Purpose:To design and develop an innovative prostate therapy motion sensor that applies an optical fiber based sensing technique to measure the deformation of a rectal balloon in order to measure real-time prostate motion for radiation therapy.
Methods:Based on the absorption spectra's high-sensitivity to curvature in a long period grating (LPG) written in an optical fiber, a LPG based fiber sensor is utilized to monitor prostate motion by being attached to rectal balloon. To mimic very realistic prostate motion, we use an anthropomorphic prostate phantom modified by Kyoto Kagaku, Inc. with a large hole for the insertion of a sphere of realistic prostate size. It moves with a rigid bent arm attached to the Washington University 4D Motion Phantom. An inserted water tank allows for water to be around the prostate at all times as it moves. The rectal balloon, with fiber sensing head attached, is inserted into the phantom and placed adjacent to the prostate sphere. To detect the sensing signal, a broadband light source and an optical spectrum analyzer are used to complete the whole sensing system.
Results:The prostate sphere movement results in curvature change of the fiber, and consequently spectral change of the LPG. The experimental results reveal that the spectral response of the LPG is linearly dependent on the degree of the curvature. Consequently, any position change of prostate is detected by monitoring the spectral change of the LPG-based optical fiber sensing system. Since the sensor's sensitivities to curvature is up to 6.87 nm/m-1, high displacement resolution of less than 0.1 mm is obtained.
Conclusions:We have demonstrated a prototype of a novel real-time prostate motion monitoring system based on optical fiber sensing techniques to measure rectal balloon deformation. Experimental results suggest the potential to improve radiation prostate treatment by monitoring prostate movement, when a balloon is used.