Prediction Model for Choosing Needle Length to Minimize Risk of Median Nerve Puncture With Dry Needling of the Pronator Teres

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ABSTRACT

Objective: The aim of this study was to relate forearm anthropometric measures to ultrasound pronator teres depth to determine the necessary needle length to prevent median nerve (MN) injury during pronator teres dry needling.

Methods: We conducted a study employing a diagnostic accuracy prediction model (NCT03308279) at a Spanish university center. The study recruited 65 participants to predict the depth of the MN (measured with ultrasound) in the pronator teres using a decision tree algorithm to reduce the risk of MN puncture using 2 needle lengths (13 mm or 25 mm). The decision tree was developed by automatically selecting a cutoff for body mass index, forearm length and circumference, and pronator teres thickness.

Results: For forearm circumferences ≤27.5 cm, the predictive value for the 13-mm needle was 92%. For forearm circumferences >27.5 cm and forearm lengths ≤26.75 cm, the predictive value for the 25-mm needle was 100%.

Conclusion: Based upon the findings of this study, we suggest that needle length should be selected according to forearm anthropometric measures to prevent MN injury during pronator teres dry needling. (J Manipulative Physiol Ther 2019;42:366-371)

Key Indexing Terms: *Acupuncture; Median Nerve; Myofascial Pain Syndromes; Musculoskeletal Diseases; Rehabilitation*

Introduction

Although pronator syndrome (PS) can be considered a rare compression neuropathy, the ulnar head of the pronator teres has been described as the main origin of median nerve (MN) entrapment proximal to the carpal tunnel. Therefore, minimally invasive forearm procedures depend on the location of the median nerve compression with respect to the morphology and size of the pronator teres.[1]

The pronator teres is in the anterior forearm and consists of 2 heads: the ulnar and the humeral. The median nerve runs between the 2 heads and exits the muscle 5 to 8 cm distal to the lateral epicondyle or 4 cm distal to the medial epicondyle; however, some variations in this distribution are possible.[2] The mean width (± standard deviation) of the ulnar head is 16.3 ± 8.2 mm, and the MN is anterior to the ulnar head, 50.4 ± 10.7 mm from the inter-epicondylar line. Up to 5 types of pronator teres ulnar heads have been classified based on their morphology: type 1, fibromuscular (53.6%); type 2, muscular (20.5%); type 3, fibrotic band (16.1%); type 4, absent (8%); and type 5, 2 arches (1.8%).[1]

Regarding the peripheral nervous system distribution in the forearm muscles, there are several possible MN compression areas proximal to the carpal tunnel, including Struthers' ligament, the bicipital bursa, anomalous arteries and muscles, PS, and anterior interosseous nerve syndrome.[3] Specifically, PS and anterior interosseous nerve syndrome are the 2 most common MN compression neuropathies in the upper part of the forearm.[2,3]

Ultrasound is one of the most useful imaging methods for evaluating soft tissue and for guiding invasive procedures in patients with entrapment neuropathies such as PS.[4]

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In the field of rehabilitation, dry needling (DN) and acupuncture approaches have been applied to the pronator teres to treat musculoskeletal and nervous system disorders.[5-9] However, complications have been reported during DN and acupuncture procedures, and MN and radial nerve neuropathies have been reported during the use of deep DN and acupuncture in the forearm muscles.[10-13]

The use of ultrasound could minimize the risk of MN injury, which is considered an adverse effect of DN and acupuncture.[14-16] However, not all physical therapy degree programs include diagnostic and procedural imaging curricula,[17] and high-resolution ultrasound tools are not accessible and available to all clinicians in their daily practice.[18]

Therefore, the aim of this study was to correlate anthropometric measures of the forearm in healthy individuals using the depth of the pronator teres measured by ultrasound to determine needle length to prevent median nerve injury during pronator teres DN. We hypothesized that a prediction model based on anthropometric measures of the forearm would predict the optimal needle length for DN in the pronator teres.

Methods

Study Design

We developed a diagnostic accuracy study to determine the most suitable needle length for DN of the pronator teres. The procedure was simulated by measuring the appropriate needle length with an ultrasound tool to avoid an unnecessary DN procedure and thus possible damage to the MN. This study adhered to the updated list of essential items for the Standards for Reporting of Diagnostic Accuracy Studies guidelines and checklist.[19] The protocol was conducted in accordance with the Declaration of Helsinki, approved by the La Salle University ethics committee. Two needle lengths (13 mm and 25 mm) were employed, according to prior DN guidelines.[5-9] The procedure was simulated to predict the most suitable needle length for preventing MN injury (cutoff determined by the MN depth measured by ultrasound), based on sociodemographic data (sex, age, and body mass index [BMI]), anthropometric measures (forearm length and circumference), and ultrasound measurements (pronator teres thickness).

Sample

Based on the results of a prior study on the optimal needle insertion site for needle electromyography of the pronator teres, this present study required 50 forearms.[20] We therefore recruited a convenience sample of 65 healthy university students by a consecutive sampling method (with a balanced sex distribution) from the La Salle University Center for Advanced Studies, Autonomous University of Madrid, Spain. All participants were placed in prone decubitus with wrist and elbow extension and forearm supination for all anthropometric and ultrasound measurements.[1,21]

Sociodemographic Data

We recorded the participants' sociodemographic data (eg, sex, age, and BMI, calculated by the Quetelet index).[22]

Anthropometric Measurements

We measured the participants' anthropometric data (eg, forearm length and circumference). The forearm length was measured from the elbow to the wrist skin folds, which coincided with the flexion-extension motion articular axes, while the forearm circumference was measured at the largest perimeter located in the upper third of the forearm.[20]

Ultrasound Measurement

The ultrasound probe was placed on the anterior part of the dominant forearm where the pronator teres was located through its origin at the medial epicondyle. All ultrasound evaluations and measurements were performed by the same evaluator who had more than 4 years of experience and employed a diagnostic ultrasound system (General Electric Vivid 7 ultrasound system with a 3.5 transducer) with a 2.4- to 4.5-MHz range curved transducer to assess the resting B-mode ultrasound. Once the entire pronator teres was located, the evaluator measured the total length of this muscle and marked the skin at the longitudinal center of the pronator teres. The center of the probe was then placed at the center of the skin mark in a transversal and perpendicular position to the pronator teres fibers. Muscle thickness and MN depth were measured between the pronator teres fascia and MN epineurium, respectively, with the skin mark located at the center of the probe footprint (Fig 1).[1] The evaluator then captured 3 ultrasound images at the same point. The mean of the 3 repeated measurements was calculated for the analysis. A single transverse imaging was shown to be reliable for quantifying muscle size in the upper extremity, and it was comparable to panoramic ultrasound.[23]

Statistical Analysis

We employed Statistical Package for the Social Sciences version 22.0 for Windows (IBM Corp, Armonk, New York) for the data analysis and used the Kolmogorov-Smirnov test for the normality analysis. The parametric data are reported as mean (± standard deviation), the nonparametric data are reported as median (± interquartile range), and the total sample was described using ranges.

We constructed a predictive model for MN depth into the pronator teres using a decision tree analysis algorithm according to a multivariable analysis,[24,25] which provides a clinically comprehensive classification algorithm for clinical practice enabling clinicians to reduce the MN puncture risk for each patient, using two needle lengths (13 mm and 25 mm), according to prior DN guidelines.[5-9] The decision tree was developed using an exhaustive classification and regression tree method,[24,25] that is, a recursive partitioning

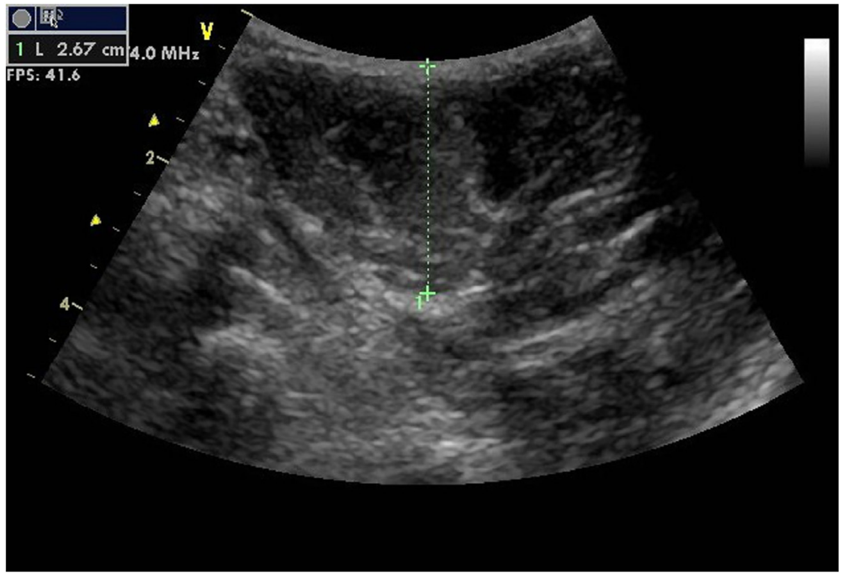

Fig 1. *Ultrasound measurements of the pronator teres.*

method that builds classification trees to predict categorical variables (with the 2 13-mm and 25-mm needle lengths as dependent variables) by automatically selecting a cutoff (determined by the MN depth measured by ultrasound) for all parameters, including sex, age, BMI, forearm length, forearm circumference, and pronator teres thickness (measured by ultrasound) as independent variables. The results of the prediction model included the forearm length and circumference and excluded the rest of the parameters (sex, age, BMI, and pronator teres thickness).

Results

Descriptive Data

The sample of 65 university students, balanced in sex distribution (33 men and 32 women), with a median age and BMI of 26.0 ± 11.5 years (range, 22.0-47.0) and 21.41 ± 4.0 (range, 18.0-29.0), respectively, completed the study. Anthropometric measurements showed a mean forearm length of 26.08 ± 2.07 cm (range, 21.2-30.0) and a median forearm circumference of 26.0 ± 4.7 cm (interquartile range, 21.00-30.0). The mean MN depth was 21.03 mm (range, 10.80-28.77), while the needle lengths used in the prediction model were 13 mm and 25 mm.

Prediction Model

The algorithm (Fig 2) showed a sensitivity of 87.7% in predicting the MN depth using the forearm circumference. For forearm circumferences ≤27.5 cm, the predictive value for using the 13-mm needle was 92%. For forearm circumferences >27.5 cm and forearm lengths ≤26.75 cm, the predictive value for using the 25-mm needle was 100%.

Discussion

We believe that this study is the first to develop a decision tree prediction model for minimizing MN puncture during DN based on anthropometric and ultrasound measurements, thereby minimizing the adverse effects caused by applying DN.

Although this study focused on the MN and pronator teres, these prediction models should be performed to prevent potential adverse effects and other complications in various body regions.[14-16] Indeed, peripheral nerve lesions have been reported with deep DN and acupuncture approaches in musculoskeletal conditions, specifically in the forearm region.[11-13]

The reviewed literature does not recommend inserting the entire length of the needle.[5-9] Not introducing the complete length of the needle could increase DN safety and strengthen the presented clinical prediction model to minimize MN puncture risk in the pronator teres.

We employed a pronator teres DN approach based on prior studies and trigger point manuals, and the needle lengths used in the study (13 mm and 25 mm) were based on these recommendations.[5-9] Therefore, clinicians who follow this study's recommendations should first measure their patients' forearm circumference and forearm length. Based on the anthropometric measurements, clinicians can determine more precisely the most appropriate needle length for each patient by following the prediction

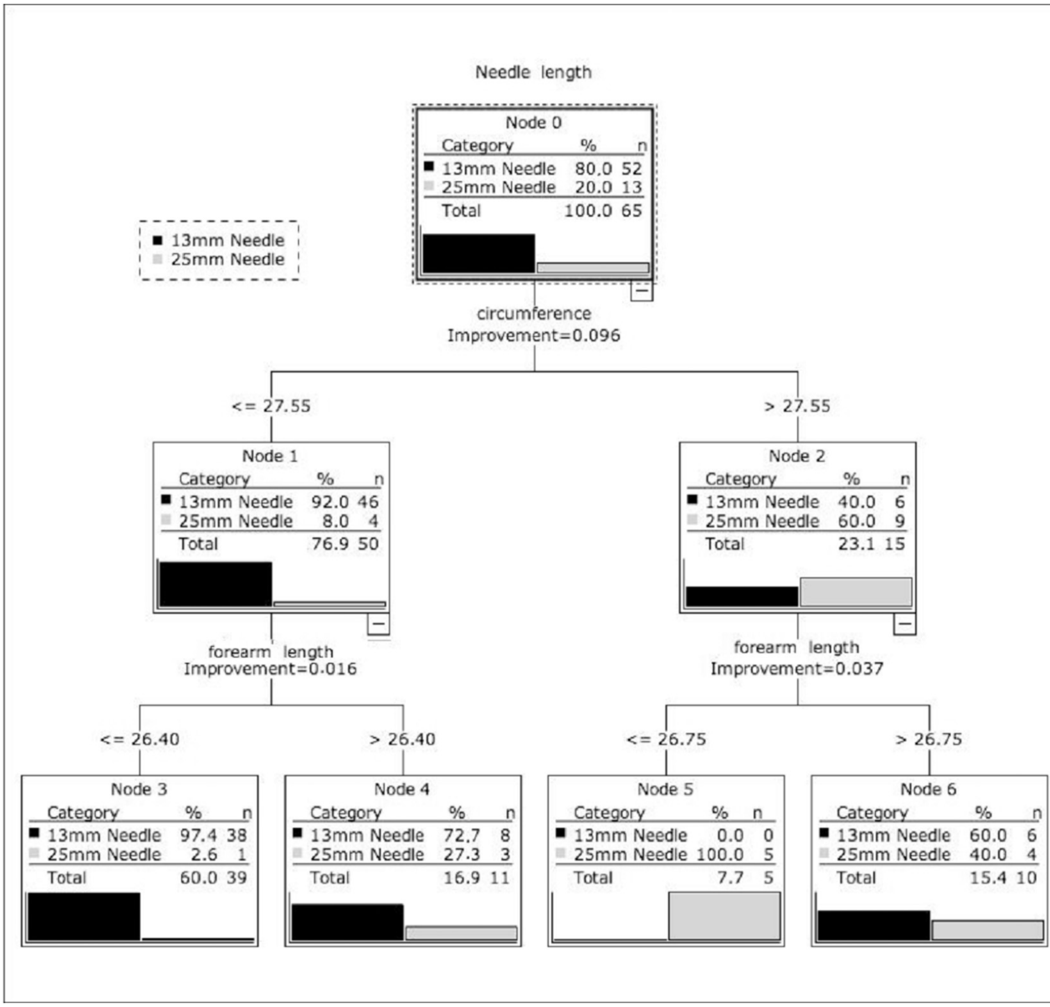

Fig 2. *Tree decision model. Read from top to bottom to determine the appropriate needle length (13 mm or 25 mm), according to the anthropometric measures.*

percentage for the needle recommendation in each box of Figure 2. According to the results of the prediction model, a 13-mm needle is more appropriate for patients with a forearm circumference ≤27.5 cm (to prevent an MN puncture during DN with a 92% probability). For patients with a forearm circumference >27.5 cm and a forearm length ≤26.75 cm, the choice should be the 25-mm needle (to prevent an MN puncture during DN with a 100% probability). Furthermore, the ultrasound assessment should be performed as described in prior procedures to evaluate peripheral MN entrapment.[4]

Future studies should compare the anatomical types of pronator teres ulnar heads between healthy individuals and cadaveric neurorehabilitation patients by anatomical dissection and in vivo using ultrasound to optimize the prediction models and minimize adverse effects during DN procedures.[1,21]

As a first approach, we prioritized the ultrasound estimate of the needle length according to the anthropometric measures of the forearm of healthy individuals to prevent MN injury during pronator teres DN. Most peripheral nerve injuries resulting from DN can be avoided by using ultrasound-guided procedures, which require a needle insertion angle of <30° to provide a full view of the needle.[14-16,21] However, our ultrasound measurements were performed with a perpendicular (90°) needle approach to the MN and muscle fibers, given that it is the most commonly used DN/acupuncture procedure according to prior recommendations.[5-9] Guidelines for safe DN using ultrasound measurements of the pronator teres need to be created to prevent these forearm nerve injuries.[11-13,26] We suggest that pronator teres DN can be a safe procedure even without ultrasound guidance, provided the needle length is selected according to the specific forearm measures.

Limitations

Only healthy individuals were recruited; however, future studies should include patients undergoing neurorehabilitation or with peripheral nerve entrapment.[2-4,6] The ultrasound evaluation of PS could show a different pronator teres thickness or MN cross-sectional area in these patients.[1,27] Another limitation was that we did not perform a sample size calculation; however, this study reached the sample size requirement to perform a decision tree prediction model and the recommended sample size of prior studies.[21,28] A further limitation was that we did not consider the 5 types of pronator teres ulnar head (fibromuscular, muscular, fibrotic band, absent, and 2 arches), although the same methodology was applied regardless of these anatomic variations.[1,29] Finally, we recognize that consecutive sampling might be a limitation and should be reconsidered in future studies.

Conclusion

Based upon the findings of this study, we suggest that needle length should be selected according to forearm anthropometric measures to prevent MN injury during pronator teres DN. This study demonstrated a new regression tree prediction model that may help minimize adverse effects during DN procedures.

Funding Sources and Conflicts of Interest

No funding sources or conflicts of interest were reported for this study.

Contributorship Information

Concept development (provided idea for the research): R.F.-P., D.M.-G.

Design (planned the methods to generate the results): R.F.-P., D.M.-G.

Supervision (provided oversight, responsible for organization and implementation, writing of the manuscript): R.F.-P., C.C.-L., D.M.-G.

Data collection/processing (responsible for experiments, patient management, organization, or reporting data): R.F.-P., D.M.-G.

Analysis/interpretation (responsible for statistical analysis, evaluation, and presentation of the results): R.F.-P., C.C.-L., M.G., D.M.-G.

Literature search (performed the literature search): R.F.-P., C.C.-L., M.G., D.M.-G.

Writing (responsible for writing a substantive part of the manuscript): R.F.-P., C.C.-L., M.G., D.M.-G.

Critical review (revised manuscript for intellectual content, this does not relate to spelling and grammar checking): R.F.-P., C.C.-L., M.G., D.M.-G.

Practical Applications

- This study aimed to minimize the risk of MN puncture during DN or acupuncture approaches.
- Anthropometric measurements may predict the recommend needle length to avoid MN puncture into the pronator teres muscle.
- A new regression tree prediction model to minimize the undesirable effects during DN or acupuncture applications is proposed.

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