Proposed Torsional Spring Calibration in Torque Measurement Method Described in ASTM F2213-17

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INTRODUCTION: Amongst the safety concerns of commercial medical devices in the MR environment is static field induced torque. Similar to a compass needle aligning with Earth's magnetic field, long slender devices may align with the static field of an MR scanner. There are several internationally recognized test standards that regulate medical devices in the MR environment and the standard on induced torque, ASTM F2213-17, outlines five test methods [1,2]. Three are pass/fail criteria and two are quantitative measurements. The 'Torsional Spring Method' is one such quantitative method and relies on a platform suspended by nylon threads under an adjustable tension capable of rotating with induced torque. The method outlined in ASTM F2213-17 states the induced torque, τ, to be the product of the torsional spring constant, k, and angular deflection, $\Delta\theta$ [1,2]. To effectively use this method, the spring needs to be calibrated to quantify k. In addition, due to the $\Delta\theta_{\text{max}} = 25°$ limit, the springs need to be adjusted an appropriate k. The latest version of the standard does not include a method for calibration or quantifying k values of the torsional springs, which is necessary for its use and calculating the torque.

METHODS: The following outlines a proposed method for calibrating the torsional springs by using standard masses and relies on a constructed apparatus (**Fig. 1**). Around the holding platform, there needs to be a groove so that a thread can be wound. The thread is connected to a weight holder into which, well-known pre-defined standard masses can be placed, the use of which eliminates the need for yet another measurement. The thread is then placed over a low-friction pulley so that the τ applied from the weight of the mass creates a $\Delta\theta$ in the holding platform. The τ from the mass is the product of the platform radius and the weight of the mass used, $\tau = mgr$, which in turn can be used to quantify k from the measured $\Delta\theta$ because $\tau = k\Delta\theta$ so therefore, $k\Delta\theta = mgr$. With a desired k, the $\Delta\theta$ that would occur from the mass used is calculated and the platform-spring system is adjusted until the approximate angular position is achieved. Once the desired k has been calibrated, the ASTM published procedure can be performed for τ measurements.

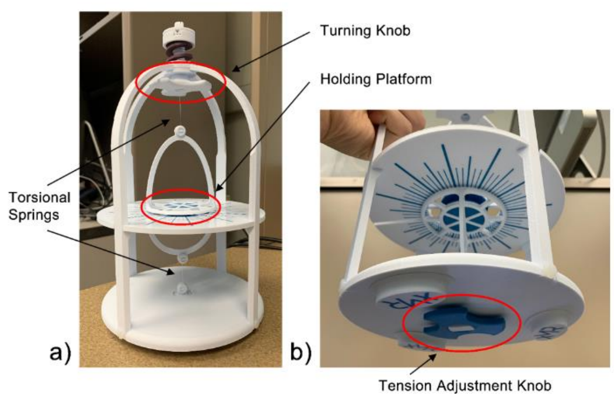
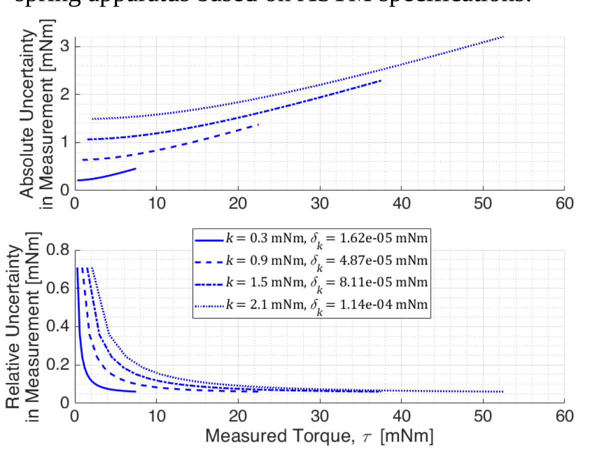


Fig. 1: a) Front and b) bottom views of a torsional spring apparatus based on ASTM specifications.



(top) and relative (bottom) uncertainties were propagated for the full range of measurable torques from 1° to 25°.

RESULTS: The calibration and accuracy of $k = 0.3, 0.9, 1.5,$ and 2.1 mNm were calculated. These values were used to propagate the absolute and relative instrument uncertainties of the torsional spring method (**Fig. 2**).

CONCLUSIONS: The $\Delta\theta_{\text{max}} = 25°$ is restrictive of the the torsional spring method. Even more cumbersome, information on the type of springs used and how k is quantified are absent from the current standard. The proposed calibration schema for the springs allows the apparatus to be dynamically calibrated for the necessary range of torque measurements. Appropriate use depends upon choosing the right k which depends on the torque being measured. For small torques a large k results in a large error, so k would need to be reduced. Therefore, the torsional spring method, in spite of present limitations, can be used for a variety of devices by the calibration of the springs and it would be even better if the ability to calibrate the springs was built into apparatus. This work proposes such a method to enhance the utility of an internationally recognized test standard.

[1] Woods, T. O. (2007) *J Magn Reson Imaging*, 26, 1186–1189
[2] ASTM F2213-17 (2017)