual palpation and a pressure algometer.[15] Advantages of this device are that it is small, nonelectrical/purely mechanical, lightweight, low cost, and easily carried.

The aims of this descriptive study were first to demonstrate site-to-site differences in craniofacial pain sensitivity with an electronic pressure algometer (experiment 1, session 1) in accordance with several other studies.[16–18] The craniofacial sites were limited to the extraoral sites described in the Research Diagnostic Criteria for TMD (RDC/TMD).

The second aim was to test if manual palpation and the new palpometer could equally well detect the expected site-to-site differences in a similar pattern as shown by the electronic pressure algometer (experiment 1, session 1). The third aim was to test if there were differences between repeated sessions in craniofacial sensitivity assessed with the palpometer and manual palpation (experiment 1, session 2). The final aim was to test for differences in within-session variability between the palpometer and manual palpation (experiment 2, session 1).

Materials and Methods

Subjects

Sixteen healthy dental students, eight men and eight women (mean age, 27 years; range 19 to 36 years) participated in the study. The students completed the RDC/TMD history questionnaire and underwent a clinical examination using the RDC/TMD examination protocol.[6] The examination included palpation of masticatory muscles and the TMJs, range of mandibular motion measurements, and assessment of joint noises. The subjects selected had to be free of pain symptoms in their masticatory muscles and TMJs during the previous 6 months. Furthermore, they had to have a lifetime history of no limitation on jaw 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 past year. They also had to be free of any musculoskeletal or rheumatologic diseases. Participants who fulfilled these criteria were included in the study. Ten of the healthy subjects (five men and five women) participated in a subsequent session 2 months after the first session. In accordance with the Helsinki Declaration, ethical approval was obtained and all participants consented to participate in the study.

Apparatus

Three new palpometers were used in the experiments.[15] They were calibrated to deliver a pressure load of 0.5, 1.0, or 2.0 kg. The new palpometers (Fig 1a) consisted of a plastic cylindrical shell in which there was a spring. The spring was made of stainless steel with a spring constant of 0.58 N/mm. The spring was in contact with a circular metal stamp (10 mm in diameter, made of aluminum) which was in contact with the surface of the structure to be palpated (Fig 1b). In the other end of the cylinder, there was a hole through which the stamp-tapering

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Table 1 Goals, Sites, Side, and Techniques Used for the Two Experiments

Experiments	Goals	Sites	Side	Techniques used
1. Site-to-site differences				
Session 1	To detect site-to-site differences with the algometer and test if manual palpation and palpometer could identify the expected site-to-site difference	1. Posterior temporalis 2. Middle temporalis 3. Anterior temporalis 4. Superior masseter 5. Middle masseter 6. Inferior masseter 7. TMJ 8. Retromandibular site 9. Submandibular site	Right and left	1. Electronic pressure algometer 2. Manual palpation 3. Palpometer
Session 2	To test for between-session variability	1. Posterior temporalis 2. Middle temporalis 3. Anterior temporalis 4. Superior masseter 5. Middle masseter 6. Inferior masseter 7. TMJ 8. Retromandibular site 9. Submandibular site	Right and left	1. Manual palpation 2. Palpometer
2. Within-session variability				
Session 1	To compare within-session variability	1. Anterior temporalis 2. Middle masseter 3. TMJ	Right	1. Manual palpation 2. Palpometer

end could be pushed out. When the examiner felt the tapering end on the finger, it corresponded to the pressure force of 0.5, 1.0, or 2.0 kg, respectively. The palpometer is intended to be held perpendicularly to the skin surface with the thumb and middle finger. The examiner can detect the tapering end with the index finger when the correct pressure is applied. Each palpometer weighs 25 g and is 5 cm high and 2 cm in diameter. A patent has been filed for the device (USPTO #61/293,299).[15] Manual palpation with the index finger was also done in the experiments in accordance with the RDC/TMD. The examiner conducting the manual palpation was an experienced orofacial pain dentist and was carefully trained for the examination techniques. When the study started, the examiner had shown the ability to apply a standardized amount of pressure needed to palpate muscle sites and the TMJ.

An electronic pressure algometer (Somedic, Type II) was used to measure pressure pain thresholds (PPT) in subjects. The PPT was determined as the intensity at which the pressure stimulus applied to skin changed from a sensation of pressure to pain.[18] It consists of a gun-shaped handle with a pressure strain gauge at the tip. The device is equipped with a flat, round rubber tip with a surface of 1 cm^2. The handheld part is provided with a small LED window on which the rate of applied pressure is displayed in kilopascals (kPa). The examiner is able to maintain a constant application rate by keeping the "+" sign in the middle of the LED window.[19] The handheld part has buttons for start, reset, and switch and is connected with a transmission wire to a stop button attached with a cord. The subjects indicated the PPT by pressing the stop button, which froze the current pressure readings on the digital display.

Clinical Procedure

The study comprised two experiments (Table 1). Only the first experiment was repeated in two sessions; the second experiment was carried out in a single session. An electronic pressure algometer was used only in experiment 1, session 1. Manual palpation and palpometer were used during both sessions in the first experiment and also during experiment 2.

PPT was measured using an electronic pressure algometer. The pressure was gradually increased on each site until the subject reported the pressure to be painful. Subjects were carefully instructed with regard to the use of algometer and detection of PPT.

For manual palpation, the examiner standardized the index finger pressure to 0.5 kg for use on the TMJ and 1.0 kg for use on the temporalis and masseter muscle with the help of a weight scale before each experiment. All the test subjects received

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a thorough instruction in the use of a categorical scoring scale for pain (0 to 3, where 0 = none, 1 = mild, 2 = moderate, 3 = severe pain) and a 0 to 100 numerical rating scale (NRS), where 0 = no pain, 50 = just barely painful, ie, pain threshold, 100 = most pain imaginable). Both scales were drawn on a piece of A4 paper that was then used as a visual guidance throughout all the experiments by each subject. The 0 to 100 NRS has been described and used in several previous studies.[20–23] This scale was chosen to include both nonpainful and painful sensations in one scale. All subjects affirmed that they understood the scale.

Test sites were marked on the craniofacial region prior to each experiment. Rectangular labels were then glued on each side of the temples to prevent hair moving the marked test sites on the temples. The test sites were palpated perpendicularly in a random sequence and a circular label was placed on each test site (10 mm in diameter).

Experiment 1

This experiment was carried out to detect site-to-site differences with the pressure algometer and subsequently test if manual palpation and palpometers could equally well identify the expected site-to-site differences. Thus, in the first session of this experiment, nine different craniofacial musculoskeletal sites according to the RDC/TMD description were palpated/examined perpendicularly using the three different techniques in all 16 subjects (Table 1).

First, an electronic pressure algometer was used on each test site and the PPT values were recorded. This device was used in only the first session of experiment 1. Thereafter, manual palpation of each test site was carried out. A force of 0.5 kg was applied to every test site except for the temporalis and masseter muscle where 1.0 kg of force was applied according to the RDC/TMD. Subsequently, the new palpometers were tested. The palpometer that delivered a force of 1.0 kg was applied to the temporalis and masseter muscle while the other palpometer, which delivered a force of 0.5 kg, was applied to the remaining test sites. In both techniques, the NRS and categorical scale scores were registered and the sequence was always manual palpation before the palpometers. Manual palpation and the palpometers were used in both sessions of experiment 1.

A second session was carried out 2 months after the first session to test for between-session variability for both the palpometer and manual palpation. Here, an electronic pressure algometer was not used. Five men and five women who had participated in session 1 were recalled to participate in the second session (Table 1). The exact same protocol as in session 1 was followed except for assessment of PPTs.

Experiment 2

This experiment was designed to compare the within-session variability between manual palpation and palpometer. This experiment was carried out in a single session (Table 1). All 16 subjects participated in this experiment. Three of the nine test sites on the right side of the craniofacial region were examined/palpated in this experiment with two different techniques (Table 1). The techniques were applied randomly to the sites and also the sites were examined randomly. This was done 10 times for each technique at each site. A short pause of approximately 10 to 15 seconds was given between each measure to avoid sensitization of the test sites. The anterior part of the temporalis muscle and the middle part of the masseter muscle were palpated with 1 kg of force while the TMJ was palpated with a force of 0.5 kg (palpometer/manual palpation). NRS values were recorded for both techniques.

Statistical Analyses

For detection of the site-to-site differences by the use of an electronic algometer, the PPT values were compared with two-way analysis of variance (ANOVA). The factors in the ANOVA were sites (nine) and sides (two). Then, to compare the palpometer and manual palpation for detection of site-to-site differences, the NRS scores of both techniques were analyzed with a three-way ANOVA with repeated measures. The factors in the ANOVA were techniques (two), sites (nine), and sides (two). As the palpometer and manual palpation categorical scale scores were not normally distributed, the Friedman test followed by Wilcoxon matched paired test was used to compare between sites, techniques, and sides. To compare between the two sessions for detection of site-to-site differences in craniofacial sensitivity, NRS scores from the palpometer and manual palpation were compared using four-way ANOVA. The factors in the ANOVA were sessions (two), techniques (two), sites (nine) and sides (two). Finally, for assessment of the within-session variability between the palpometer and manual palpation, coefficients of variation (CVs) were compared between the techniques (two) and sites (three) with two-way ANOVA. When appropriate, the ANOVAs were followed by post-hoc Tukey tests with adjustment of multiple comparisons. The level of significance was set at $P < .05$.

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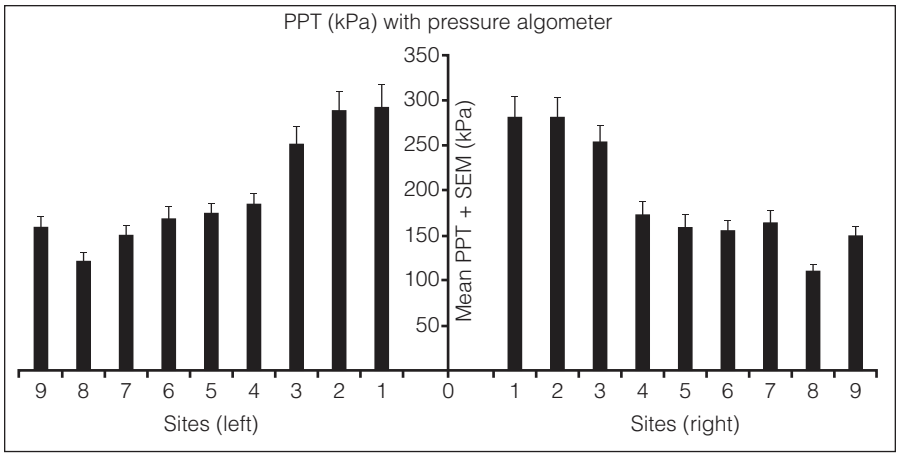

Fig 2 PPT (kPa) scores of nine sites (1: posterior temporalis, 2: middle temporalis, 3: anterior temporalis, 4: superior masseter, 5: middle masseter, 6: inferior masseter, 7: TMJ, 8: retromandibular site, 9: submandibular site) for site-to-site differences in session 1 using electronic pressure algometer. Mean values (n = 16) and SEM are shown. There was no significant difference between left and right side.

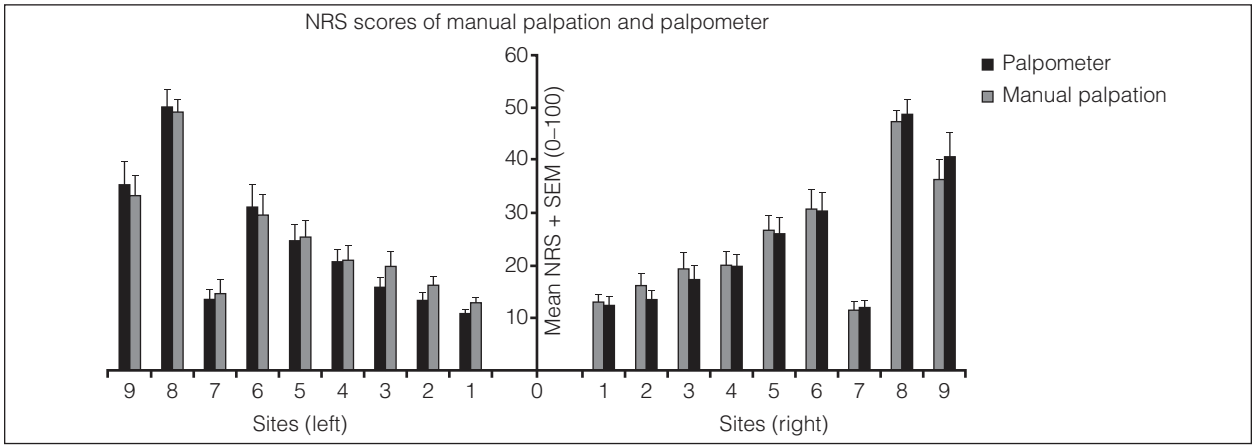

Fig 3 NRS (0 to 100) scores of nine sites (1: posterior temporalis, 2: middle temporalis, 3: anterior temporalis, 4: superior masseter, 5: middle masseter, 6: inferior masseter, 7: TMJ, 8: retromandibular site, 9: submandibular site) for site-to-site differences in session 1 using manual palpation and palpometer. Mean values (n = 16) and SEM are shown. There was no significant difference between the techniques and also between left and right sides.

Results

Experiment 1

The ANOVA of the PPT values showed that there was a significant effect of site (F = 49.358, $P < .001$), no significant effect of side (F = 2.323, $P = .148$), and no significant interaction between site and side (F = 0.845, $P = .565$). Post-hoc tests for site showed that the PPT values on the temporalis muscle (posterior, middle, and anterior) were significantly higher (less sensitive) than all other sites ($P < .001$) and that the PPT values at the retromandibular site were significantly lower (more sensitive) than all other sites ($P < .001$) except for the submandibular site ($P = .068$) (Fig 2).

When the NRS scores from the palpometer and manual palpation were compared, the ANOVA showed that there was no significant effect of technique (F = 0.339, $P = .569$). However, there was a significant effect of site (F = 38.759, $P < .001$) and no significant effect of side (F = 0.276, $P = .606$). There was a significant interaction between technique and site (F = 3.722, $P < .001$). Post-hoc tests for sites revealed that the NRS scores of the temporalis muscle (posterior, middle, and anterior) and superior masseter were significantly smaller (ie, less sensitive) than the inferior masseter, retromandibular, and submandibular sites ($P < .001$). The NRS scores of the middle masseter were significantly higher (more sensitive) than the posterior and middle temporalis ($P < .004$). The NRS scores of the TMJ were significantly smaller than the middle and inferior masseter, retromandibular, and submandibular sites ($P < .001$). The NRS scores of the submandibular site were significantly different from all

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Table 2 Frequency of Subjects Reporting Scores 0, 1, 2, or 3 on a Categorical Scale for Two Different Techniques at Nine Sites

Technique	Manual palpation						Palpometer					
Side	Left			Right			Left			Right		
Categorical scale score	0	1	2,3	0	1	2,3	0	1	2,3	0	1	2,3
Posterior temporalis	16	–	–	16	–	–	16	–	–	16	–	–
Middle temporalis	16	–	–	16	–	–	16	–	–	16	–	–
Anterior temporalis	15	1	–	15	1	–	16	–	–	16	–	–
Superior masseter	16	–	–	16	–	–	16	–	–	16	–	–
Middle masseter	15	1	–	15	1	–	14	2	–	14	2	–
Inferior masseter	12	4	–	13	3	–	12	4	–	13	3	–
TMJ	16	–	–	16	–	–	16	–	–	16	–	–
Retromandibular site	4	12	–	6	10	–	6	10	–	5	11	–
Submandibular site	12	4	–	11	5	–	11	5	–	10	6	–

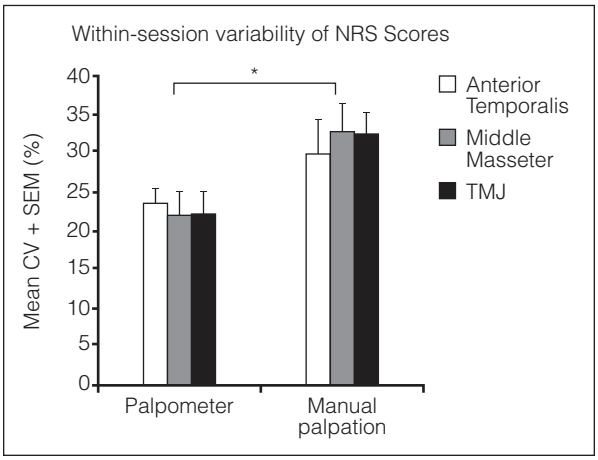

Fig 4 Within-session variability with CVs of three sites for two different techniques. The new palpometer showed lower within-session variability compared to manual palpation (P = .03). *indicates significantly different from each other. Mean values (n = 16) and SEM are shown.

other sites (P < .001) except the inferior masseter (P = .447). The NRS scores of the retromandibular site were significantly higher than all other sites (P < .001). A post-hoc test of the interaction between technique and site did not demonstrate differences in NRS scores between the techniques for the sites (Fig 3).

The Friedman test for categorical scale scores of manual palpation and palpometer showed that there was no significant difference between the techniques or sides. However, there was significant difference between the sites (P < .001) for both techniques. Further, Wilcoxon matched paired test for sites showed that the retromandibular site had significantly higher scores than all other sites (P < .001) and the submandibular site had significantly higher scores than the posterior, middle, and anterior temporalis, superior masseter, and the TMJ (P < .001) (Table 2).

Between-session Variability

The ANOVA of the NRS scores from the manual palpation and the palpometer showed that there were no significant differences between technique (F = 0.792, P = .396), but a significant effect of site (F = 36.270, P < .001). Importantly, there was no significant effect of session or side (F < 0.897, P > .368). There was a significant interaction between technique and site (F = 3.330, P = .002) and between session and site (F = 2.796, P = .009). However, post-hoc tests could not demonstrate differences in NRS scores between sites, technique and session (P > .580).

Experiment 2

In terms of the within-session variability of the NRS scores from the manual palpation and the palpometer, there was a main effect of technique on the CV values (F = 5.698, P = .03), but there was no effect of site (F = 0.028, P = .972). There was no significant interaction between technique and site (F = 0.497, P = .613). Post-hoc tests for technique showed that the palpometer (22.7 ± 1.5%)had lower variability compared with manual palpation (31.8 ± 2.1%; P = .03) (Fig 4).

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Discussion

Site-to-Site Differences

This study has shown the ability of a new palpometer and manual palpation to discriminate between the sensitivity of different craniofacial regions. This difference was shown by the pressure algometer in accordance with several other studies.[18,24,25] Pressure algometry in deep tissue is indeed a validated technique for pain sensitivity assessment and is widely used.[11,26] Finger pressure palpation has also been reported to have reasonable reliability, provided that methodologic issues are properly addressed and the procedure is well-controlled.[27,28] In this study, the examiner conducting the manual palpation was an experienced orofacial pain dentist and was carefully trained for the examination techniques. When the study started, the examiner had shown the ability to apply a standardized amount of pressure needed to palpate muscles sites and TMJ.

All the techniques showed highest sensitivity at the retromandibular site and lowest sensitivity on temporalis muscle (posterior, middle, and anterior). This is the first study to demonstrate such differences in craniofacial pain sensitivity in the recommended RDC/TMD palpation sites. Almost all the sites showed a good inverse relationship between the PPT values of algometer and the NRS scores. However, at the TMJ, the algometer showed a relatively low PPT level. One explanation could be that the smaller diameter of the algometer probe tip might have allowed greater penetration into the tissues overlying the joint. It is also possible that the harder and less resilient flat rubber tip might have provided increased loading level per square centimeter, especially at its edges if it was not held parallel to the surface of the joint. Considering the validity and reliability of the algometer and manual palpation and taking into account that the results showed no significant difference between the techniques either for NRS scores or categoric scale scores but a significant effect of site for all the techniques, it can be inferred that the palpometer performed as well as the other two techniques in identifying site-to-site differences. Furthermore, no significant differences between the two sessions were detected, suggesting that the palpometer is a reliable technique. However, the new palpometer has a drawback. It is not suited for intraoral palpation due to its physical constraints, but it can be used efficiently for extraoral palpation. Nevertheless, the diagnostic significance of intraoral palpation of the lateral pterygoid muscle for example has been challenged due to low reliability.[29] It should be noted that although the sample size was fairly small (n = 16), the study was designed for a within-subject comparison (repeated measures). The aim of this descriptive study was not to demonstrate age or sex differences or to compare healthy versus various pain groups. Subsequent studies will be needed to test such factors, but the present study strongly suggests that the new palpometer may be useful for clinical assessment of craniofacial pain sensitivity.

Within-Session Variability

The reproducibility and validity of PPT measurements have been compared between algometers and fingertip palpation techniques in several studies.[27,30] The present study compared the test-retest within-session variability between the new palpometer and manual palpation. The new palpometer (22.7 ± 1.5%) had lower test-retest variability than the manual palpation (31.8 ± 2.1%), thus indicating good reproducibility. This is in agreement with a previous study where the authors have shown that the new palpometer has very low test-retest variability of applied forces (5.0 ± 0.7%) and is very accurate compared to manual palpation (12.6 ± 0.7%) in a nonclinical setting.[15] In contrast to the present study, the previous study was not based on the reports from subjects, ie, subjects did not report scores and no comments were obtained from the subjects, because no palpation of muscle or joint was carried out. Subjects were instructed to apply the palpometer or manual palpation directly on a force meter to target certain force levels, and the displayed force values were simply recorded.[15] Thus, the palpometer has very good reproducibility and appears to perform better clinically than the manual palpation. There is a possibility that there could have been some bias as the subjects knew that the same force should have been applied with the palpometer or manual palpation. This expectancy might have influenced the verbal responses and reported scores. One way to prevent or minimize this bias would be to include multiple levels of applied forces (stimulus—response functions).

In conclusion, the palpometer and manual palpation can detect differences in craniofacial sensitivity in healthy subjects with no significant differences between repeated sessions. All techniques showed the highest sensitivity at the retromandibular site and the lowest at the temporalis muscle site. The palpometer has significantly lower within-session variability compared to manual palpation and seems to be useful for a standardized examination of deep craniofacial pain sensitivity. Further studies in deep pain conditions and TMD patients are needed to

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determine the applicability of the new palpometer in clinical practice.

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