Original article

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A magnetic internal mechanism for precise orientation of the camera in wireless endoluminal applications

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Background and study aims: The use of magnetic fields to control operative devices has been recently described in endoluminal and transluminal surgical applications. The exponential decrease of magnetic field strength with distance has major implications for precision of the remote control. We aimed to assess the feasibility and functionality of a novel wireless miniaturized mechanism, based on magnetic forces, for precise orientation of the camera.

Materials and methods: A remotely controllable endoscopic capsule was developed as proof of concept. Two intracapsular moveable permanent magnets allow fine positioning, and an externally applied magnetic field permits gross movement and stabilization. Performance was assessed in ex vivo and in vivo bench tests, using porcine upper and lower gastrointestinal tracts.

Results: Fine control of capsule navigation and rotation was achieved in all tests with an external magnet held steadily about 15 cm from the capsule. The camera could be rotated in steps of 1.8°. This was confirmed by ex vivo tests; the mechanism could adjust the capsule view at 40 different locations in a gastrointestinal tract phantom model. Full 360° viewing was possible in the gastric cavity, while the maximal steering in the colon was 45° in total. In vivo, a similar performance was verified, where the mechanism was successfully operated every 5 cm for 40 cm in the colon, visually sweeping from side to side of the lumen; 360° views were obtained in the gastric fundus and body, while antrally the luminal walls prevented full rotation.

Conclusions: We report the feasibility and effectiveness of the combined use of external static magnetic fields and internal actuation to move small permanent intracapsular magnets to achieve wirelessly controllable and precise camera steering. The concept is applicable to capsule endoscopy as to other instrumentation for laparoscopic, endoluminal, or transluminal procedures.