

EXPERIMENTAL DESIGN: Robotic Bone Drilling Assessment

Experiment title:

Evaluation of the Galen System in the Bone Drilling Procedure

People Involved:

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Mentors: Yunus Sevimli, Paul Wilkening, Dr. Russell Taylor, Dr. Matt Stewart

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Experiment goal:

Compare the use of the Galen System to free hand use of the drill to evaluate the performance of the robot in assisting the bone drilling process.

Location of experiment:

Experiments will be conducted in the Swirnow Mock Operating Room in Hackerman Hall on the Johns Hopkins Homewood campus.

Levels of robotic assistance:

1. No assistance
2. Hand tremor elimination
3. Hand tremor elimination and virtual fixtures

Groups of test subjects:

1. Laymen (no prior surgical experience): 4 subjects
2. Surgeons in training: 2 subjects
3. Senior surgeons: 2 subjects

Replicates of experiments:

Each test subject will perform 2 trials under each robotic assistance level.

Randomization of experiment order:

The order in which each subject will operate under the different robotic assistance modes will be randomized based on random numbers generated before the session begins.

Phantom design:

The phantom will be 3D printed. It contains a simulated facial nerve, and a simulated auditory sinus to facilitate the locating of the facial nerve. The facial nerve will be printed as a hollow channel, and a cable will then be inserted into the channel to represent the facial nerve. The cavity in the 3D printed model will be filled in with wax, which is used to simulate the diseased tissue to be removed. The phantom will also

have fiducials located at its four corners for registration purposes. A frame will be constructed to hold the phantom in place. The frame will be attached to a tray that will be used to hold water from irrigation.

Discuss with Yunus and Dr. Taylor. Do we need to purchase more wax?

Virtual fixture design:

We will create two planes to limit the user's motion, shown by yellow lines. As a result, the drill attached to the robot should be forbidden to enter the regions highlighted in yellow. This will help protect against damaging the facial nerve.

Discuss with Paul

Performance evaluation criteria:

Safety

- An attempt will be deemed a failure if the simulated facial nerve is touched by the drill, and a success otherwise. The number of successes and failures will be recorded.
- If an attempt is successful, the closest distance the tip of the drill approached the facial nerve during the experiment will be measured.
- The temperature of the cable will be recorded with a thermocouple. This is because in real surgeries, the facial nerve may be burned even if the drill does not come in direct contact with it, so assuring that the heat produced by the drill is under a certain threshold is also necessary.
- **Do we need to make purchases of the cables and the thermocouple?**

Effectiveness

- How much of the pre-defined portion remains in the phantom after the surgery
- How much of the material that was not to be removed was removed
- **How to measure these?**

Speed

- Time taken to perform procedure will be recorded.

Additional

- An expert surgeon will provide a qualitative assessment based on examination of the post-operative phantoms and of intraoperative photos and videos of the operative field.
- Participants will be asked to fill out an anonymous questionnaire about their experience with the robot once they have completed the experiment.

