Introduction

Local anesthesia (LA):
- Results in loss of sensation of targeted region
- Sometimes various chemicals associated with peripheral nerves, which blocks the propagation of action potentials

Anatomy and techniques of Inferior Alveolar Nerve Block (IANB):
- Site of injection is below oral mucosa on the mandible (usually in the mental foramen in the mental triangle)
- Needle is advanced slowly from a position above the mental foramen until loss of resistance to LA (usually 15-25 mm)
- Injection: 2-3 mm aspiration twice, administer anesthetic

Difficulties and complications of the IANB:
- Dental LA needle stuck with highest failure rate (15-25%) or more
- Most common reasons for failure include anatomical variations and poor technique (e.g., improper needle placement, inadequate mouth opening, or insufficient depth of injection)
- Complications include intravascular injection (most common), permanent injury to the IAN or lingual nerve, fractured needles, parapharyngeal tip and/or tongue, and facial nerve palsy

Local anesthesia mandatory:
- The most widely used model is students-to-student administration, which is often stressful and a risk of passage for dental students
- However, it is essential for both provider and recipient and is common because of logistical issues
- In contrast, students receiving LA from a student that had practiced on a simulation model experienced fewer post-injection complications

Design Process

Mechanical capabilities of simulation training model:
- Model includes a virtual needle as adjustable (0-30 degrees), 15-degree, and 30-degree
- Flexibility of needle to accommodate the full physiological range of mental/lingual opening
- Training maneuver allows to accommodate the full physiological range of mandible movement

Electrical capabilities of simulation training model:
- Bladderless pressure sensors/actuators at IANB needle insertion position is correct (punctured needle only for now)
- Feedback is provided using green light: mimic only forward facing (looser pressure) and only retrofacing (compensatory evaluation)
- Additionally, pressure can be used to indicate correct needle insertion position as an alternative to the green light

Design Results

Figure 4: Cross-sectional views showing the design and fabrication process of the mechanical component and model. From top to bottom: top – 3D scan downloaded from internet; middle – scans converted to mesh files and modified in a computer-aided design (CAD) program (Autodesk Fusion 360); bottom – 3D-printed prototype.

Figure 5: Cross-sectional, sagittal, and coronal views of the mechanical component of the simulation training model assembled in CAD.

Figure 6: Coronal and sagittal views showing the ability of the simulation training model to adjust the plane of anesthesia (from left to right: functional angles of 15 degrees, and 30 degrees).

Figure 7: From left to right: left - coronal view of bilateral pressure sensor placement for the current IANB kit; middle - coronal view of left IANB pressure sensor placement; right - complete set-up of simulation training model (electrical components - including an Arduino Uno, breadboard,uggle molex, two green lights, two pressure sensors, and wiring).

Discussion

The current iteration of the simulation training model did not fully meet all three original goals. For goal number one, the model appropriately reproduces the critical facial nerve anatomical anatomy, but it does not portray the soft tissue components. Goal number two was accomplished. For goal number three, the model is not yet able to reliably and consistently allow for a positive aspiration result.

Future Plans

Modifications and additions to the simulation training model:
- Refine size of mandible models
- Integrate soft-tissue simulation with supply of oil resistant water to stimulating sensations and allow for a positive aspiration result
- Utilize Elastic Silicone to reproduce and tissue-relevant anatomy
- Optimize mounting approach to reduce complexity
- Design and fabricate component to pressure sensors from being punctured by needle head

Verification/validation testing:
- Future experts to test the simulation training model and provide feedback from an anatomical perspective, clinical simulation, scale of model, logical feedback, and positioning of the “puncture”
- Modify the training model with incorporation of the feedback

Educational research project (following NIH approach):
- Evaluate the value of the simulation training model for improving students' learning and confidence in performing the IANB
- Central group: students that will participate in the current method for learning the IANB (traditional didactic)
- Experimental group: students that have the simulation training model used for teaching purposes and available for practice
- Evaluate the quality/quantity of instructional material and patient perceptions of performance and reported anxiety levels, and occurrence of post-injection complications

Acknowledgements

The research team would like to thank the Michigan Media-The Clinical Simulation Center for access to 3D printers, Mr. Louis Gibson for his guidance on the electrical components of the simulation training model and for access to his woodworking shop, the Department of Dental Materials & Restorative Science, College of Dentistry, University of Michigan, for their support, and the University of Michigan College of Dentistry Pathways Program for both support and mentorship.

References