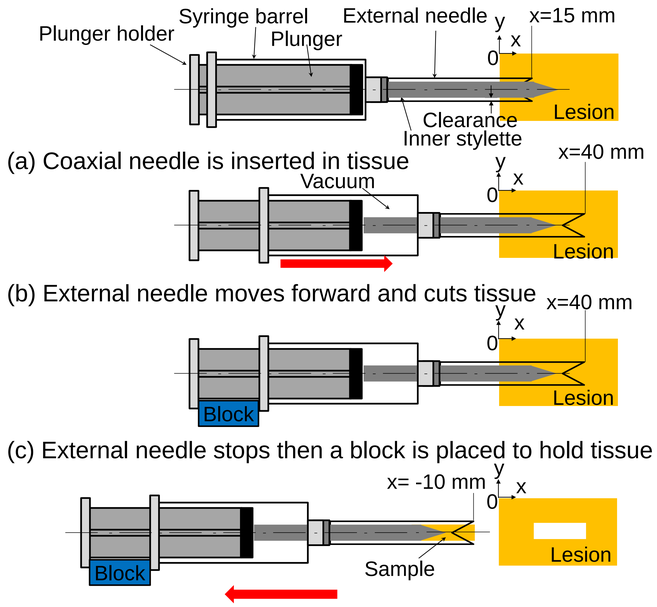
Aspiration-Assisted End-Cut Coaxial Biopsy Needles[1]

Pei-Ying Wu, Hamit Kahraman, Hitomi Yamaguchi
Department of Mechanical and Aerospace Engineering, University of Florida, Gainesville, FL, USA

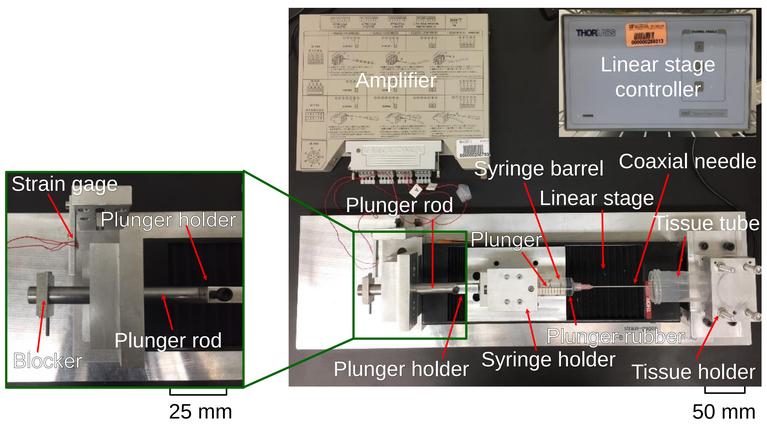
Abstract

A new end-cut-type coaxial needle with a modified aspiration mechanism has been developed to extract large tissue with minimal damage. The study shows that the clearance between the inner stylette and external needle and the insertion speed are the key factors affecting the biopsy performance including syringe friction force and amount of tissue extracted. This research presents the design and manufacture of the system, protocol to evaluate the needle biopsy, and evaluation of the needle biopsy performance using gelatin and chicken breast as tissue samples.

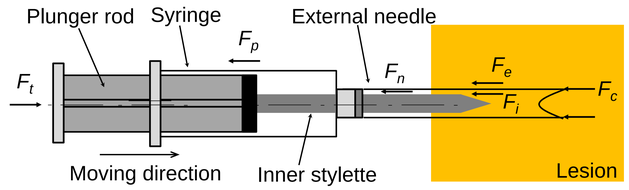
Schematic of Biopsy System



Developed Biopsy System



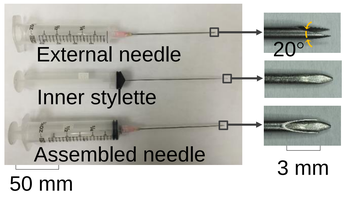
Force Measurement



F_t: total force
F_c: cutting force the needle tip
F_i: friction force between tissue and inner wall of the external needle
F_e: friction force between tissue and the external needle
F_n: friction force between the coaxial needle
F_p: friction force between the rubber plunger and syringe barrel

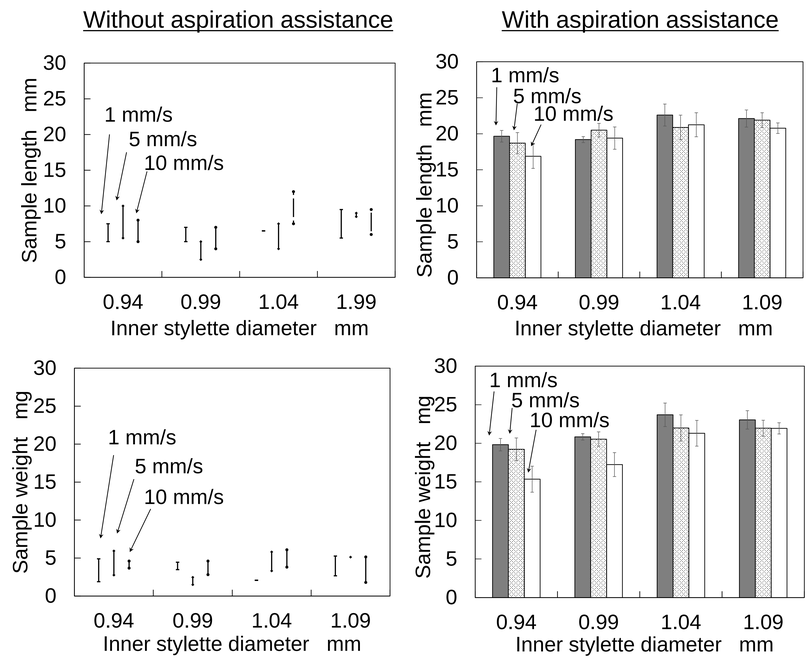
$$F_t = F_c + F_i + F_e + F_n + F_p$$
$$F_s = F_n + F_p$$

Experimental Conditions

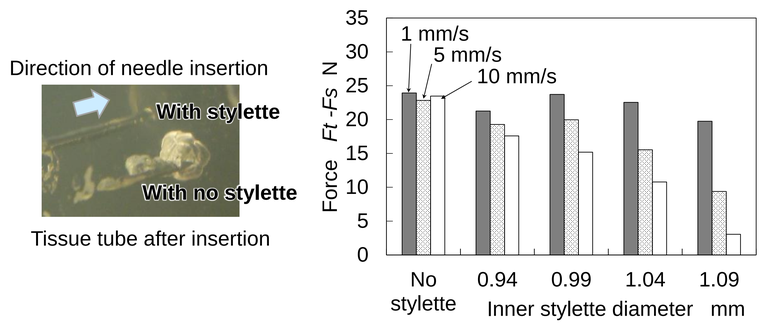


Needle size	18 Gauge (OD: 1.27 mm, ID: 1.14 mm)			
Total insertion length (mm)	40			
Biopsy length (mm)	25			
Needle clearance (μm)	25	50	75	100
Needle insertion speed (mm/s)	1	5	10	

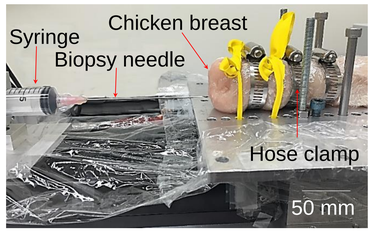
Biopsy Experiments (Gelatin)



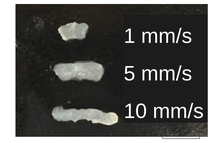
Needle-gelatin interaction force w/ aspiration



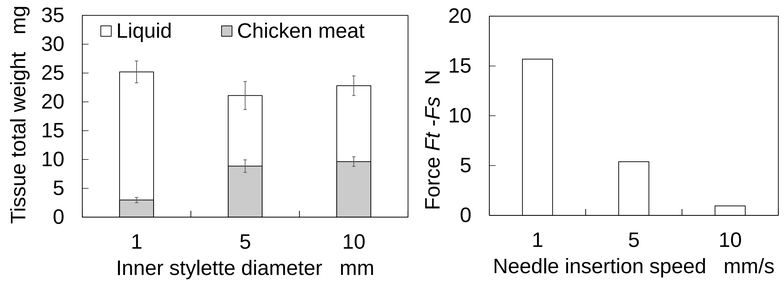
Biopsy Experiments (Chicken Breast)



System modified for chicken breast biopsy



Representative chicken meat samples



Conclusions

1. The developed system collects samples, with a zero biopsy rate of 0 %, by means of simultaneous cutting and aspiration of the coaxial needle assemblies.
2. The needle-tissue phantom interaction force decreases with increasing inner stylette diameter and needle insertion speed.
3. Coaxial needles with less clearance yields a larger and better shaped sample with less force required. However, faster needle insertion does not lead to a large sample extraction due to the greater influence of the sample deformation.
4. The biopsy tests using inhomogeneous chicken breast samples also showed the same trend: lower needle insertion speeds facilitate sample collection. However, the extracted samples contain more liquid and less solid. To increase the ratio of solid to liquid, higher needle insertion speeds are required.

[1] Wu, P. Y., Kahraman, H., Yamaguchi, H., 2017, “Development of aspiration-assisted end-cut coaxial biopsy needles”, Journal of Medical Devices, Vol. 11, pp. 011012.

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