

Effect of an 8K ultra-high-definition television system in a case of laparoscopic gynecologic surgery

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Abstract

Various endoscopic devices have been developed for advanced minimally invasive surgery. We recently applied a new 8K ultra-high-definition television system during laparoscopic treatment of endometriosis. The procedure, which is described in detail, stands as the first reported application of an 8K ultra-high-definition system for laparoscopic gynecologic surgery. Comparison is made between depiction of the lesion by the new system and depiction by a full high-definition system. Improved diagnostic accuracy resulted from the increased image resolution, and we believe that this and other advantages will lead to widespread acceptance and further application of 8K ultra-high-definition systems in the field of gynecologic surgery.

Key words: endometriosis, ultra high-definition, laparoscopic surgery.

Introduction

Advances in endoscopy have led to its use in various fields for minimally invasive examination as well as minimally invasive surgery. The first clinical endoscopic observation occurred in 1910, when Hans Christian Jacobaeus used a cystoscope for thoracoscopic examination of a patient with tubercular intra-thoracic adhesions. He termed the procedure “laparoscopy” [1]. In 1955, Palmer [2] presented the first laparoscopic motion picture, which he had recorded on color 8 mm film. Technical developments have since yielded increases in the capacity of the recording systems, allowed miniaturization of the devices used, and improved image quality, thereby expanding the clinical applications and providing significant benefits to patients.

Full high-definition (FHD) endoscopy systems are in common use, and 4K ultra-high-definition

(4K UHD) endoscopy systems, with 2-fold more vertical and horizontal pixels, have become commercially available and are now being used clinically. When applied to laryngoscopy, improved image quality was reported [3]. We recently obtained an 8K UHD system, which has 2 times more vertical and horizontal pixels than the 4K UHD systems (Figure 1) have, and we have applied this new system to laparoscopic gynecologic surgery.

Herein, we describe the 8K UHD television system and our initial experience with the system in the surgical treatment of endometriosis. Use of the system was approved by the Institutional Review Board of Nihon University School of Medicine, and the patient provided informed consent for its use during the surgical procedure. The International Review Board and patient also provided consent for publication of the surgical data and photographs as an anonymized report.

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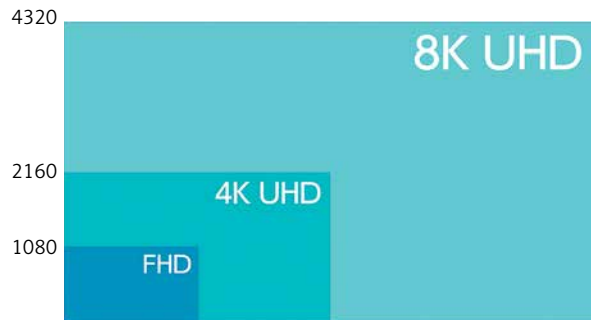


Figure 1. Pixels per inch (determining the resolution) of full high-definition (FHD), 4K ultra-high-definition (4K UHD), and 8K ultra-high-definition (8K UHD) monitors

The 8K UHD television system and set-up

A 10-mm, 30-degree rigid endoscope (SK-2D10S, Shinko-Koki, Tokyo, Japan) with a 300-W xenon lamp CL-300X (Shinko-Koki) is used for illumination. The 8K camera, which weighs approximately 2 kg, was

originally designed (Medical Imaging Consortium, Tokyo, Japan) as a camera that allows manual adjustment of the focus (Photo 1 A). A Super Hi-Vision camera control unit (Hitachi, Tokyo, Japan) is used for image adjustment. The 8K recording system is an HR-7512-C (Astrodesign, Tokyo, Japan), with a pixel depth of 12 bits. It records at a rate of 60 fps, allowing for an 8-TB recording over 50 min (Photo 1 B). The SC-8213 interface converter (Astrodesign) is used for image quality adjustment. The amount of information transmitted by a converter cable is the same as that transmitted by a single FHD cable; therefore, 8K UHD can transmit 16 times as much information as FHD. Sixteen cables are used to connect all necessary devices, including the monitor (Photo 1 C). The monitor DM3814 (Astrodesign) provides complete reproduction of the 8K images with 8K resolution (7680 × 4320 pixels) in a 55-inch LCD (liquid crystal display) panel (Photo 1 D). For simultaneous comparison of images, we use the Olympus

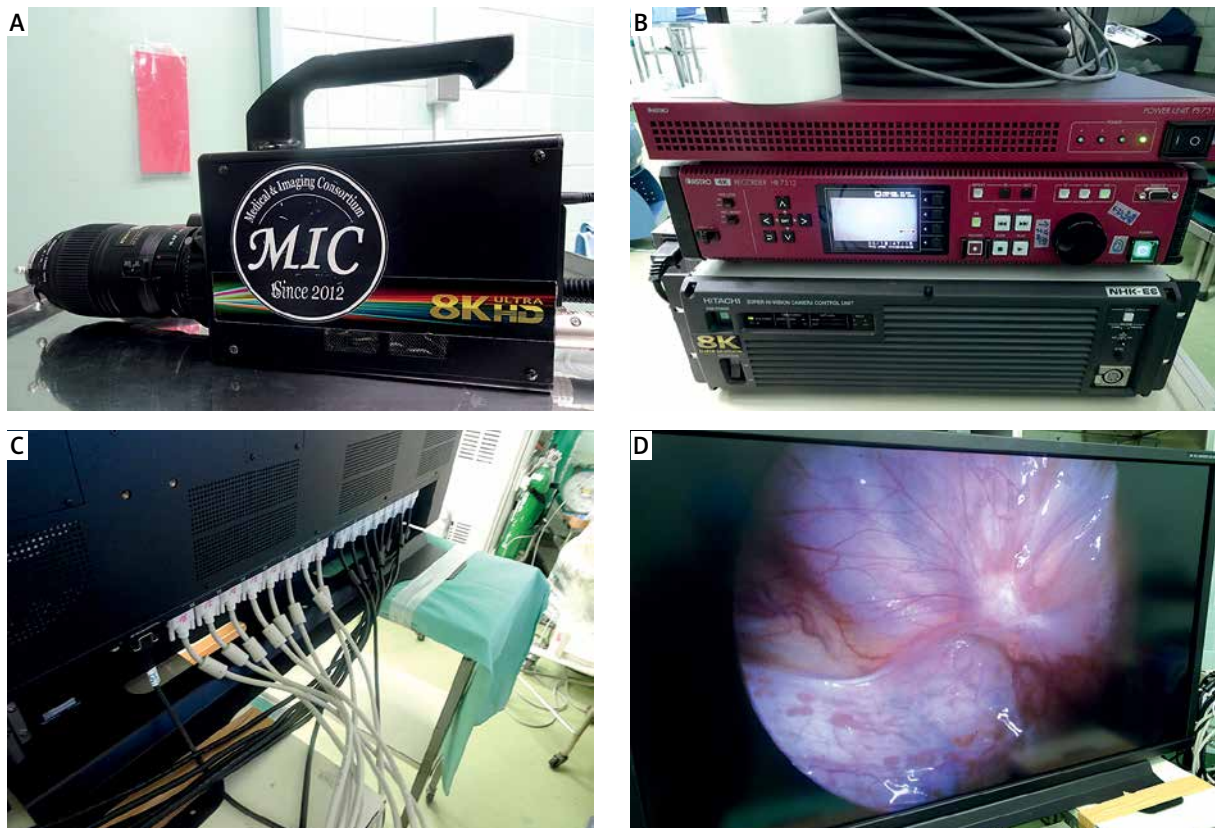


Photo 1. The 8K UHD television system. **A** – 8K camera. **B** – Super Hi-Vision camera control unit (Hitachi, Tokyo, Japan) and 8K HR7512C recording system (Astrodesign, Tokyo, Japan). **C** – DM3814 8K monitor viewed from the back (Astrodesign). **D** – DM3814 8K monitor (Astrodesign): 8K resolution 7680 × 4320, 55-inch LCD panel

LTF-S190-10 videoscope with the Olympus VISERA ELITE FHD system (1920 × 1080 pixels) (Olympus Medical Systems Corp., Tokyo, Japan).

In the case described, 4-port conventional laparoscopic surgery was performed under general anesthesia. The primary surgeon stood at the patient's left side, and the first assistant supported the surgeon in performing the operation, while the second assistant stood at the patient's left side and controlled the videoscope and changed the 8K UHD and FHD systems.

Case report

A 46-year-old woman suffering dysmenorrhea underwent magnetic resonance imaging. Ovarian endometrial cysts involving both ovaries were observed, but blood tests revealed no CA 125 or CA19-9 tumor marker elevation. Salpingo-oophorectomy was indicated and performed laparoscopically for the large, left-sided cyst, but because the patient wished that an ovary be spared so that her hormone balance could be maintained, laparoscopic cystectomy was performed for the smaller right-sided cyst.

Intraoperatively, papular lesions consistent with endometriosis were observed on the surface of the vesicouterine peritoneum and pouch of Douglas. In the 8K UHD images, small vessels were apparent on the surface of the whitish lesions characteristic of endometriosis. Characteristic whitish tissue was

also visible in FHD images, but the small vessels were not clearly depicted (Photo 2). The endometriosis was evaluated according to the Revised American Society for Reproductive Medicine classification of endometriosis [4] and judged to be stage 4. Total operation time was 59 min, and estimated blood loss was 5 ml. Together, the surgical specimens weighed 27 g. The final histopathologic diagnosis was bilateral ovarian endometrioma.

Discussion

Laparoscopic surgery is the preferred treatment for ovarian cyst. The minimal invasion results in less pain and faster recovery than the pain and recovery time experienced by patients who are treated by open surgery [5]. However, because the laparoscopic surgeon must understand the status of the target organ based on visual information without the sense of touch, information obtained from the videoscope and projected onto the television monitor is extremely important.

The 8K UHD system display consists of 7680 × 4320 (33,177,600) pixels, exceeding the 1920 × 1080 (2,073,600) pixels of FHD system displays by more than 4-fold, both vertically and horizontally [6], and the 3840 × 2160 (8,294,400) pixels of 4K UHD system displays, both vertically and horizontally. The information content of images provided by the 8K UHD system is enormous and requires a video recording capacity of 8 TB per 50 min. A 50-minute

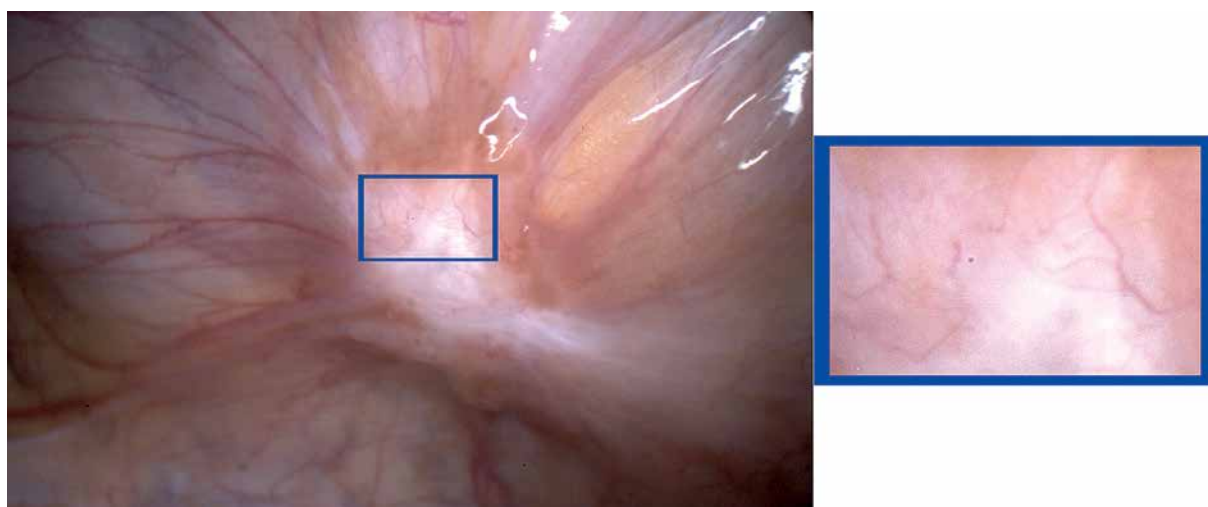


Photo 2. Images of surface endometrial lesions on the vesicouterine peritoneum. A zoom image of the same lesion captured with an 8K camera depicts not only the whitish tissue but also numerous small vessels

video recording at the highest image quality with an Olympus VISERA ELITE Platform IMH-20 (Olympus Medical Systems Corp, Tokyo, Japan), the recording medium of the commonly available FHD systems, requires a capacity of about 11.5 GB; thus, 8K UHD systems necessitate use of a recording medium of exceptionally large capacity. However, 8K UHD systems provide an important advantage in that any part of the image can be magnified without compromising the image quality.

We applied the 8K UHD system for real-time visualization of laparoscopic surgery in a case of bilateral endometrial cyst. We used a television monitor and suffered no loss of resolution. We believe that application of such a system has potential for improving live imaging during surgery and for postoperative image analysis. The 55-inch monitor that we used in this case displayed the 8K image as a clear, high-quality image. The number of pixels per unit area of a 55-inch monitor is much greater than the number of pixels per unit area of an FHD monitor or a 4K monitor of the same size, and the fine details are resolved even if the monitor is viewed at a close distance. Currently, the camera assistant must maneuver the endoscope during surgery to focus the camera on the target tissue, but in the future, if the number of pixels is increased, we might be able to place the endoscope in a fixed position and identify the target by zooming the image sent to the monitor.

Whether improved image quality enhances surgical skills has been a topic of study. In a laboratory comparison of surgical tasks performed using a digital 3-chip CCD camera or an HD camera (1080 pixels), operators' knot-tying time was significantly shorter when the HD camera was used [7]. Thus, it seems that improving the image quality is effective for enhancing laparoscopic surgical skills. A later comparative study performed using a box trainer showed faster improvement in surgical skills when the three-dimensional (3D) monitor, which has undergone extensive development in recent years, was used [8], and a very recent study comparing a 3D-HD monitor with a 2D-HD monitor showed that operation time for patients undergoing laparoscopic liver resection was reduced when the 3D-HD monitor was used [9]. These findings suggest that overcoming the limited depth perception provided by conventional 2D monitors increases surgical efficiency. The 8K UHD system that we used in the case described was a 2D system, but from our point of view, the

tissue surface appeared much smoother than it appears when using an FHD system, and despite the 2D projection, the effect of contrasting shadows was clearer and even approached that of a 3D system.

In patients suffering from infertility, laparoscopy is performed to search for or rule out endometriosis as a possible cause [4, 10]. In addition, identifying extra-genital lesions is important [11]. In our patient, we identified small vessels on the surface of whitish tissue characteristic of endometriosis. Although previous studies have shown the presence of lesions on the peritoneum not to be laparoscopically observable [12, 13], improved image quality may enable us to identify abnormal tissues that would otherwise appear normal.

In the case described, we compared only 8K and FHD images. We anticipate additional cases in which we will be able to compare FHD, 4K UHD, and 8K UHD systems for improving suturing and for grading peritoneal tumors.

Conclusions

The potential of 8K UHD systems has yet to be recognized. Use of such systems in clinical practice has just begun, and therefore many technicalities pertaining to image quality and the automatic processing of enormous amounts of information remain to be fine-tuned. We believe the improved surgical efficiency and diagnostic accuracy resulting from increased image resolution will lead to acceptance and further application of 8K UHD systems.

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Conflict of interest

The authors declare no conflict of interest.

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