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Experimental Research

Do your surgical glove characteristics and wearing habits affect your tactile sensibility?

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ABSTRACT

Backround: Tactile sensibility plays a critical role in medicine, especially in surgical practice. In order to prevent surgical site infections and protect the surgeon, the use of surgical gloves is standard practice. However, wearing these might affect the sensibility of the hand disadvantageously, especially in disciplines that require precision work.

Methods: We evaluated the influence of six different glove types, as well as gloves wearing habits (double gloving, over- and undersized gloves) on tactile sensibility using two-point-discrimination and Semmes-Weinstein monofilament testing in 27 non-surgeons.

Results: There were significant differences regarding tactile sensibility of gloved compared to bare hands and between different types of gloves. While undersized gloves and double gloving did not affect tactile sensibility, oversized gloves were associated with a significant deterioration of the sensibility of the hand in the Semmes-Weinstein monofilament test.

Conclusion: This study demonstrates that surgical gloves negatively affect the sensibility of the hand and show significant differences between different types of gloves.

1. Introduction

The human hand's tactile sensibility is central to its complex function [1]. Finger pulps are extremely sensitive, containing many sensory receptors, e.g. Merkel cells, Meissner corpuscles, or Pacini bodies [1]. Placing a barrier, such as a glove, between these sensory receptors and a surface being explored or manipulated, will impede tactile sensibility, which plays a critical role in medical – especially surgical – practice [2]. When surgeons started using gloves over a century ago, this was mainly for hygienic purposes. Later on, other reasons, such as prevention of hand dermatitis, became similarly important [3,4]. Over the years, using surgical gloves to prevent surgical site infections and protect the surgeon has become common practice [3]. However, presumed disadvantages, such as diminished manual dexterity and tactile sensibility, stand in contrast to these safety advantages [5,6]. Although the importance of glove use for infection control is commonly accepted, studies have shown that compliance with glove use guidelines may vary, depending on the user's confidence in glove performance [2]. A recent survey showed that clinicians may remove their protective gloves when performing tasks necessitating a higher level of sensibility, e.g. palpation of a pulse [7], as they feel that gloves may limit their clinical performance [2].

As data regarding the tactile performance, while wearing surgical gloves, remain controversial, this study aimed to evaluate the effect of different glove types and wearing habits (double gloving, over- and undersized gloves) may have thereupon.

2. Patients and methods

2.1. Ethical approval

This explorative pilot study was authorized by the ethics committee of our institution (reference number: 613/19 S; UIN: researchregistry5868) and is in line with the declaration of Helsinki. The work has

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been reported in line with the STROCSS criteria [8]. Only patients who gave their written consent, after having had the study procedure explained to them, were included. No patient refused to participate.

2.2. Study collective

The patients were recruited in our hand surgical outpatient clinic over the course of four weeks (02/2020). They were screened for exclusion criteria and volunteers were included. Exclusion criteria included neurological disorders, peripheral vascular disease of the upper extremities, rheumatoid arthritis or other collagen disorders affecting the peripheral nerves. Also, patients incapable of participating due to mental disorders, such as dementia and psychosis, or latex allergy were excluded. The patients age was limited to 20–35 years to increase comparability.

We included and evaluated 27 healthy patients with an average age of 24.7 years ±3.2 years (min.: 21 years, max.: 33 years). Due to the preclinical screening, no patient had to be excluded later on (for patient demographics, see Table 1).

2.3. Methods

The individual glove size was assigned, using the Archimedean principle (sizing through water displacement) to determine the individual hand volume: Size 6 = 174–218 ml; size 6,5 = 201–285 ml; size 7 = 222–304 ml; size 7,5 = 288–365 ml; size 8 = 327–381 ml. The correct glove size was defined as: 1. The glove fits well everywhere when the fingers are stretched. 2. Wrinkling is only acceptable at the base joints. 3. There is neither glove tension nor restriction of movement.

Six different glove types were tested (Table 2.), as well as double-worn, oversized and undersized gloves. Examinations on wearing habits were performed using Semper Med Supreme gloves, because these are the standard gloves in our clinic. Wearing too large or too small gloves was defined as a difference of one glove size compared to the calculated ideal size.

2.4. Experimental procedure

Testing was performed by one examiner in a quiet examination room. Patients were investigated in a seated position with their hands placed comfortably on a table in front of them. Before each individual was examined, the investigator explained the procedure to them and demonstrated the testing devices. First, both ungloved hands were evaluated. Then, different glove types (Table 2.) and wearing habits (double gloving, oversized, undersized) were tested in random orders, to reduce a learning effect as a bias, with the patients blindfolded throughout the examination.

The sensibility of the radial and ulnar digital nerve of the index finger (N3/4) was assessed using two-point-discrimination (2PD) and monofilament testing on both hands. For static 2PD tests, we used the Arex Discriminator (F - Palaiseau Cedex; 2 mm - 25 mm). We used monofilaments with calibrated pressures of 0.0043 g, 0.0230 g, 0.0275 g, 0.0677 g, 0.1660 g, 0.4082 g and 0.6958 g (Texas Medical Design, Inc.), applying pressure to them, until they bent, then documenting inconsistent or consistent (100%) detection of touch for the lowest filament.

Table 1
Demographic data.

Total number	**27**
Gender (male/female)	10/17
Age (years)	24.7 ± 3.2
Dominant hand (right/left)	24/3

Table 2
Glove characteristics (taken from product sheets). AQL = Acceptance quality level.

Glove type	Manufacturer	Glove thickness	Glove price (size 7.0)	AQL
Biogel Surgeons®	Mölnlycke®	0.21mm–0.27 mm (finger)	1.53 Euro/ glove	0.65
Vasco OP sensitive®	Braun®	0.17mm–0.21 mm	0.59Euro/ glove	0.65
Protexis Neoprene® *(latex-free)*	Cardinal Health®	0.17 mm (finger)	1.03Euro/ glove	0.65
Gammex Latex Sensitive®	Ansell®	0.14mm–0.17 mm	1.70Euro/ glove	1.5
Supreme®	Sempermed®	0.19mm–0.23 mm	1.20Euro/ glove	0.65
Syntegra® *(latex-free; hypoallergenic)*	Sempermed®	0.19mm–0.24 mm	1.69Euro/ glove	0.65

2.5. Statistics

Data are expressed as mean ± standard error. For statistical analysis, we used SPSS 14 software. The analysis methods included Student's independent *t*-test, comparing a maximum of two groups, as well as one-way ANOVA, accompanied by post-hoc pairwise comparisons for more than two groups. The probability of a type one error was set to 5% ($\alpha = 0.05$) unless noted otherwise.

3. Results

3.1. Effect of competing surgical gloves

The different surgical gloves were tested using 2PD and SW- monofilament (Fig. 1.). There were significant sensibility differences between patients wearing and not wearing gloves (* = $p < 0.05$). The sensibility test results were significantly better with Gammex Latex Sensitive gloves then with the other tested gloves ($p < 0.05$).

3.2. Effect of double gloving

Not infrequently, surgeons wear two pairs of gloves for security reasons during a surgical procedure. This seems to not deteriorate sensibility (2PD and SW monofilament testing) significantly compared to wearing one pair of gloves (Fig. 2.) ($p > 0.05$).

3.3. Effect of oversized gloves

We found a significantly deteriorated tactile sensibility in the SW-monofilament test when wearing oversized gloves compared to well-fitting gloves and bared hands ($p < 0.05$), while the 2PD test did not reveal differences (Fig. 3.).

3.4. Effect of undersized gloves

Wearing undersized gloves showed no significant effect on 2PD ($p > 0.05$) or SW-results compared to well-fitting gloves ($p > 0.05$) (Fig. 4.). However, this may lead to reduced wearing comfort: Without exception, all participants indicated increased discomfort when under-sizing their gloves.

4. Discussion

Nowadays, it is unimaginable to perform surgical procedures without surgical gloves. However, this study showed that wearing gloves disadvantageously affects tactile sensibility. Especially in disciplines such as microsurgery, where a high level of tactile sensibility is

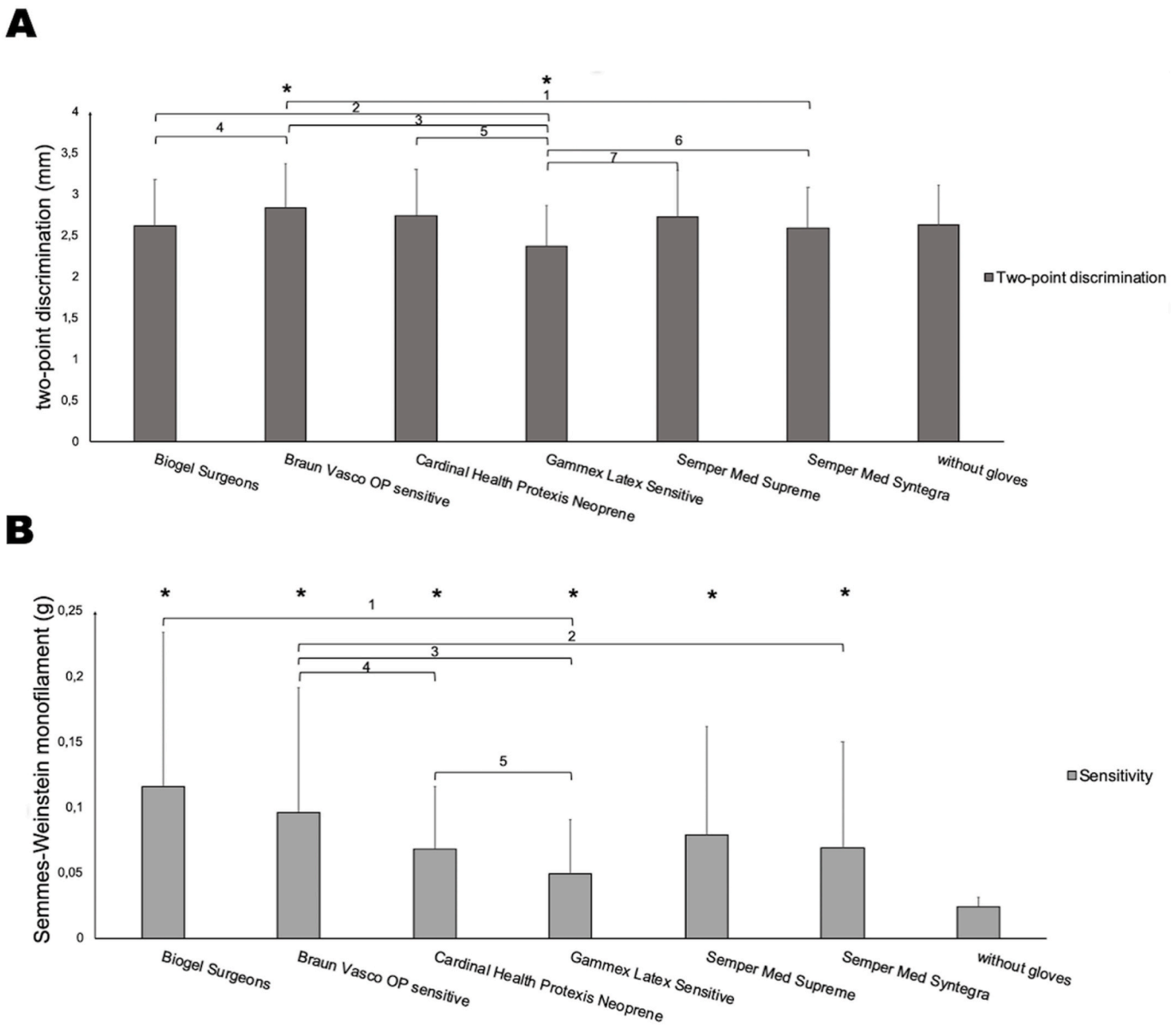

Fig. 1. The mean static two-point discrimination (2PD) values and Semmes-Weinstein test values of the index finger in dependence of the glove type and without gloves. **(A)** Two-point discrimination (mm), (1,2,3,4,5,6,7 = $p < 0.05$); **(B)** Semmes-Weinstein monofilament (g) (1,2,3,4,5 = $p < 0.05$). Asterisks (*) indicate the significant differences to bared hands.

indispensable, this might prove problematic.

As studies using existing sensibility tests (SW-monofilament, 2PD) already found, gloved hands have a lower cutaneous sensibility than bare hands [5,9]. This we were able to confirm. However, our results are in contrast to Bucknor et al. (2011) [5], who reported no objective difference between different glove types regarding static and dynamic 2PD, although a difference in subjective preference was observed [5]. Studies comparing the tactile performance of different glove types, using the SW-monofilaments [2,5] and Roughness Discrimination Test [6], did not find significant differences between them, either [2]. In contrast, we noticed that Gammex Latex Sensitive™ gloves provide significantly better tactile sensibility than the other glove types.

The reason therefore is not clear. Gammex Latex Sensitive gloves are made of thinner material compared to the other gloves, yet some of the competing gloves have comparable properties (Table 2). This may cause a higher acceptance quality level (AQL), even though the thinner material increases the chance of leaks. At the same time, a daily dependent market price analysis of size 7.0 gloves showed, that the significantly better sensibility may come with higher financial expenses. One must bear in mind, that careful choices in surgical equipment can significantly reduce costs, as a national audit of the NHS in Scotland showed: They spend approximately £2.6 million per year on surgical gloves alone [5,10]. Therefore, the choice of glove must remain well balanced between cost and clinician preference.

Double-gloving did not affect 2PD- and SW- discrimination in our study. In many different specialties, surgeons use double gloving, as it effectively reduces the risks of needlestick injuries and blood contact during surgery and thus the transmission of infections between the surgeon and patient [5,6,11–13]. Most glove manufacturers also advertise double gloving without significantly reduced sensibility. Novak et al. (1999) [14] examined the tactile sensibility of 25 surgeons wearing no, single and double latex gloves, using cutaneous pressure thresholds, moving and static 2PD for the dominant hand index finger. In contrast to our results, they found significant differences in tactile sensibility between single- and double-gloved hands [14]. However, this study is more than 20 years old, therefore in the comparison may be

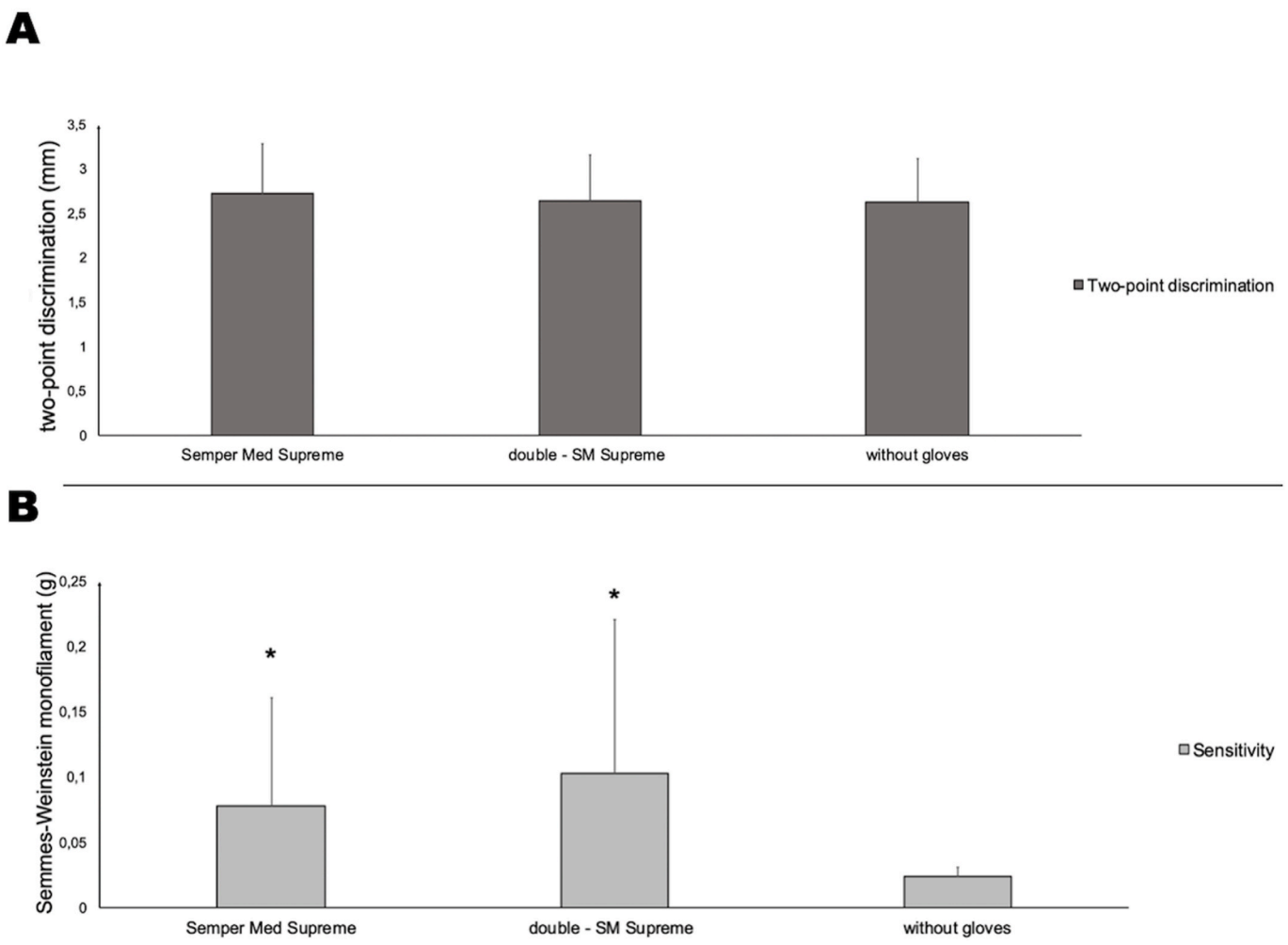

Fig. 2. Effect of double gloving on sensitivity. **(A)** Two-point discrimination (mm) **(B)** Semmes-Weinstein monofilament (g). Asterisks (*) indicate the significant differences to bared hands.

poor due to the constant advances in medical products. Likewise, Wilson et al. (1996) [6] compared single with double gloves in 32 surgeons, aiming to assess their effects on comfort, sensibility and dexterity. They concluded, that double gloves may protect the surgeon against needle-stick injuries, but can reduce subjective comfort, sensibility and dexterity [6].

A conceivable reason for oversized gloves is the increased wearing comfort. However, our study demonstrated that this might cause significant deterioration of tactile sensibility. Undersized gloves have no influence thereupon, but are associated with reduced wearing comfort.

Therefore, choosing the appropriate glove size is important to avoid significantly reduced tactile sensibility, as well as discomfort. Besides, the impact of different glove types must not be underestimated.

4.1. Strengths and limitations

A limitation of this study might be the small number of patients and that each country used different glove types.

We only included subjects aged 20–35 years in our study, since we previously showed that the hand's tactile sensibility peaks in the third decade of life, age-dependently declining thereafter [1,15]. This might be caused by a not-yet-terminated digital nerve and haptic feedback maturation during childhood and adolescence, making tactile sensibility in the third decade of life superior to that in the second [15]. Weinstein reports that in 2PD, tactile sensibility correlates with the number of innervating nerve axons and that axon transport may decline with age [1,16].

Furthermore, we questioned patients, as opposed to surgeons who are used to wearing surgical gloves. On the other hand, this considered to evaluate the actual effect of gloves. For this reason, we are planning to conduct a study with microsurgeons, since studies here already suggest that they have learned better sensitivity throughout their career [1].

5. Conclusion

This study demonstrates that surgical gloves negatively affect the sensibility of the hand and show significant differences between different types of gloves. Since the sensibility of the hand is crucial for surgeons, especially when performing precision work, medical companies should focus on producing surgical gloves that, amongst things, permit a high level of tactile sensibility.

Ethical approval

This study was authorized by the ethics committee of our institution (Klinikum Rechts der Isar, Technical University of Munich) (613/19 S).

Sources of funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

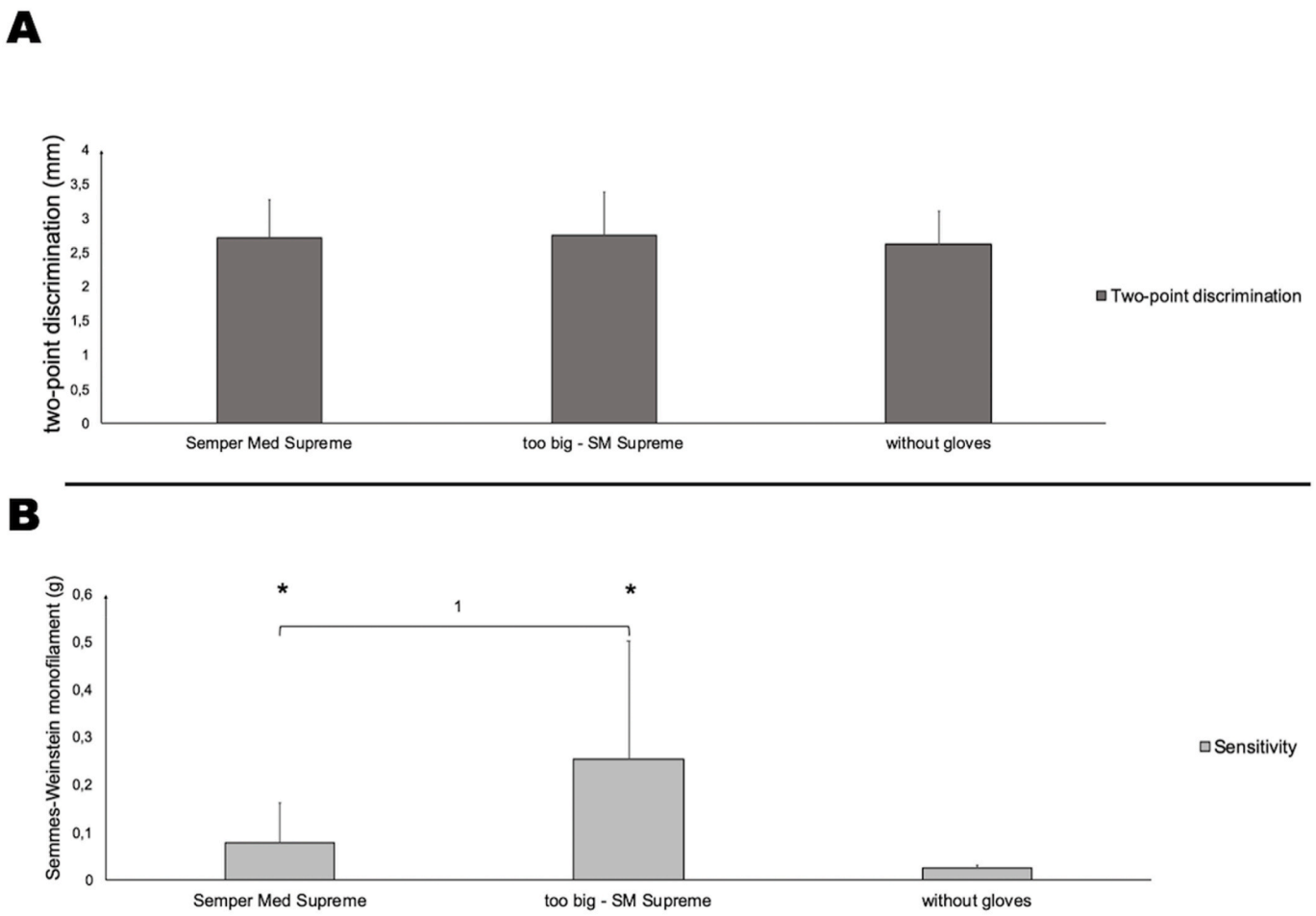

Fig. 3. Effect of oversized gloves on tactile sensibility. **(A)** Two-point discrimination (mm) **(B)** Semmes-Weinstein monofilament (g); (* = $p < 0.05$). Asterisks (*) indicate the significant differences to bared hands.

Author contribution

Conceptualization, Moog, P.; Schmauss, D.; Lohmeyer, J.; Megerle, K.; Erne, H.C. **methodology,** Moog, P.; Schulz, M.; Betzl, J.; Schmauss, D.; Lohmeyer, J.; Megerle, K.; Erne, H.C. **software,** Moog, P.; Schulz, M.; Betzl, J.; Erne, H.C. **validation,** Moog, P.; Schultz, M.; Erne, H.C. **formal analysis,** Moog, P.; Schultz, M.; Betzl, J.; Megerle, K.; Erne, H.C. **investigation,** Moog, P.; Schultz, M.; Erne, H.C. **resources**, Machens, H. G. **data curation,** Moog, P.; Schultz, M.; Betzl, J.; Erne, H.C.; **writing—original draft preparation,** Moog, P.; Betzl, J.; Erne, H.C. **writing—review and editing,** Moog, P.; Schultz, M.; Betzl, J.; Schmauss, D.; Lohmeyer, J.; Machens, H.G.; Megerle, K.; Erne, H.C.**; visualization,** Moog, P.; Schultz, M.; Betzl, J.; Erne, H.C. **supervision,** Machens, H.G.; Erne H.C. **project administration,** Machens, H.G.; Erne, H.C.**; funding acquisition,** Machens, H.G. **All authors have read and agreed to the published version of the manuscript.**

Reasearch registration number

No human study.
1. Name of the registry:
2. Unique Identifying number or registration ID:
3. Hyperlink to your specific registration (must be publicly accessible and will be checked):

Guarantor

Moog, P.; Schultz, M.; Betzl, J.; Schmauss, D.; Lohmeyer, J.; Machens H.G.; Megerle, K.; Erne, H.C.

Disclosure statement

The patients involved in this study do not have any direct relationship or dependency relationship with the project leader.

Consent

Only patients who agreed to be part of the study and gave their written consent, after having had the study procedure elucidated, were included . No patient refused to participate. See also section 3.1. in the paper.

All of this was done in accordance with our ethics committee as described above.

Provenance and peer review

Not commissioned, externally peer reviewed.

Declaration of competing interest

The authors declare no conflict of interest.

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.amsu.2020.08.002.

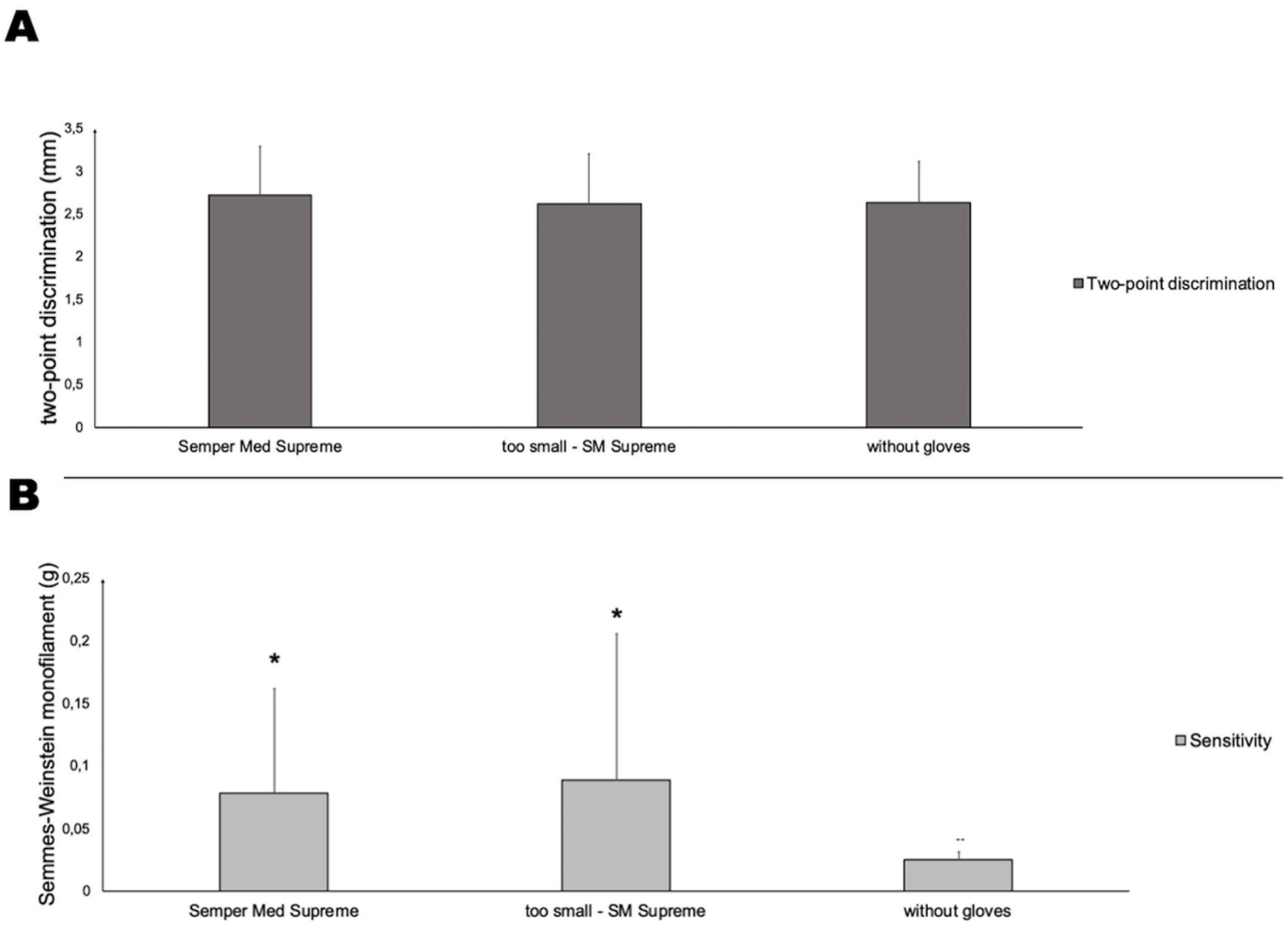

Fig. 4. Effect of undersized gloves on tactile sensibility, regarding two-point discrimination and Semmes-Weinstein test. **(A)** Two-point discrimination (mm) **(B)** Semmes-Weinstein monofilament (g). Asterisks (*) indicate the significant differences to bared hands.

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