Design of a Bending Section Auto-Driven Mechanism for Colonoscope

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Colon cancer is the second leading cause of cancer-related death in the United States. Colonoscopy is the best technology available to detect and treat abnormalities within the colon. It is a procedure that enables a gastroenterologist to evaluate the appearance of the inside of the colon by inserting a flexible tube with about 3/8 in diameter into the anus, and then advancing it slowly, under visual control, into the rectum and through the colon. This procedure is often onerous due to that the driving of the bending section (tip) of the scope and perforation may occur with the rate of 1 out of 1700 procedures. The tip driving system consists of two angulation knobs, two chain-sprocket mechanisms, a series of ring-pivot mechanism, and two pair of wires. Rotating each knob extends and retracts a pair of wires which changes the orientation of the bending section. The up/down angulation knob generates an elevation motion and the left/right angulation knob generates an azimuth motion. Based on the traditional colonoscopy, this work developed an intelligent technology to extend and enhance the diagnostic and surgical capability of the instrument. This intelligent colonoscope includes an image-based control of the tip to release a doctor from onerous work, advanced imaging systems for diagnostics, and advanced human-machine interfaces to facilitate the doctor's operation in an effective manner. In the realization of the bending section driving automation, the driving mechanism design is one of the key issues. In our design of the bending section motion control mechanism, the handle of the colonoscope and the motors are fixed on a holder. The holder can travel along a track. The track can be fixed on any flat surface such as a desk in order to enlarge the motion range of the colonoscope body. Belt mechanism is used to translate the motion from motors to the knobs. The belt pulley is fixed on the driving knob through four equally distributed screws. In order to keep the belt tied all the time, a rocker mechanism with a spring is used between the motor and the knob. Two motors are used to drive the two angulation knobs. Two limit switches are used to identify the homing position of the two motors. The driving torque is limited through the constraint of the current supplied to the motor by an amplifier to avoid the damage to the mechanical system. Together with the motion control system, the mechanism has been lab-tested using an artificial colon. It is observed that the mechanism performs well to accomplish the automation of the knob driving tasks. The system has also been tested using a pig in the animal lab of a hospital satisfactory results have been obtained.

A Muscle Energy Converter for Powering Implantable Cardiac Assist Devices

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Harnessing skeletal muscle for circulatory support would improve on current blood pump technologies by eliminating infection-prone drivelines and expensive transcutaneous transmission systems. Here we describe an implantable muscle energy converter (MEC) designed to transmit the contractile energy of the latissimus doris muscle in hydraulic form. The MEC weighs just 290 grams and comprises a metallic bellows actuated by a rotary arm fixed to the humeral insertion of the muscle via a looped artificial tendon. The housing is anchored to the ribcage using a perforated mounting ring (83 mm diameter). Lessons learned through six design iterations have produced a pump with excellent durability, energy transfer efficiency, anatomic fit, and tissue interface characteristics. This report describes recent improvements in MEC design and summarizes results from in silico, in vitro, and in vivo testing. The components most subject to wear in this device are the stainless-steel bellows, spring-loaded lip seals, and load-bearing surfaces (bearings, cams and shafts). Roller bearings supporting the camshaft and cam follower were replaced with needle bearings for better stress distribution and longer cycle life. Camshaft bearings were improved still further by changing to a full-complement configuration to lower stress concentration and reduce lateral (off-axis) shaft movement that could reduce lipseal life. Bellows cycle life was estimated using ANSYS V11 finite element analysis (FEA) software with a mesh size of 0.002”. In this simulation a pressure of 22 psi was applied to the internal surface of the bellows and compression length was set to the longest possible stroke (0.177”). All load-bearing surfaces were analyzed for fatigue stress and cycle life under these same loading conditions following closed form equations. Results show that the overall durability of the MEC device can be expected to exceed 450 million cycles, resulting in a minimum working life of 14.5 years given a 1 Hz cycle rate. Lipseal durability was tested empirically in a 37°C saline bath using a cycling apparatus designed specifically for that purpose. After 55 days (12.3 million cycles) the test was stopped and the unit disassembled and inspected. The shaft and seals showed evidence of contamination buildup in front of the lip seal but not behind it, indicating that the seal had functioned properly throughout the test period. Importantly, implant studies in 30–35 Kg dogs (n=7) confirm excellent anatomic fit, patient comfort, and device functionality to one month. These results suggest that muscle-powered cardiac assist devices are feasible and that efforts to further develop this technology are warranted.

