Design of an Instrument Guide for MRI-Guided Percutaneous Interventions

Xuefeng Chen
Stanford University

Conor J. Walsh
MIT

Kemal Tuncali
Brigham and Women's Hospital

Alexander Slocum
MIT

This paper describes the design of an instrument guidance device for percutaneous interventions in closed bore magnetic resonance (MR) imaging systems. The device consists of a curved arm piece that travels around a circular base and an additional needle holder that travels along the curved arm, thus providing two angular degrees of freedom that enable an ablation probe to pivot about a remote center of motion located at the skin entry point. The device is intended to be mounted onto a custom built MR coil that rests on the patient while they are imaged. Exact constraint design principles were used to incorporate translational bearings into the plastic parts. Thumbscrews were used for preload and locking so that the probe guide could be fixed along a specific trajectory. The device was prototyped via stereolithography as a proof of concept and demonstrated that a probe could be angled about a remote pivot point.

Simultaneous In Vivo Assessment of Contractile Properties and Electromyographic (EMG) Activities in a Knock-Out Mouse Model of Myotonic Dystrophy

Oliver Bandschapp, Charles Soule, and Paul A. Iaizzo
University of Minnesota

Myotonic dystrophy is a dominantly inherited disorder characterized by myotonia and delayed muscle relaxation due to repetitive action potentials in the muscle fibers (hyperexcitability). In this study, a knockout mouse model for the muscle blind proteins ($Mbnl1^{\Delta E3/\Delta E3}$), a valid model for myotonic dystrophy, was assessed, using an in vivo force assessment device, used in conjunction with EMG recording. The aim of the study was to verify whether the muscle force assessment device we developed was capable to sensitively detect the typical characteristics of myotonic muscle. To date, two wild-type and four myotonic female mice have been assessed. After anesthetic induction by isoflurane, the mice were positioned in the apparatus. Hindlimb muscles were stimulated noninvasively by electrodes placed on the muscle of the leg being stimulated. After establishing optimal muscle length, muscle force was assessed after single pulse stimulation at supramaximal voltage followed by double, triple and quadruple pulses. Both legs from each animal were tested and included in the analyses. Muscle force characteristics (peak force, half relaxation time, and area under the force curve (AUC)) and EMG data were recorded and analyzed. Peak forces generated in the myotonic mice were significantly lower ($P<0.02$), half relaxation times significantly prolonged ($P<0.02$), and AUCs significantly increased ($P<0.002$) as compared with the wild-type mice. The recorded EMGs showed characteristic after depolarizations for the myotonic mice. In conclusion, the muscle force assessment device we developed here was able to detect the typical myotonic features in both reproducible and sensitive ways. This device can be considered as a valid tool for future projects concentrating on the in vivo effects of anesthetic agents or therapies on mouse models of myotonia.

