Quantification of tumor localization needle displacement prior to tumor excision in navigated lumpectomy

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Consortium: Cancer

Introduction. Early stage breast cancer is typically treated with lumpectomy. Lumpectomy is preferred over mastectomy for cosmetic reasons. A current challenge with lumpectomy is optimizing cosmetic appearance while ensuring full tumor resection, as pre-operative imaging is not always sufficient to determine the tumor's location. Electromagnetic tracking can be used to monitor tumor position using a localization needle during surgery. The tracked needle is stabilized in the tumor with tissue locking wire hooks, which are deployed once the needle is inserted. The localization needle may displace from its initial position of insertion which provides false spatial information about the tumor position and increases the probability of an incomplete resection. In this work, we offer a quantitative investigation of the role of mechanical forces on the magnitude of needle displacement prior to tumor resection. These mechanical forces can deform the breast; deformations are strongest when ultrasound scanning motions are performed while creating a 3D tumor model for navigated lumpectomy. This can cause the tracking needle to slip out of the tissue by decompressing the stabilizing wire hooks.

Methods. Ten ultrasound scans were obtained from lumpectomy procedures, and were performed immediately before tumor resection to measure needle displacement. Needle position was approximated by the distance between the needle tip and the tumor boundary on a 2D ultrasound image, and needle displacement was defined by the change in position. Ultrasound scans were collected with a Sonix Touch (Analogic Corp., Peabody, MA, USA) ultrasound scanner, and tracking data was acquired through the Ascension 3D trakSTAR and Model 800 electromagnetic sensors (NDI, Waterloo, ON, Canada). Tumor location marked with the DuaLok hooked needle (Bard Biopsy, Tempe, Arizona, USA). The angle between the localization needle and the coronal plane was computed in an open-source software platform.

Results. A significant relationship ($p = 0.04$) was found between the needle to coronal plane angle and increased needle displacement. Needles inserted vertically, pointing towards the operating room ceiling, tended to exhibit greater needle displacement. Average needle displacement was 1.7 ±1.2 mm and maximum needle displacement was 4.5 mm.

Conclusion. Needle to coronal plane angle has been shown to affect needle displacement, and should be taken into consideration when inserting the localization needle. Results suggest that inserting the localization needle horizontally may reduce needle displacement. Future works can be directed towards investigating tools that eliminate the bulk and weight of the electromagnetic sensor clip to the tumor tracking needle, or replacing the tracking needle entirely with a flexible guidewire that has an electromagnetic sensor in the wire tip. Improving the clinical workflow and the mechanical design of the localization needle to reduce slippage during surgery are other areas for improvement.

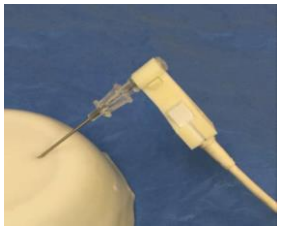

Figure 1: Electromagnetic sensor on tracking needle.

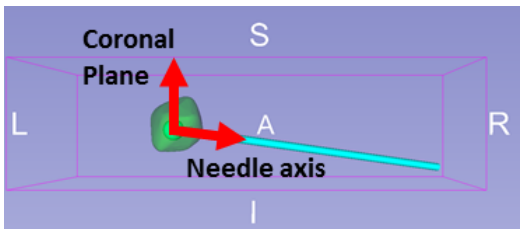

Figure 2: Needle to coronal plane angle.

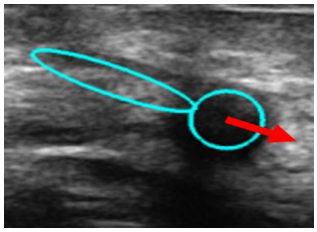

Figure 3: Distance between needle and tumor boundary.