

The presence of shadows is one of the more fundamental cues used by visual systems when processing three-dimensionality. However, traditional laparoscopes produce essentially shadowless images, which are then displayed on two-dimensional monitors. In an effort to produce natural, three-dimensional laparoscopic views apparent to the naked eye, we designed a soft-light overhead illumination system (SOIS) for use during laparoscopic surgery. Using a newly developed overhead illumination device, this system casts shadows on abdominal organs in order to create and display three-dimensional images. The SOIS contains a light source comprised of ten 2.5 x 1.0 cm light-emitting diode panels arranged in an open hexagonal shape and enclosed in silicon. The design of the device allows it to be inserted into a body cavity via a 2.5-cm incision. The SOIS is then fixed to the ceiling of the intra-abdominal cavity by traction threads. Set-up time is estimated at around 4-5 minutes.

To evaluate the feasibility of the system, various laparoscopic surgeries were performed on porcine models. A total of 19 surgeons from four departments performed laparoscopic procedures in their respective specialties—a gastrectomy, colectomy, hepatectomy, nephrectomy, and a suturing of the ovarian tube—with the SOIS. Depending on the procedure performed, the illumination device was fixed to the upper, lower or lateral abdominal region. All surgeries but the hepatectomy were successfully completed using the SOIS. Of the 19 participants, 12 noted the increased brightness and better depth perception allowed by the SOIS. However, 10 participants criticized the SOIS for significant blurring experienced when direct light from the device hit the lens of laparoscope, as well as for excessive shadows cast behind and between organs. The blurring issue, in particular, was a factor in the unsuccessful hepatectomy and needs to be resolved. However, allowing for further modifications and improvements, the future of the SOIS appears promising.