

## The Era of 4K Three-dimensional Imaging is Coming

The surgical evolution in the field of laparoscopic and reconstructive gynecology has been very dynamic and is marked by continual technological advancements with the goal of improving patient outcomes and minimizing invasiveness. The transition from traditional open surgeries to laparoscopic procedures represents a paradigm shift which revolutionized the surgical approach to gynecologic conditions. This enabled surgeons to access surgical sites through small incisions and view the surgical field through monitors without compromising surgical effectiveness and safety. Moreover, its advantages in terms of reduction in intraoperative blood loss, infections, and pain as well as shorter hospitalization and better cosmesis are now well recognized.<sup>[1]</sup> Currently, the laparoscopic technique is increasingly being utilized in performing simple and complex gynecologic procedures for various benign and malignant gynecologic conditions.<sup>[2-8]</sup>

Despite the advantages of laparoscopy to patients, its introduction as an innovative surgery a few decades ago met a lot of resistance from surgeons because it is more challenging than laparotomy. This is due to limitations in movement, instrument design, unnatural ergonomics, and visualization.<sup>[9]</sup> As early laparoscopic techniques relied on conventional two-dimensional (2D) imaging with limited depth perception, surgeons have to acquire different psychomotor skills as well as visuospatial competencies to work in a 3D abdominal space reflected in 2D images.<sup>[1,9-11]</sup> Attempts to address these concerns and to overcome the major drawback in the traditional 2D imaging system led to the development of 3D laparoscopy.<sup>[1,10]</sup>

The adoption of 3D imaging in laparoscopy introduced a new dimension, providing surgeons with enhanced depth perception, facilitating more precise maneuvers, and better anatomical understanding during gynecologic surgeries.<sup>[1,9,11-13]</sup> Since its introduction in the 90's, improvements have been made effectively minimizing the adverse effects experienced by the laparoscopist such as nausea, vomiting, dizziness, and visual fatigue associated with the early generation of 3D technology.<sup>[1,12]</sup> Gradually, the 3D high-definition (HD) endovision system has gained acceptance among laparoscopic surgeons worldwide.<sup>[12]</sup> Moreover, the European Association of Endoscopic Surgery reached a consensus recommending the use of 3D technology because it was associated with not only a shortened operative time but also a significant reduction in complication rate, especially in surgeries that involved laparoscopic suturing.<sup>[12,13]</sup>

Meanwhile, a move to upgrade the existing 2D system led to the incorporation of ultra-HD (4K) technology to improve its depth perception.<sup>[9,11,12]</sup> As a technological milestone, 4K resolution features a fourfold increase in pixel density compared to traditional HD imaging providing better anatomical differentiation of the surgical field. It provided stronger monocular depth perception cues and seemed to have better surgical performance than the 2D HD representation. It was considered an alternative to the 3D system,<sup>[10,12]</sup> although a meta-analysis done by Singla *et al.* in 2021 concluded that 3D technology is likely to result in a shorter operative time and better efficiency of movement as compared to the 4K technology by the virtue of its better depth perception.<sup>[12]</sup>

Most recently, the integration of 4K into the 3D imaging system was introduced. It can be considered a significant leap in visualization capabilities as this innovation combines their best features; that is, the highest resolution with the best depth perception. 4K 3D imaging promises unparalleled precision, offering surgeons a clearer and more detailed view of anatomical structures. These improved features not only aid the laparoscopists in the ease and safety of performing simple minimally invasive gynecologic surgery and fertility-sparing procedures but, more importantly, they become invaluable in procedures where precise anatomic and tissue identification, dissection, and removal of lesions are necessary and crucial, such as in cases of deeply infiltrating endometriosis and oncologic staging surgery where procedures may be technically complicated and risk of bowel or ureteral injuries are higher possibly due to dense adhesions.<sup>[14-16]</sup> It can potentially further minimize the margin for surgical error, reduce complications, and optimize surgical interventions. 4K 3D imaging makes the standardization of radical hysterectomy feasible.

As the newest laparoscopic technology, it can bridge the gap between conventional 2D imaging and the more complex robotic system. This allows surgeons to maneuver with greater precision and accuracy approximating some of the advantages of robotic surgical systems but within the framework of traditional laparoscopic methods.

### Data availability statement

Data sharing not applicable to this article as no datasets were generated or analyzed during the current study.

### Author contributions

Both authors contributed to the article and approved the submitted version.

Mary Evangeline Villa Mercado<sup>1\*</sup>, Chyi-Long Lee<sup>2</sup>

<sup>1</sup>Department of Obstetrics and Gynecology, N. L. Villa Memorial Medical Center, Lipa, Batangas, Philippines, <sup>2</sup>Department of Obstetrics and Gynecology, Division of Gynecologic Endoscopy, Linkou Chang Gung Memorial Hospital, Linkou, Taiwan

**Address for correspondence:** Dr. Mary Evangeline Villa Mercado, Department of Obstetrics and Gynecology, N. L. Villa Memorial Medical Center, Lipa, Batangas, Philippines. E-mail: vangievilla@yahoo.com

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