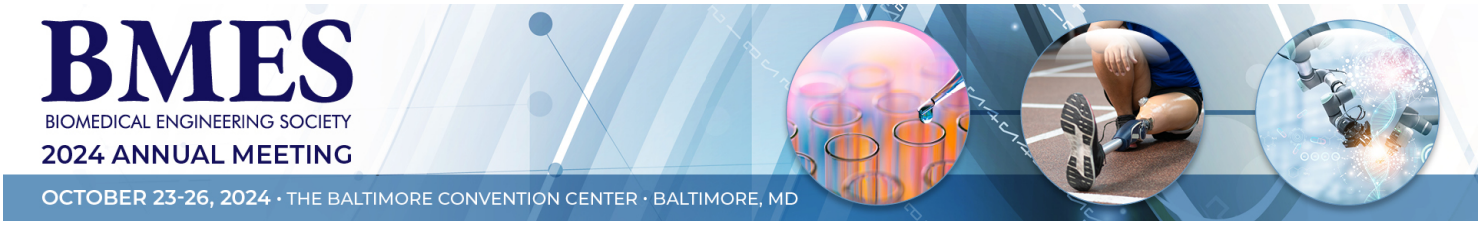

PRESENTATION DATA

Undergraduate Lightning Talks

Session: Undergraduate Lightning Talks (12:30 PM – 2:00 PM)

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12:55 PM – 1:00 PM

Augmentation of Breast Fine Needle Aspiration: Enhancing Sample Yield Through Mechanical Agitation

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Introduction: Fine Needle Aspiration (FNA) is an affordable, rapid, and minimally invasive procedure for diagnosing breast cancer, especially suited for low-resource settings. Unfortunately, due to limited resources and expertise, FNA is performed in less than 1% of Ugandan healthcare facilities concentrated in urban regions, known as National and Regional Referral Hospitals. Consequently, for the 74% of people residing in rural areas, a oneway trip costs approximately 10 to 50 hours of travel time and 10% of monthly income. Even when a person is able to receive the FNA, there is a 26.5% likelihood of a false negative result. False negatives delay treatment initiation and may require repeat biopsies, resulting in unmanaged disease progression and financial burdens from repeat hospital visits. They stem from inadequate sampling during aspiration, with insufficient cells being aspirated from the lesion to accurately diagnose pathology. If the false negative rate of FNA can be reduced, it has the practical potential to become an effective diagnostic tool, as it is a less expensive and invasive modality compared to surgical and core breast biopsies. Previous studies have demonstrated that incorporating additional agitation in the form of linear, vibrational, and rotational motion could increase the number of cells sampled from a breast lesion. This study aims to evaluate and compare the effectiveness of automated linear, vibrational, and rotational motion in increasing sample cellularity of FNA, leveraging patients to minimally invasive, cost-effective biopsies that facilitate more accurate diagnoses.

Materials and Methods: Three testing rigs were developed to simulate the motion modalities. The linear rig utilized a linear actuator at a 65-degree angle with a 3D-printed bracket. The rotational rig consisted of a 3D-printed housing for a VEX Smart Motor, connected to a syringe via bearings and gears. The vibrational rig used a syringe with an eccentric rotating mass motor at the 7cc mark. Each rig was connected to a voltage source to adjust motion parameters: manual FNA at 2.5 passes/second, linear motion at 4 passes/second, vibrational motion at 220 Hz, and rotational motion at 300 RPM.

Fresh goat liver was cut into 2-inch cubes for 10 trials per group. In each trial, voltage was set for the desired parameter and negative pressure was maintained at 3 CCs of air by pulling up the syringe. The sample was collected for 30 seconds. For vibrational and rotational modalities, linear motion was performed at 2.5 passes/second by the same operator. Following this, the sample was

expelled into a 1.5 mL Eppendorf tube, flushed with 400 µL of 10x TAE buffer, and vortexed for 30 seconds. Trypan Blue was added in a 1:1 ratio, and 20 µL of solution was analyzed under an EVOS M5000 microscope (10x objective). Nuclei-stained cells were counted using the Cell Counter plug-in on Fiji software, and cell concentration was estimated using the average four-grid count on a hemocytometer. Average counts and standard deviations were calculated, and two-tailed Mann-Whitney U Tests assessed statistical significance between modalities (Fig. 1).

Results, Conclusions, and Discussions: From the aspirate collection protocol, it was observed that most samples obtained were liquid, with increasingly semi-solid consistency when more tissue was aspirated. Microscopic analysis (Fig. 2) revealed that all three agitational motions yielded samples with higher cell concentration ($p < 0.05$) compared to those yielded by manual FNA (Fig. 3). In particular, rotational motion yielded the highest average cell concentration, followed by vibrational and linear motions. All agitational motions were effective at increasing sample cellularity compared to manual FNA; however, the average sample cell concentration between the three motions was not statistically different, indicating that their effectiveness at doing so was similar (Table 1).

Computing the F-test for sample cell concentration revealed each modality's standard deviation cell concentration was significantly different from manual FNA's. Although the average cell concentration increased when employing all three modalities, the consistency of such results was low due to large variation. When comparing the modality's standard deviations to each other, only a comparison between rotational and vibrational motion yielded an insignificantly different result (Table 2). Therefore, incorporating additional agitation to the FNA procedure will result in higher average cell concentrations per sample, but higher cellular variability across multiple passes.

Based on these findings, further investigation will be required to determine the most optimal motion and associated mechanical parameters that can consistently yield samples with higher cellularity compared to manual FNA. Mastectomy samples or models that more closely mimic human breast tissue will be utilized for further analysis. Additionally, different combinations of the motions will also be tested to evaluate which yields samples with the highest cellularity. The combinations include linear and rotational, linear and vibrational, rotational and vibrational, and all three modalities in one. It is hypothesized that because individual motions demonstrated higher effectiveness at yielding samples with higher cellularity, combining them could potentially further increase the cellular yield. Prototype testing for the final device will involve assessing the clinical integrability of the device as well as validating the clinical acceptability of the modalities for use in Uganda's healthcare centers to increase FNA sample adequacy and hence enable more accurate diagnoses to be made.

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