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DOI: https://doi.org/10.1097/PRS.0000000000002023

Evaluation of Cutaneous Spatial Resolution and Pressure Threshold Secondary to Digital Nerve Repair

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Background: As the sophistication of functional reconstruction procedures continues to increase, so does the need for valid, precise, and reliable instruments to assess their clinical results. The authors compare two tests for spatial resolution and two for cutaneous pressure threshold in an adult patient cohort having undergone microsurgical digital nerve repair after traumatic transection.

Methods: Patients who underwent epineural coaptation after digital nerve transection at the authors' institution between June of 2006 and December of 2011 were asked to participate in a follow-up examination assessing spatial resolution (two-point discrimination and grating orientation test) and cutaneous pressure threshold (Semmes-Weinstein monofilament test and pressure-specifying sensory device). Interinstrument correlations were conducted and critically elucidated.

Results: Eighty-one patients (26 female and 55 male patients; median age, 42 years; interquartile range, 23 years) were examined with a mean follow-up period of 3.5 ± 1.4 years. Although all tests could differentiate between the healthy and operated fingers, poor to moderate correlations were found between two-point discrimination and grating orientation test ($\rho_{operated} = 0.483$, $p < 0.0001$; $\rho_{healthy} = 0.350$, $p < 0.0001$), and between Semmes-Weinstein monofilament test and Pressure-Specified Sensory Device testing ($\rho_{operated} = 0.287$, $p = 0.01$; $\rho_{healthy} = 0.382$, $p < 0.001$), indicating that they measure different properties. Altogether, the grating orientation test proved superior to two-point discrimination, whereas Pressure-Specified Sensory Device testing was superior to Semmes-Weinstein monofilament testing.

Conclusions: Thoughtful use of test instruments is advisable when assessing sensibility of the hand. This study suggests including Pressure-Specified Sensory Device testing to assess cutaneous pressure threshold and the grating orientation test to assess spatial resolution in clinical, routine test batteries. (*Plast. Reconstr. Surg.* 137: 1203, 2016.)

CLINICAL QUESTION/LEVEL OF EVIDENCE: Diagnostic, III.

Since the inception of microsurgical reconstruction techniques, assessment of functional recovery after traumatic nerve transections has gained an entirely new dimension. Quantitative measurements with elaborate instruments assessing different functional modalities with their imminent change over time have become clinical routine with the aim of either diagnosing neural impairment or evaluating the result of different surgical strategies and influencing factors. This issue has become particularly apparent in the field of reconstructive hand

From the Division of Plastic Surgery and Hand Surgery, University Hospital Zurich.
Received for publication July 8, 2015; accepted November 20, 2015.
The first two authors contributed equally to this article.

DOI: 10.1097/PRS.0000000000002023

Disclosure: *The authors have no financial interest to declare in relation to the content of this article.*

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surgery, as microsurgical procedures involving small nerves and vessels of the hand were nearly unthinkable in the premicrosurgical era. Assessment of sensory recovery after digital nerve transection thereby plays a major role and has thus been addressed by numerous studies in recent decades.[1–10]

To date, a plethora of test instruments is available to expediently evaluate sensory recovery after transection of nerves.[11] Regrettably, all of these are associated with different drawbacks. Most of them have been criticized because they do not meet the scientific demands of validity, reliability, and responsiveness.[11] Given the long-term follow-up of patients with peripheral nerve injury, instruments and methods investigating the sensory modality of the hand are supposed to capture meaningful information in the shortness of time within the clinical routine and to be reproducible over time, responsive to small but clinically relevant changes, comfortable to the patient, and standardized with the aim of comparing interindividual and intraindividual differences.[12]

The two-point discrimination test is undoubtedly one of the most widely used instruments to assess hand sensibility regarding the spatial threshold. It was originally described by Weber "as the distance between compass points necessary to feel two contacts."[13] Another, far more uncommon method of testing spatial threshold is the grating orientation test introduced by Johnson and Phillips in 1981.[14] The grating orientation test is considered superior to the two-point discrimination test in capturing spatial discrimination, as the surface area stimulated remains constant and only the spatial threshold varies.[11] However, the grating orientation test has barely found its way into clinical routine for assessing sensibility.

A potent method for assessing cutaneous detection thresholds was introduced by von Frey in 1906 and later modified by Semmes and Weinstein as the now well-known Semmes-Weinstein monofilament test.[15,16] The principles of the Semmes-Weinstein monofilament test were transferred by Dellon et al. in 1992 as the Pressure-Specified Sensory Device (NK Biotechnical Engineering Company, Minneapolis, Minn.), permitting the specification of human pressure threshold for both static and moving one- and two-point discrimination on a continuous scale.[17] Whereas the Semmes-Weinstein monofilament examination as a noninvasive, low-cost, and easy-to-apply method is regularly used in clinical and scientific settings, the far more complex and costly Pressure-Specified Sensory Device is rarely applied. In addition, the Pressure-Specified Sensory Device has never been tested for sensory recovery after digital nerve transections so far.

As the sophistication of functional reconstruction procedures, such as free toe transplant, digital replantations, sensory innervated free-tissue transfers, and digital nerve reconstructions, continues to increase, so does the need for adequate instruments to assess their clinical results. Against this background, we set out (1) to compare two tests for spatial resolution (static two-point discrimination versus grating orientation test) and (2) to compare two tests purporting to measure cutaneous pressure threshold (Semmes-Weinstein monofilament versus static one-point Pressure-Specified Sensory Device) in an adult patient cohort having undergone microsurgical digital nerve repair after traumatic transection.

PATIENTS AND METHODS

After approval of the Ethics Committee of the University of Zurich, 155 patients who underwent epineural coaptation after digital nerve transection at our institution between June of 2006 and December of 2011 were asked to participate by means of phone. Inclusion criteria were complete transection of one or more digital nerves, treatment by epineural coaptation performed within 5 days after injury, intact contralateral digit, and a follow-up period of at least 12 months. Exclusion criteria were age under 18 or over 80 years at the time of surgery, incomplete nerve lesions, complex injuries including replantation, additional proximal nerve injuries or compression syndromes, nerve reconstruction with grafts or conduits, and documented neurologic disorders. Our standard method of digital nerve coaptation is an epineural end-to-end technique with two 9-0 nylon sutures under magnification. Sensory testing was performed by one of two residents of our department who were not the operative surgeon in any event. They were not blinded to the side of the nerve repair, as the scar pattern (including the Tinel sign) was part of the examination. All tests were applied on the hemipulp corresponding to the repaired nerve. The sequence of the tests was always the same, in favor of standardization. The first test performed was two-point discrimination, followed by Semmes-Weinstein monofilament testing, the grating orientation test, and finally Pressure-Specified Sensory Device testing. In that way, each modality (spatial discrimination versus pressure threshold) was tested alternately, aiming at a reduction of potential "learning effects."

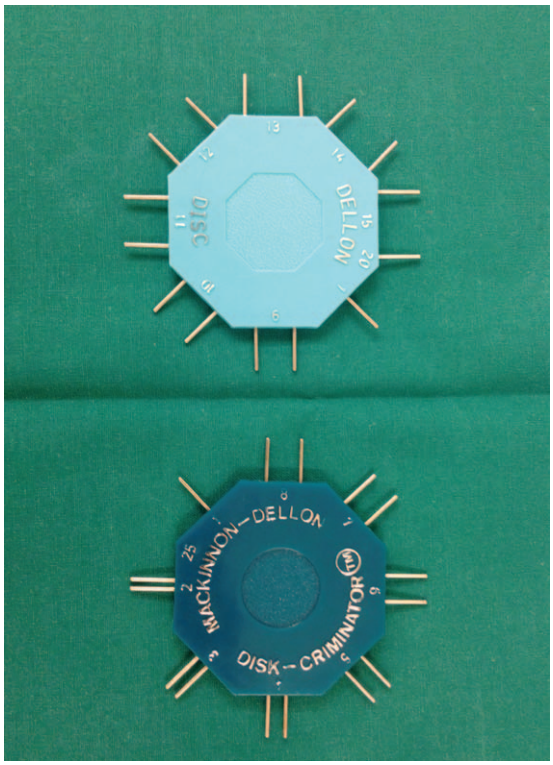


Fig. 1. Disk-Criminator for two-point discrimination.

Assessment of Spatial Discrimination

Spatial discrimination was assessed by the static two-point discrimination test and grating orientation test, both expressed in millimeters. The two-point Disk-Criminator was used for the two-point discrimination test according to manufacturer's instructions (Dellon-Mackinnon, AliMed, Mass.) (Fig. 1). (**See Video, Supplemental Digital Content 1**, which shows two-point discrimination using the Disk-Criminator. See Patients and Methods section for further details and correct instruction, ***http://links.lww.com/PRS/B647***.) One or two prongs were placed randomly parallel to the long axis onto the patient's pulp 10 times starting with 20 mm. Patients were asked how many points they felt. If 70 percent (seven of 10) of the answers were correct, we proceeded with the next smaller distance. The procedure stopped when the subject's level of correctness sank below 70 percent.

The grating orientation test was performed by means of hemispheric plastic grating domes (Stoelting Co., Wood Dale, Ill.). Each grating is a gently rounded, circular (25-mm diameter), solid plastic dome with deep, rectangular grooves cut into the surface. Each dome is mounted on a cylindrical handle to allow convenient manual application to the skin. The set consists of 10 domes with equidistant bar and groove widths nominally equal to 0.25, 0.5, 0.75, 1.0, 1.2, 1.5, 2.0, 2.5, 3.0, and 3.5 mm, respectively (Fig. 2). (**See Video, Supplemental Digital Content 2**, which shows the grating orientation task. See Patients and Methods section for further details and correct instruction, ***http://links.lww.com/PRS/B648***.) The examiner applied the domes perpendicular to the surface of the subject's finger, indenting the skin by approximately 2 mm, with durations of approximately 1.5 seconds.[18–20] The participant had to indicate in a two-alternative forced-choice manner whether the gratings were parallel or perpendicular to the axis of the finger. In the first block, the dome with the largest spacing was applied 20 times in a random order. If more than 75 percent of the responses were correct, the next smaller dome was used for the next block of 20. The procedure stopped when the subject's level of correctness sank below 75 percent.[18–20]

Video 1. Supplemental Digital Content 1 shows two-point discrimination using the Disk-Criminator. See Patients and Methods section for further details and correct instruction, ***http://links.lww.com/PRS/B647***.

Fig. 2. Grating domes in different sizes.

Assessment of Detection Threshold

Semmes-Weinstein monofilaments (Patterson Medical, Warrenville, Ill.) were used to evaluate cutaneous pressure threshold according to the manufacturer's suggested technique (Fig. 3). (**See Video, Supplemental Digital Content 3**, which shows Semmes-Weinstein monofilament testing. See Patients and Methods section for further details and correct instruction, ***http://links.lww.com/PRS/B649***.) The filament was pressed onto the skin for 1.5 seconds using three trials for each filament. Particular attention was paid to apply force at the correct angles to the filament. The nylon filament with the lowest marking was chosen for which the patient could detect the constant-touch stimulus. Results are reported as calculated pressure in grams per square millimeter for each monofilament (2.83, 0.07 g and 0.13 mm (5.38 g/mm^2); 3.61, 0.4 g and 0.18 mm (16 g/mm^2); 4.31, 2 g and 0.31 mm (26.6 g/mm^2); 4.56, 4 g and 0.36 mm (39.2 g/mm^2); and 6.65, exceeds 300 g and 1.14 mm (>292 g/mm^2).

The Pressure-Specified Sensory Device was used as second method for cutaneous pressure threshold detection (Fig. 4).[17] (**See Video, Supplemental Digital Content 4**, which shows the Pressure-Specified Sensory Device. See Patients and Methods section for further details and correct instruction, ***http://links.lww.com/PRS/B650***.) The one-point static discrimination test of the Pressure-Specified Sensory Device follows conceptually the same principle as the traditional Semmes-Weinstein monofilament test, with the advantage of a continuous scaling. The Pressure-Specified Sensory Device consists of two metal prongs that are connected to a hand-held instrument transducing the force applied to a computer. The examiner brings—in case of the static one-point condition used for the present study—one of these prongs into contact with the surface of the hemipulp to be tested and exerts increasing pressure.[21,22] Participants were instructed to press a button with the hand not being tested when they perceived the touch stimulus. A series of five stimuli is recorded with the computer-linked software. The maximum and minimum of the collected values are discarded, and the mean of the remaining three values is taken as the force at threshold in grams. Cutaneous pressure threshold in grams per square millimeter is finally calculated by the mean force divided by the projected surface area of the hemispherical prong (0.09 mm^2).[23]

Statistical Analysis

Data were analyzed using IBM SPSS, Version 20 for Macintosh (IBM Corp., Armonk, N.Y.). Discrete values are expressed as counts and percentages,

Video 2. Supplemental Digital Content 2 shows the grating orientation task. See Patients and Methods section for further details and correct instruction, ***http://links.lww.com/PRS/B648***.

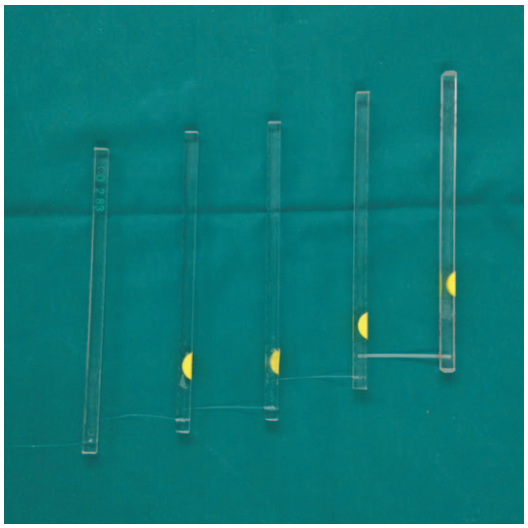


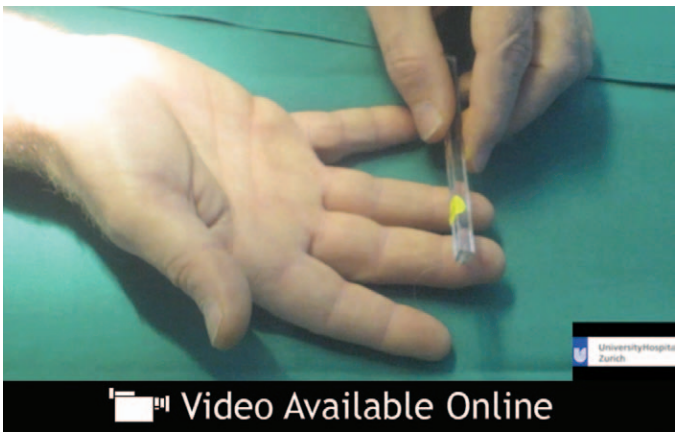
Fig. 3. Set of five Semmes-Weinstein monofilaments.

whereas continuous variables are given as both means ± SD and medians with interquartile ranges according to their distribution. The nonparametric Wilcoxon matched-pairs signed rank test was applied to test for differences between the operated and healthy fingers. Accounting for nonparametric data distribution, Spearman rank correlation coefficient ρ (rho) was calculated to express associations between the test instruments and analyze any age-related correlation. All tests were two tailed, and a value of $p < 0.05$ was considered significant.

RESULTS

Seventy-two of the contacted 155 patients refused to participate for various reasons, with the majority naming time and travel as the main obstacles. Of the 83 remaining patients, two had to be excluded from the analysis because of unreliable examination. Therefore, 81 patients (26 women and 55 men) joined our examination, with a mean follow-up period of 1274 ± 503 days (3.5 ± 1.4 years). Raw data of the test instrument variables and patient age did not follow a Gaussian distribution; thus, these variables are presented as median with interquartile range. Median patient age at follow-up was 42 years (interquartile range, 23 years), ranging from 21 to 77 years. Median two-point discrimination on the injured finger was 9 mm (interquartile range, 6 mm), compared with the healthy side, with a median two-point discrimination of 4 mm (interquartile range, 1 mm) ($p < 0.001$). The median grating orientation test score on the injured finger was 2.50 mm (interquartile range, 2.21 mm), whereas the median grating orientation test score on the healthy contralateral side was 1.00 mm (interquartile range, 0.75 mm) ($p < 0.001$). The median pressure threshold tested with the Semmes-Weinstein monofilament was 26.6 g/mm^2 (interquartile range, 10.6 g/mm^2) on the operated side, and the median pressure threshold on the contralateral side was 16.0 g/mm^2 (interquartile range, 5.9 g/mm^2) ($p < 0.001$). Median Pressure-Specified Sensory Device testing value on the operated finger was 0.40 g/mm^2 (interquartile range, 0.74 g/mm^2), whereas that on the healthy contralateral side was 0.29 g/mm^2 (interquartile range, 0.3 g/mm^2) ($p < 0.001$).

A statistically significant correlation was found between two-point discrimination and grating orientation test, both on the operated and on the healthy side ($\rho_{operated} = 0.483$, $p < 0.0001$; $\rho_{healthy} = 0.350$, $p < 0.0001$). Testing for correlation between Semmes-Weinstein monofilament test and Pressure-Specified Sensory Device testing also



Video 3. Supplemental Digital Content 3 shows Semmes-Weinstein monofilament testing. See Patients and Methods section for further details and correct instruction, ***http://links.lww.com/PRS/B649***.

Fig. 4. Pressure-Specified Sensory Device.

showed a statistically significant association on both the operated and healthy sides ($\rho_{operated} = 0.287$, $p = 0.01$; $\rho_{healthy} = 0.382$, $p < 0.001$). Interinstrument correlations are depicted in Figures 5 through 8 as linear regression models. Age turned out to be correlated with the Semmes-Weinstein monofilament test on the healthy side ($\rho = 0.433$, $p < 0.0001$) and with the grating orientation test on the healthy side ($\rho = 0.224$, $p = 0.045$), whereas the other test results did not show any age-related association.

DISCUSSION

Nerve lesions appear in approximately 10 percent of all hand injuries requiring surgical intervention, with the proper and common digital nerves being most frequently affected.[24,25] Because the hand is a complex organ, the function of which depends on the coherence of sensory and motor modalities, traumatic sensory nerve transections frequently impair this functional interaction, with potentially long-lasting sequelae. Our study did not aim at an evaluation of the clinical long-term outcome and its potentially influencing factors after digital nerve repair as presented by Fakin et al.[1] Rather, the main focus of our study was the correlative contraposition of sensory tests, which purport measuring similar or equal sensory qualities (spatial discrimination/cutaneous pressure threshold). In addition, some of the applied test instruments have not been described in this distinct context before.

Spatial discrimination tests are designed to quantify the threshold at which distinction of different spatial properties of stimuli occurs. We found an average two-point discrimination on the healthy side of 4 mm, confirming the findings of earlier studies that agreed on a normal two-point discrimination on the fingertip of less than 6 mm.[13] Two-point discrimination on the operated side was significantly higher with 9 mm, suggesting that sensibility after epineural coaptation of transected digital nerves most probably does not recover to a restitutio ad integrum, which is in line with previous findings.[8,10,26] For the grating orientation test, too, we found an average value of 2.5 mm on the operated side—significantly differing from the average grating orientation test result of 1.0 mm on the healthy side. Comparable (normative) data for grating orientation test performed on healthy fingertips are rare throughout the literature: Tremblay et al. analyzed the grating orientation test threshold in a healthy adult series ($n = 21$) aged between 60 and 70 years resulting in a mean grating orientation test score of 2.7 ± 0.6 mm.[27] Van Boven and Johnson found a mean grating orientation test threshold of 0.98

Video 4. Supplemental Digital Content 4 shows the Pressure-Specified Sensory Device. See Patients and Methods section for further details and correct instruction, ***http://links.lww.com/PRS/B650***.

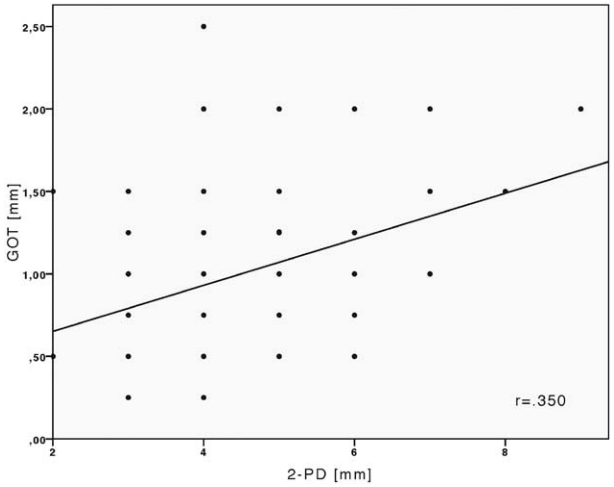


Fig. 5. Interinstrument correlation between two-point discrimination (*2-PD*) and grating orientation test (*GOT*) for healthy fingers.

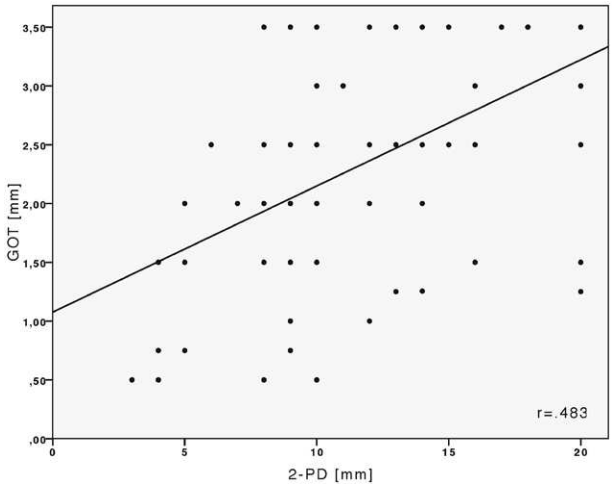


Fig. 6. Interinstrument correlation between two-point discrimination (*2-PD*) and grating orientation test (*GOT*) for operated fingers.

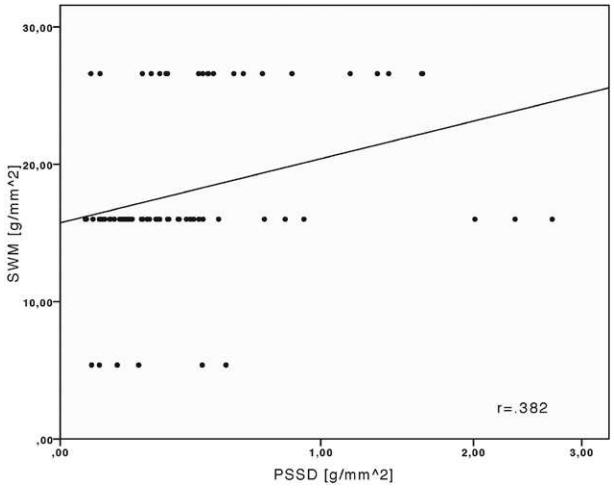


Fig. 7. Interinstrument correlation between Pressure-Specified Sensory Device (*PSSD*) and Semmes-Weinstein monofilament (*SWM*) testing for healthy fingers. Note that abscissa is $\log_{10}$ scaled.

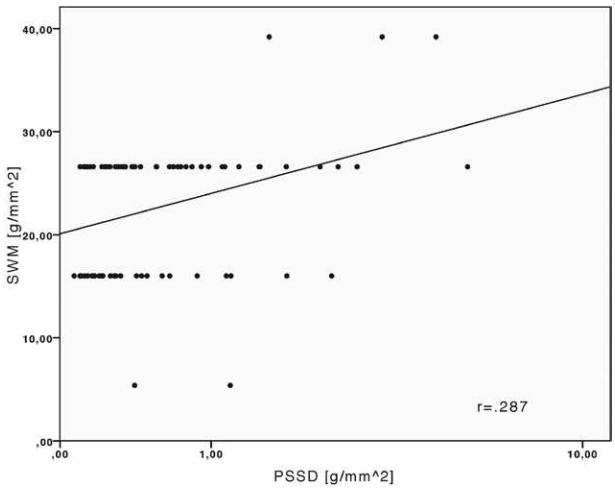


Fig. 8. Interinstrument correlation between Pressure-Specified Sensory Device (*PSSD*) and Semmes-Weinstein monofilament (*SWM*) for operated fingers. Note that abscissa is $\log_{10}$ scaled.

± 0.12 mm in a healthy student cohort (23 to 25 years, n = 15), which was later confirmed by Sathian and Zangaladze, with mean values ranging from 0.89 (index finger) to 1.44 mm (little finger).[18,28] When stratifying our data according to the age-related upper (53 to 77 years) and lower quartiles (21 to 30 years), we found similar results, at least for the younger cohort (on the healthy side): 0.83 mm (interquartile range, 0.43 mm) (first quartile) and 1.15 mm (interquartile range, 0.59 mm) (fourth quartile). A possible explanation for this disparity in elderly patients might be their inability to provide reliable reports of grating orientations even when presented with the widest dome available.[27,29] Consistent with previous findings, we showed that spatial acuity measured by the grating orientation test declines with age—at least for "healthy" fingers.[30] This trend could not be shown for the injured side. A neural mechanism explaining why age is associated with the grating orientation test only on the healthy side might be the age-related reduction in peripheral innervation density.[29] After digital nerve transection, recovery of innervation density is obviously impaired, which probably outweighs the age-related effect on operated fingers leading to the depicted noncorrelation.

Even though both test instruments could differentiate between the healthy and operated fingers, we found a poor to moderate correlation for the two tests ($\rho_{operated}$ = 0.483; $\rho_{healthy}$ = 0.350). This

finding suggests that the two tests measure different properties. Tactile discrimination is based on the slowly adapting type I afferent fiber system, one of the four afferent fiber systems in the glabrous skin. Accordingly, we chose two tests (two-point discrimination and grating orientation test), both addressing the slowly adapting fiber system by means of ostensible "constant touch stimuli."[29] By contrast, the moving version of the two-point discrimination test primarily evaluates the innervation density of the quickly adapting fiber-receptor system and was therefore not considered suitable for comparison in the underlying test scenario.[31] Individual slowly adapting type I afferent fibers, terminating in Merkel receptors, have a high spatial resolving capacity and are selectively sensitive to spatial discontinuities.[32,33] Any reduction in the density of these afferent fibers comes along with a detrimental effect on spatial acuity. Moberg stated in 1991 that what the patient feels when undergoing the two-point discrimination test is not always one or two points. The response is rather based on an experience of a narrow or broader application on the skin serving as a "nonspatial cue," which led to the conclusion that the result not only is a function of the peripheral innervation density but is also based on cognitive functions.[34] In this context, the grating orientation test has proven superior, as it yields a measure of spatial resolution that is consistent with measures obtained with more complex stimuli such as embossed letters or Braille characters, which can only be resolved by spatial cues.[14] In addition, the neural mechanisms of spatial acuity are based on information conveyed by slowly adapting type I afferent fibers, whose center-to-center spacing is approximately 1 mm on the fingertip.[35] This distance corresponds closely with the spatial resolution found with the grating orientation test in our (1 mm) and in previous studies (0.98 mm).[18,36] Consequently, a reduction in afferent nerve fibers caused by traumatic lesions results in lower spatial resolutions as demonstrated in our study (2.5 mm). Comparable data for injured/operated digital nerves are completely lacking. Despite its ubiquity, the two-point discrimination test has ever since been criticized for its large unexplained variations—within subjects, between subjects, and between studies.[13] Nerve repair studies in particular—whether by primary suture, grafts, or transfers—gave striking evidence that two-point discrimination outcome in adults is extremely variable, thus reducing the meaningfulness of cutoff values. In contrast, grating domes have been found to have highest sensitivity to detect and quantify sensory loss in patients who have sustained nerve injury compared with four other common sensory tests.[19] Further drawbacks of the two-point discrimination test are the nonsynchronous application of pressure points and the discontinuity of force applied by the examiner.[13] This is certainly a limitation of the technique, which indeed every study using (handheld) two-point discrimination instruments struggles with. Although these shortcomings might exist for the grating orientation test as well, some studies have demonstrated that cutaneous spatial resolution is relatively insensitive to the force of application.[14] Consequently, there is a need to establish (automated) instruments to rule out those examiner-dependent influences (e.g., with the principles of counterweights). However, in summary, the grating orientation test seems to be superior in measuring spatial discrimination compared with two-point discrimination.

Cutaneous pressure sensation is a basic sensory modality, which is independent from spatial resolution measures.[15] Semmes-Weinstein monofilament testing significantly differed between the healthy (16 g/mm^2) and operated sides (26.6 g/mm^2). Manufacturers' normative Semmes-Weinstein monofilament data for fingers of healthy adults are reported with 5.38 g/mm^2, indicating that most of our "healthy and operated" subjects have at least diminished light touch sensation. Average Pressure-Specified Sensory Device value was 0.29 g/mm^2 on the healthy and 0.40 g/mm^2 on the operated side, which closely resemble normative Pressure-Specified Sensory Device data for healthy fingers provided by Dellon and Keller (little finger, 0.4 ± 0.2 g/mm^2; index finger, 0.5 ± 0.2 g/mm^2).[37] Accordingly, the cutaneous pressure threshold of most of our operated fingers were within that norm, indicating that cutaneous pressure perception recovers well after epineural coaptation. Regrettably, comparable data are entirely lacking.

Of note, Semmes-Weinstein monofilament testing yielded remarkably higher values in our study than did the Pressure-Specified Sensory Device. This considerable difference has been studied extensively before, pointing out some general problems inherent in the Semmes-Weinstein monofilament set: (1) the discontinuous scale of the Semmes-Weinstein monofilament test does not allow precise measurement; (2) the problem of measuring a force threshold rather than a pressure threshold; (3) the inability to know the true surface area in contact with the skin at the moment the filament buckles; (4) the variance in manufacturing allowing a 10 percent error

in the initial applied force of the filaments; and (5) the fatigue of the nylon with more than 100 uses.[23,38–42] These circumstances led to the conclusion that normative data are impossible to generate for the Semmes-Weinstein monofilament, thus harshly limiting its intrainstrument and interinstrument comparability. Indeed, the Pressure-Specified Sensory Device clearly compensates for most of the mentioned points of criticism: it is measured on a continuous scale (with "open ends"), which even captures extreme values and outliers reliably; whereas the Semmes-Weinstein monofilament test is limited to five grades, potentially neglecting higher or lower values, thus pretending a smaller variance. The surface of the prong applied to the skin does not vary in size and measures pressure as a physical unit reliably and reproducibly without fatigue. Most probably, these circumstances explain the poor interinstrument correlation ($\rho_{operated} = 0.278$; $\rho_{healthy} = 0.332$), which confirms the findings of an earlier study correlating Pressure-Specified Sensory Device and Semmes-Weinstein monofilament testing on fingers and feet ($r = 0.295$).[23] Above that, consistent with previous findings, the Semmes-Weinstein monofilament test showed an age-related association for the healthy side, whereas the Pressure-Specified Sensory Device turned out to be independent of aging processes.[17,37]

In summary, the Pressure-Specified Sensory Device proved to be superior to the Semmes-Weinstein monofilament test, emphasizing that the Pressure-Specified Sensory Device, too, is a handheld instrument being influenced by the examiner's inherent vibration. Future research and engineering might therefore focus on an automated application of the Pressure-Specified Sensory Device—utterly eliminating potential examiner influence. Furthermore, it has to be borne in mind that not all individuals are eligible for the Pressure-Specified Sensory Device because of difficulties of comprehending the test procedure. Besides that, the Pressure-Specified Sensory Device is a cost-intensive tool to which only few examiners, mostly belonging to large institutions, have access.

Because there is no gold standard available with which the instruments applied could have been compared, and even normative data vary or are completely lacking, it is basically impossible/invalid to conduct a quantitative analysis of superiority (regarding specificity and sensitivity of a test instrument). Histopathologic analyses could potentially serve as gold standard by identifying receptors/fibers indicating the amount of innervation or reinnervation; still, cognitive components remain hardly understood and might complicate those analyses. Thus, besides generating useful normative data on healthy and operated fingers, our data suggest with a poor to moderate interinstrument correlation that the compared instruments measure different properties. Along with previous findings on a cellular level and a qualitative compilation of benefits and drawbacks of the test instruments used, we concluded that the Pressure-Specified Sensory Device and the grating orientation test are superior when assessing hand sensibility after sophisticated functional reconstruction procedures.

CONCLUSIONS

Due to rapid advances in reconstructive microsurgery, valid and precise measurements of spatial discrimination and cutaneous pressure threshold as two components of an overall assessment of sensory function after nerve repair have become more important than ever before. Strengths and weaknesses of our current test methods need to be critically reconsidered in light of what is needed for objective testing. Ubiquity and easy handling of instruments do not equate with validity. Therefore, our study suggests including superior assessment tools, such as the Pressure-Specified Sensory Device and grating orientation test to test batteries applied in clinical routine.

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