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### Are Thiel-embalmed Cadavers Effective Tools in Educating Medical Students to Perform Knee Arthrocentesis?

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## Introduction

**Background:** Medical students learn to perform physical examination techniques and procedural skills through a combination of lectures, demonstrations, and practice using models or simulated patients (SPs). The ability to gain hands-on practice is a crucial component of this learning process, but there are situations in which suitable training models are unavailable, and the use of SPs is limited as they cannot accurately replicate certain physical exam findings (e.g. torn ligaments) or be used to practice procedural skills (e.g. knee arthrocentesis). In these situations, the inability to gain hands-on practice in a realistic environment results with students who are unprepared to properly execute certain physical exam techniques, accurately interpret their associated findings, and perform basic procedural skills such as knee arthrocentesis.

We believe that the use of Thiel-embalmed cadavers can provide a solution to this gap in medical education. In contrast to traditional formalin-embalmed cadavers, this embalming method allows for increased joint mobility and preserved fascial integrity while closely mimicking the aesthetics of live tissue [1,2]. These unique qualities allow students to practice skills in a realistic environment in situations when SPs cannot be utilized.

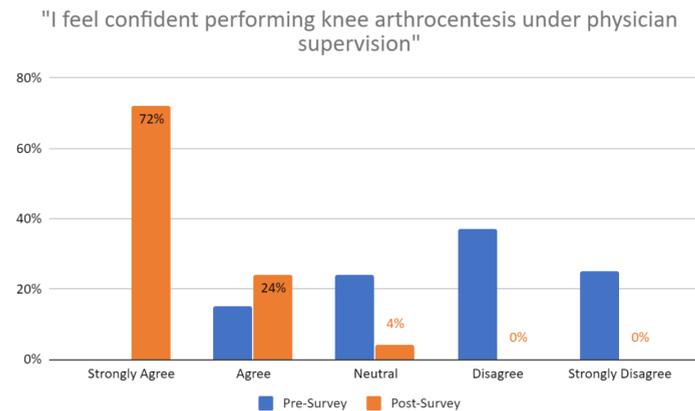
**Purpose:** The purposes of this study are to 1) determine whether Thiel-embalmed cadavers are an effective educational tool in teaching medical students to perform knee arthrocentesis, 2) to compare the use of Thiel-embalmed cadavers to formalin-embalmed cadavers in arthrocentesis education, and 3) to determine whether the use of Thiel-embalmed cadavers is potentially generalizable to the instruction of other orthopedic procedures.

## Methods

**Subjects:** The participants of this study consisted of sixty-eight third-year medical students.

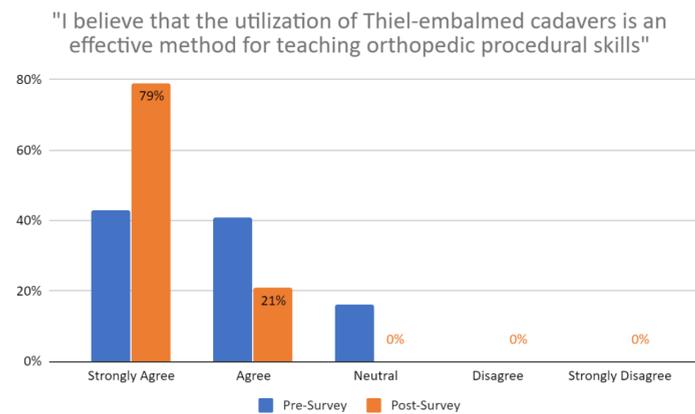
**Procedure:** The participants first completed a pre-survey to assess their prior experience with arthrocentesis procedures and Thiel-embalmed cadavers. Participants then attended an instructional session where the knee arthrocentesis procedure was demonstrated on a Thiel-embalmed cadaver. Participants then individually performed the simulated knee arthrocentesis procedure twice: once on a Thiel-embalmed cadaver and once on a formalin-embalmed cadaver. Success of each attempt was determined through the visualization of aspirated joint fluid. Following the laboratory session, each participant completed a post-survey to determine whether the session improved their perceived confidence in performing knee arthrocentesis, if they preferred the use of Thiel-embalmed cadavers or formalin-embalmed cadavers as a teaching tool, and if they believed simulated practice using Thiel-embalmed cadavers would be effective for learning other orthopedic procedural skills.

## Figure 1



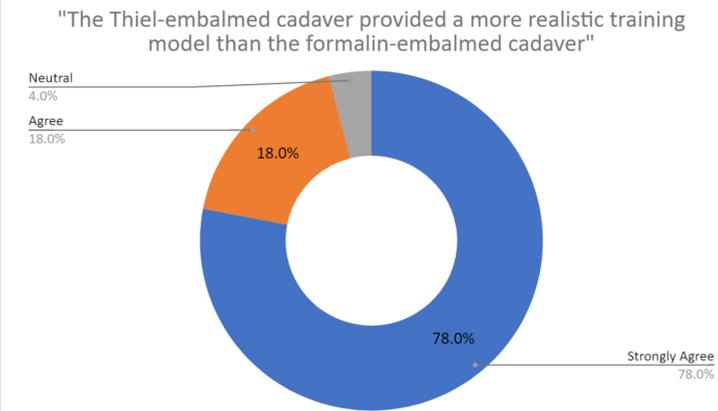
**Figure 1** displays the differences between the participants' perceived confidence in performing knee arthrocentesis under physician supervision before and after participating in this study. In the pre-survey, ten individuals (15%) reported that they felt confident performing knee arthrocentesis under physician supervision (0% strongly agree, 15% agree). In the post-survey, sixty-five students (96%) reported that they felt confident performing knee arthrocentesis under physician supervision.

## Figure 2



**Figure 2** displays the pre-survey and post-survey differences regarding the participants' perceived effectiveness of Thiel-embalmed as an educational tool when teaching orthopedic procedural skills such as knee arthrocentesis. In the pre-survey, fifty-seven students (84%) reported that they believed the incorporation of simulated practice using Thiel-embalmed cadavers is an effective method for teaching orthopedic procedures such as knee arthrocentesis (43% strongly agree, 41% agree). In the post-survey, all sixty-eight individuals reported that they believed the incorporation of simulated practice using Thiel-embalmed cadavers is an effective method for teaching orthopedic procedures such as knee arthrocentesis (79% strongly agree, 21% agree).

## Figure 3



**Figure 3** displays the participants' perceptions of whether the Thiel-embalmed cadavers or formalin-embalmed cadavers provided a more realistic training model when learning to perform knee arthrocentesis. Sixty-five individuals (96%) reported feeling that the Thiel-embalmed cadavers provided a more realistic teaching model than formalin-embalmed cadavers for learning knee arthrocentesis (78% strongly agree, 18% agree, 4% neutral).

## Results

**Data collection:** each participant completed a post-survey which asked them about the overall quality of their experience, whether they felt that the session improved their confidence performing knee arthrocentesis, whether they believed the setting improved their ability to properly perform knee arthrocentesis in an actual patient care setting, if they believed simulated practice using Thiel-embalmed cadavers to be an effective method for learning procedural skills, and if they preferred the use of Thiel-embalmed cadavers or formalin-embalmed cadavers as a teaching tool.

**Data analysis:** Sixty-eight students participated in the laboratory session and successfully completed both pre- and post-course surveys. 96% of participants reported that they felt confident performing knee arthrocentesis under physician supervision following their participation in the laboratory session (versus 15% of participants in the pre-survey). 96% of participants reported that the Thiel-embalmed cadavers provided a more realistic teaching model than formalin-embalmed cadavers for learning knee arthrocentesis. 100% of participants believed the incorporation of simulated practice using Thiel-embalmed cadavers is an effective method in teaching students to perform knee arthrocentesis. 100% of participants reported that they would participate in future sessions using Thiel-embalmed cadavers to learn and practice other orthopedic procedural techniques.

## Discussion

**Discussion:** Medical students are frequently exposed to procedures such as knee arthrocentesis during their clinical rotations, but there is no suitable model for medical students to practice performing the procedure or interpret the results. SPs cannot be utilized due to the invasive nature of the procedure, and formalin-embalmed cadavers are unable to provide a realistic simulated training environment due to their postmortem rigidity and high susceptibility to tissue decay. This absence of a sufficient teaching model results with medical students who are forced to learn how to perform procedures such as knee arthrocentesis for the first time on actual patients.

We propose that Thiel-embalmed cadavers are suitable training models for teaching these procedural skills. We believe that their incorporation into clinical skills courses will result with improvements in medical students' confidence and competence in performing physical examination techniques and accurately interpreting the positive and negative findings of these tests which they will be expected to perform during their clinical rotations and beyond.

**Limitations:** Since this study looked specifically at teaching knee arthrocentesis to medical students, it is uncertain whether the benefits of Thiel cadavers are generalizable to the education of other orthopedic procedures and subject groups such as residents, fellows, and practicing physicians. Further studies should be performed to assess whether Thiel cadavers are beneficial in teaching other orthopaedic procedures and if these benefits extend to other subject groups.

**Conclusion:** This study used a moderate sample size of third-year medical students to provide data regarding the suitability of using Thiel cadavers in arthrocentesis education. Results indicate that Thiel cadavers are effective tools in teaching medical students to perform knee arthrocentesis, that students preferred the Thiel cadavers to the formalin cadavers, and that the use of Thiel cadavers is a safe, engaging, and high-quality teaching modality for demonstrating proper arthrocentesis procedural technique to medical students.

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