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Technical Notes & Surgical Techniques

Development of a method to compare microsurgery techniques across different levels of surgical experience

Nicole E. McAmis, BS [a], Dominic A. Prospero, BS [a], John Standeven, PhD [a], Wilson Zack Ray, MD [b], Zohny Zohny, MD [b], Jack R. Engsberg, PhD [a,*]

[a] *Department of Occupational Therapy, Washington University in St. Louis School of Medicine, Saint Louis, MO, USA*
[b] *Department of Neurosurgery, Washington University in St. Louis School of Medicine, Saint Louis, MO, USA*

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ABSTRACT

Object: Surgical training is often seen as very timely and cost consuming as it requires multiple interactions with other experienced physicians. Through the use of video motion capture (VMC), novice surgeon's skills will be compared objectively to those of more experienced surgeons.
Methods: VMC was used to capture the movements of four neurosurgery residents performing five simple tasks: (1) threading the needle through the provided plastic vessel; (2) pulling the needle through the provided plastic vessel; and (3,4,5) tying the suture three times.
Results: It was concluded that experienced subjects recorded more accurate and precise motions within a shorter amount of time when compared to novice subjects. There was a decrease in time, elapsed path, and thumb tip distance with increasing experience.
Conclusions: The use of VMC proves to be a successful way to compare the differences between different levels of surgical expertise and we hope that this research will impact training paradigms for future surgical trainees.
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1. Introduction

Microsurgery is a surgical technique that allows for the visualization, dissection, and repair of very small or complex anatomic structures. In the 1960′s, microsurgery was primarily used in emergent procedures, such as limb replantation [13]. As operative microscopes became more widely available so did the use of microsurgical techniques in non-emergent procedures throughout most surgical specialties. In neurosurgery, microsurgery is the mainstay of most procedures performed, i.e. lumbar discectomy, anterior cervical discectomy, arterial bypass, tumor resections. Therefore, neurosurgical trainees must achieve competence within microsurgery prior to completing their training.

Many training paradigms applied today are variations of the Halstedian apprenticeship method, in which the subjective opinions of senior surgeons are used to assess ability, rank and competence of trainees [7]. This method of teaching is a very timely and interactive process requiring multiple interactions with senior surgeons and multiple surgical opportunities. A surgeon cannot practice or learn a skill unless the opportunity arises. Procedures that require the greatest dexterity and training also tend to be the least commonly performed procedures due to their inherent risk further limiting surgeon training. Recent changes, such as resident duty hour restrictions, increasing ethical apprehensions about training on live patients and the push to control hospital costs by reducing procedure times, consequentially lead to a reduction of “live” training time. Additionally, the natural advancement of surgery, which results in new tools and techniques, increases the need for adjuvant training outside of the operating room [4].

Several simulation models have been shown to enhance surgeons' skills by repeated exposure and practice outside of the operating room [1,3,5,12]. The integration of novel simulation methods into the current apprenticeship model may result in better technical skills through self-directed practice, and may be more cost-effective and ethical than hands-on training [8,11]. Furthermore, when objective direct feedback and evaluation was integrated into simulation training skill acquisition was accelerated [10].

One way to help improve the novice surgeon skills may be to objectively compare his/her surgical techniques to those of expert surgeons. Such comparisons are possible through the use of video motion capture (VMC). The use of motion analysis during surgery allows for the measurement of dexterity, spatial orientation, and operative flow, while being paired with an assessment by an expert. [2]

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* Corresponding author at: Washington University in St. Louis School of Medicine, 4444 Forest Park Ave, Saint Louis, MO 63108, USA.
E-mail address: engsbergj@wustl.edu (J.R. Engsberg).

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The purpose of this study was to develop a method of comparing microsurgery techniques across different levels of surgical experience.

2. Methods

2.1. Participants

Four participants, 1 woman and 3 men, consented to participate in this Washington University School of Medicine Institutional Review Board approved study performed in the Human Performance Laboratory (St. Louis, MO). Participants included two junior neurosurgery residents and two senior neurosurgery residents. The junior residents had minimal to moderate neurosurgery experience and were considered novice trainees, while the senior residents had moderate to extensive neurosurgery experience and were considered experienced trainees. Inclusion criteria included no neuromuscular or musculoskeletal pathologies, no congenital abnormalities of bilateral upper extremities, and no history of previous nerve damage to bilateral forearms, hand, or fingers. Informed consent was obtained from all individuals prior to testing. The study was approved by the Washington University in St. Louis School of Medicine Institutional Review Board (IRB).

2.2. Hardware/equipment

Torso, arm, hand, and finger movements were captured using a Video Motion Capture (VMC) system comprised of eight cameras. An optical motion capture system (Motion Analysis Corporation; Santa Rosa, CA) detected forty-one 6 mm diameter retro-reflective markers attached to each participant (60 Hz).

Surface markers were placed on each participant at anatomically meaningful locations where subcutaneous tissues were thin to reduce marker movement artifacts. Prior to motion capture, the markers were attached to the participant when they were in an anatomically neutral position to ensure consistent placement among participants. Anatomic neutral was defined as having participants' arms relaxed at their sides, with forearms supine, with their backs comfortably straightened while seated on a stool with feet at shoulder width apart and knees bent at 90°. Markers were applied to the torso, bilateral arms, bilateral hands, and bilateral fingers in specific locations (Fig. 1). Markers were secured to forty-one palpable surface landmarks using double-sided adhesive tape.

2.3. Testing protocol

After marker placement, the participants were seated in the center of the room, facing a small table containing an anastomosis set, and instructed to follow a series of simple tasks to perform a suturing task. All participants used surgical spectacles in order to simulate actual surgery. The suturing task was performed using a Biomet ® Microfixation 2.0 mm Anastomosis Training Kit. The kit was equipped with a 9–0 suture, foam base with slits, double clamp, blood vessel, syringe, simulated blood, and instruction card.

The motion capture system was used to capture the movements of the fingers, hands, and torso during the instructed suturing task (Motion Analysis Corporation; Santa Rosa, CA). The skills of threading, pulling, and knotting a suture were selected to determine skill evaluation as these represent basic surgical skills that must be mastered. Each participant was instructed to perform the same five tasks using the anastomosis kit: (1) threading the needle through the two cut edges of provided plastic vessels; (2) pulling the needle through the provided plastic vessel; and (3,4,5) tying the suture three times.

2.4. Data processing and analysis

Following data collection, marker coordination was tracked and smoothed using a Butterworth filter with a 60 Hz cutoff. Subsequent and post processing analysis was performed in Cortex, the VMC software (Motion Analysis Corporation), Microsoft Excel, and MATLAB. X, Y, and Z coordinates were obtained for each identified marker for each

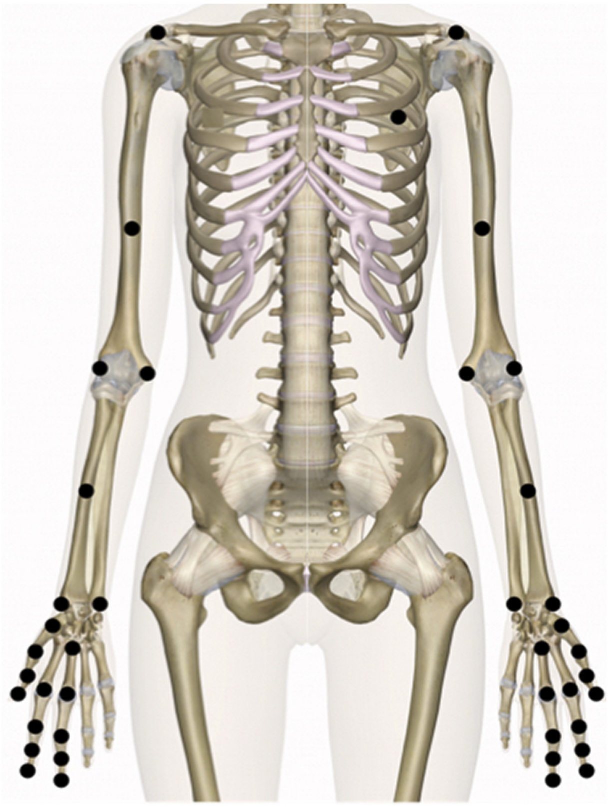

Fig. 1. Placement of retro-reflective markers. Left side of body: scapula offset; acromion; bicep; humeral lateral epicondyle; humeral medial epicondyle; radial offset (middle of forearm); radial styloid process; ulnar styloid process; thumb carpometacarpal (CMC) joint; thumb metacarpophalangeal (MCP) joint; thumb interphalangeal (IP) joint; thumb finger tip; index finger metacarpophalangeal (MCP) joint; index finger proximal interphalangeal (PIP) joint; index finger distal interphalangeal (DIP) joint; index finger tip; middle finger carpometacarpal joint (CMC); middle finger metacarpophalangeal (MCP) joint; middle finger proximal interphalangeal (PIP) joint; middle finger distal interphalangeal (DIP) joint; middle finger tip. Right side of body: acromion; bicep; humeral lateral epicondyle; humeral medial epicondyle; radial offset (middle of forearm); radial styloid process; ulnar styloid process; thumb carpometacarpal (CMC) joint; thumb metacarpophalangeal (MCP) joint; thumb interphalangeal (IP) joint; thumb finger tip; index finger metacarpophalangeal (MCP) joint; index finger proximal interphalangeal (PIP) joint; index finger distal interphalangeal (DIP) joint; index finger tip; middle finger carpometacarpal joint (CMC); middle finger metacarpophalangeal (MCP) joint; middle finger proximal interphalangeal (PIP) joint; middle finger distal interphalangeal (DIP) joint; middle finger tip.

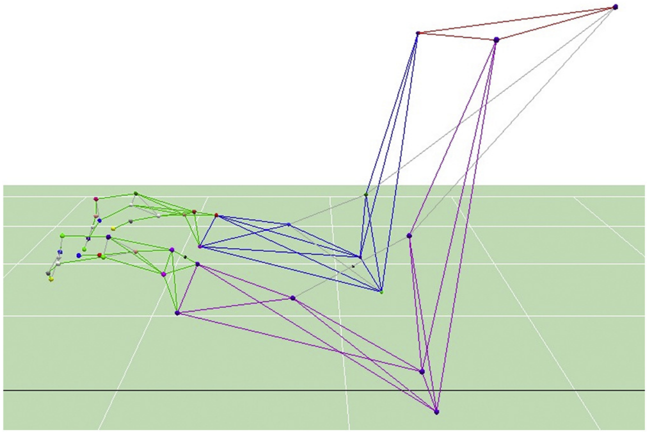

Fig. 2. Example of a subject's tracked data from Cortex software.

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