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Original Research

Resident Accuracy of Electromyography Needle Electrode Placement Using Ultrasound Verification

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Abstract

Background: Electromyography (EMG) and musculoskeletal (MSK) ultrasound (US) are core learning objectives during physical medicine and rehabilitation (PM&R) training. However, there have been no prior studies using MSK US to assess the acquisition of EMG procedural skills during residency training. This study aims to demonstrate the differences in skillful needle placement between junior and senior physiatry residents. The integration of both EMG and MSK US may have tremendous potential for additional learning opportunities related to electrodiagnostic education.
Objective: To determine the accuracy of anatomic landmark—guided EMG needle electrode placement in commonly used muscles by PM&R resident physicians.
Design: Cross-sectional study.
Setting: An academic PM&R residency program.
Participants: Twelve (5 postgraduate year [PGY] —3 and 7 PGY-4) PM&R resident physicians participating in a MSK US training course.
Methods: Twelve PM&R residents in the eighth month of their third and fourth years of postgraduate training performed anatomic landmark—guided needle placement to the extensor indicis proprius (EIP), pronator teres (PT), peroneus longus (PL), and soleus muscles of live subjects. Once the needle electrode was satisfactorily placed, needle localization was verified with US.
Main Outcome Measures: Accuracy of EMG needle electrode placement.
Results: The overall accuracy of needle electrode placement for all resident participants was 68.8%. The mean accuracy of the 4 selected muscles was 50% by PGY-3 residents and 82.1% for PGY-4 residents ($P = .01$). EIP was the most commonly missed muscle, with correct placement performed by 20% of PGY-3 and 42.9% of PGY-4 residents. PGY-3 residents demonstrated 60% accuracy with localizing the PT, PL, and soleus muscles. PGY-4 residents demonstrated 85.7% accuracy for PT, and 100% accuracy for both PL and soleus muscles.
Conclusions: Senior residents demonstrated greater accuracy of landmark-guided needle placement than junior residents. EMG procedural skills are important milestones in PM&R training, and MSK US may be a useful tool to enhance resident learning.

Introduction

Electromyography (EMG) is a time-intensive, operator-dependent diagnostic procedure that requires extensive training for the operator to become proficient. It is also a required competency of physical medicine and rehabilitation (PM&R) residency training. EMG training traditionally takes place in the classroom followed by self-study, observation, and eventually hands-on practice under supervision in the clinical setting. Critical to the performance and integrity of an EMG study is the ability of the examiner to quickly and accurately place the needle electrode in the desired muscle. The difficulty of this skill is commonly underestimated by seasoned electromyographers, and it can be one of the more daunting challenges to a trainee. When the electromyographer's proficiency and accuracy of needle placement is low, the diagnostic integrity of the study suffers, and the study itself can become more painful for patients [1].

Multiple studies have assessed needle placement accuracy in cadavers. Accuracy rates of needle placement by trained electromyographers, confirmed by dissection, ranged from 0%-100% accuracy for each muscle tested, with an overall accuracy of 57% [2]. A similar study using cadavers and placement confirmation

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by dissection demonstrated correct placement in 45% of upper limb and 52% of lower limb muscles [3]. Ultrasound was used as an adjunct to needle placement in another cadaveric study for EMG needle placement, and demonstrated 96% accuracy compared to 39% accuracy of needle placement when using anatomic landmark guidance alone ($P < .0001$) [4]. Ultrasound is also being used to confirm placement of needles in living humans. A prior study in children with cerebral palsy demonstrated 78% accuracy of needle placement for botulinum toxin type A injections into the gastrocnemius muscles when using anatomic landmarks and verification with MSK US [5]. Multiple studies have demonstrated excellent precision with US-guided peripheral joint and soft tissue injections [6-11]. In addition, US guidance for EMG needle placement into the diaphragm has been promoted to increase the safety of the study [12-14]. Expanding the use of US in EMG studies is currently a growing area of interest.

The increasing popularity of musculoskeletal (MSK) ultrasound (US) in the last decade has made it more accessible to use in education as well as patient care. MSK US is also being used to provide direct feedback to residents in training when performing other critical competency skills such as the physical examination [15,16]. The real-time feedback for a trainee performing a test is a valuable asset to any educational curriculum, because it is an objective measure of performance. The true potential of using MSK US is not yet fully actualized, and the opportunities for incorporating MSK US with EMG education are great.

It is assumed that accuracy improves with experience throughout the resident training process. However, obtaining objective evidence that residents improve with increased experience in a procedural setting is difficult. In this study, we sought to evaluate the accuracy of EMG needle electrode placement in 4 specific muscles by physical medicine and rehabilitation (PM&R) residents in their postgraduate year 3 (PGY-3) and postgraduate year 4 (PGY-4) levels of training. To our knowledge, there have been no prior studies specifically assessing the accuracy of EMG needle electrode placement through the course of PM&R residency training using US to confirm correct placement. We hypothesized that the PGY-4 residents with more EMG experience would demonstrate better accuracy of needle placement compared to the PGY-3 residents.

Methods

This study was approved by the Northwestern University Institutional Review Board. PM&R residents in the academic institution receive a 5-hour series of introductory lectures, including hands-on EMG skills training, before performing 2 months of EMG training during their PGY-3 year and then 3 months during the PGY-4 year. As part of routine formal education, residents are taught EMG electrode placement, using anatomic landmarks, on their fellow residents. Eight months into the academic year, the accuracy of needle EMG placement by residents on their peers was assessed by attending physicians using US. Informed consent was obtained to report the de-identified data. Residents were assured that their participation in this study would have no impact on their promotion and status within the residency program. Only PGY-3 and PGY-4 were included in the study to ensure that residents would have a significant level of exposure and experience with EMG. All participants had completed at least 1 EMG rotation.

The primary outcome measure was accuracy of needle placement in each of the 4 selected muscles: extensor indicis proprius (EIP), pronator teres (PT), peroneus longus (PL), and soleus. These muscles were chosen because of their frequency of use during EMG procedures and/or botulinum A toxin injections, as well as their superficial location allowing residents to palpate these muscles for localization. Residents were allowed to palpate anatomic landmarks and to use muscle activation to place the needle into the muscle, as they would typically be allowed to do during an EMG study. They were given no direction other than the name of the muscle that they were to target, and a machine was not provided for electromyographic feedback. The resident acting as the model was not allowed to assist the subject. Monopolar 25-mm, 28-gauge needle electrodes were chosen to minimize discomfort. An MSK attending physician (K.K.) with 3 years of US experience (1 year of US experience as an attending physician) evaluated the placement of the tip of each electrode with a high-frequency linear array transducer (14-6 MHz, Mindray M7, Mahwah, NJ) using in-plane and out-of-plane imaging of the needle (Figures 1-4), as well as real-time "jiggling" of the needle [17]. A sports medicine physiatrist with greater than 5 years of US experience (M.R.) was available to clarify any borderline or unclear needle placements. The residents involved (subjects and models) also participated in the verification process of needle accuracy to take advantage of the critical learning component that was available in this process.

Accuracy of needle placement was recorded for each muscle, and the data were de-identified for analysis. Sample size was determined by the number of upper-level residents participating in this voluntary US education course; therefore a power analysis was not performed. A Student *t*-test was used to make statistical comparisons between the performances of the 2 groups.

Results

Data were collected from the 12 participating resident electromyographers, including 5 PGY-3 and 7 PGY-4 resident physicians. Accuracy rates were calculated for each muscle by level of residency training. Overall