Purpose:To quantify needle deflection and study the relationship between the deflection and the force that is produced during insertion into a homogeneous phantom. A proposed model can be used to estimate needle deflection using the force that occurs on the needle during insertion into the phantom.

Methods: A model was developed that correlates needle insertion force to needle deflection. Experiments were performed to validate this model. Using a needle grid, a 30° bevel trocar was inserted bevel up and then bevel right into two separate areas within a homogeneous phantom. During and after needle insertion, a force dynamometer was used to measure the y-directional force data. After insertion and obtaining force data, needle deflection was quantified using a measurement apparatus that consisted of a digital depth gauge and two datum surfaces. A second experiment used a linear stage to bend a trocar inside the phantom, while force and needle deflection were measured. Using Matlab, the y-force directional data of the bevel up and bevel right were analyzed. After matching up peeks of both data sets, the force of interest was obtained via bevel up data minus bevel right data.

Results: With a sample size of n = 3 for the bevel up and bevel right experiments, a force reading of 0.23 ± 0.04 N and trocar deflection of 3.63 ± 0.5 mm were obtained. Similarly, the linear stage experiment was performed to obtain the Young's modulus of the needle and phantom system. The deflection and force results validate the model created, providing the experimentally determined Young's modulus of the needle and phantom system.

Conclusions: Two sets of experimental apparatus was constructed to obtain force and deflection data. A model was developed to correlate the needle force to needle deflection and validated with experimental data.