LG Business Solutions

White Paper

Study to Demonstrate the Efficacy of Pathology Mode in Medical-grade Monitors

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Medical Device Team, Marketing Team
LG Electronics

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1. Introduction

Recently, there has been a trend of increasing digitization in the field of pathology. Digital pathology is a sub-field of pathology that focuses on data management based on information generated from digitized specimen slides. Whereas in traditional pathology, the specimen would be viewed directly on a glass slide under a microscope, in digital pathology, virtual microscopy via computer-based technology is used.

The benefits of slide digitization in research and academic settings have led to rapid growth in the digital pathology market. Valued at USD 767.6 million in 2019, the digital pathology market is forecast to experience a compound annual growth rate (CAGR) of 11.8% between 2020 and 2027.[1)] The market is continually evolving and its growth is expected to continue in coming years (Figure 1).

With its growth, the market of Telepathology, a representative service of digital pathology, is also growing. Telepathology is the practice of remote diagnostic pathology facilitated by the digital transmission of pathological data via telecommunications technology. Telepathology makes sharing medical images faster and easier. Biopsies can be cut, stained, scanned, magnified and sent digitally during an operation. This allows pathologists to review the slides remotely in real-time and to provide the surgeon with an immediate diagnosis.

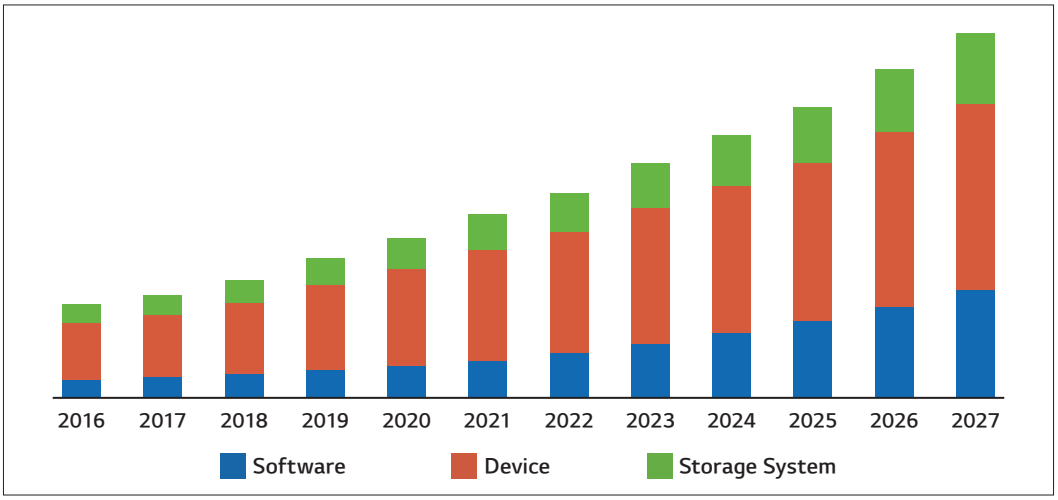

Figure 1) U.S digital pathology market size, by product, 2016-2027 (USD Million)

The reason behind this growth in digital pathology is its prospects to improve not only the working environments of pathologists, but also to advance the future development of the field. Digital pathology has four key advantages over analog pathology: easy cooperation, prevention of human error, increased labor savings, and easier knowledge sharing.

First of all, cooperation between doctors becomes easier. In conventional pathology, glass slides must be physically transferred to facilitate collaboration or if a patient visits a different hospital. This not only incurs costs in time and money, but also risks the slide being damaged in the delivery process. In digital pathology however, samples are scanned and stored digitally, allowing doctors to check, search, and share them in real-time for easier collaboration and quick and accurate diagnoses. As such, obtaining a second opinion becomes much easier and incurs fewer risks and costs, making collaboration more convenient and obtaining an accurate diagnosis easier.

1) Digital Pathology Market Size, Share & Trends Analysis Report By Product, By Application (Drug Discovery & Development, Academic Research, Diagnosis), By End Use (Hospitals, Clinics), And Segment Forecasts, 2020 - 2027, https://www.grandviewresearch.com/industry-analysis/digital-pathology-systems-market

Second, digital pathology helps to prevent human error. Automation allows digital pathology to avoid mistakes that can occur through direct diagnosis. In analog pathology, a diagnosis is conducted through the direct examination of a sample under the microscope. In fact, there have even been cases of operations being performed incorrectly as a result of human error such as the wrong slide being provided. The use of digitized scanners and image analysis techniques in digital pathology reduces the likelihood of such human errors occurring, and in this way helps to improve the accuracy of diagnostic pathology.

Third, it can reduce labor demands. Generally, pathology remains a predominantly analog, labor intensive system. The process of manually reviewing specimens, providing medical imagery, and manually storing the glass specimen slides is extremely time consuming for trained pathologists. Additionally, the specific glass slide must be relocated, and the whole inefficient process repeated if a sample requires additional review. To address this issue, digital pathology uses technology to scan specimens, which can then be easily transferred and stored as data, creating a more efficient system under which samples can be easily located and accessed. This also allows pathologists to reach a more accurate diagnosis by making it easy to compare similar cases, and greatly reduces the time spent on storing and organizing samples.

Finally, it facilitates knowledge sharing. In analog pathology, specimen samples and individual cases are not stored as image data, limiting their use in research or as case studies. Digital pathology therefore, is highly valued in academia and educational circles, as the ability to scan specimen samples allow for them to be easily used for educational purposes and for a wide collection of data to be accumulated for research. Additionally, digital pathology allows for samples to be presented more conveniently at conferences by eliminating the need to directly transport specific sample slides, or attempt to capture clear images of the sample. Furthermore, the ability to supplement a pathologist's expertise with computer analytics that may reveal patterns hidden within tissue samples, provides an attractive prospect that could lead to discoveries that may change the way in which we diagnose and treat diseases.

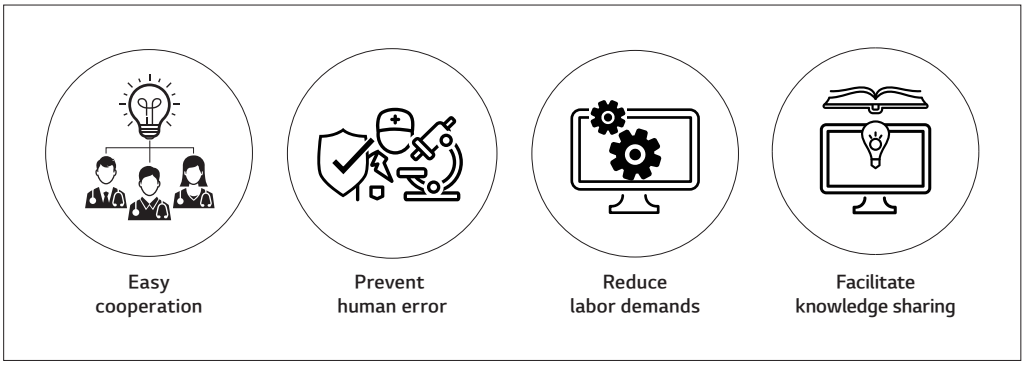

Figure 2) 4 key advantages of digital pathology

2. Purpose

The purpose of this study is to verify the efficacy of the Pathology Mode feature of the 8MP Diagnostic Monitor (32HL512D).

Pathology Mode is a feature that increases the color reproduction and image consistency of scanned images to ensure fidelity to the original sample. This allows specimen samples to be accurately depicted on screen, ensuring that medical professionals can view the same details as would be visible under the microscope.

A common problem pathologist currently face when using non-medical grade monitors for their work, is insufficient color reproduction levels making an accurate review difficult. In fact, inaccurate color reproduction increases the chances of misdiagnosis significantly, for example by reproducing pink colors as red on the monitor (Figure 3). The ability to detect of minor changes or abnormalities is extremely important in pathology, therefore it is essential that monitors used can accurately display specimen color and shape on screen in order to eliminate the inconvenience of pathologists having to conduct a secondary review of the specimen directly under the microscope.

This means that there is an increasing demand for monitors that can provide highly accurate color reproduction within digital pathology. In order to meet this demand, LG, in collaboration with medical professionals, developed a Diagnostic Monitor featuring a specialized Pathology Mode. Medical staff reported that non-medical grade monitors without a Pathology Mode showed a large discrepancy between specimen color as viewed directly under the microscope and when reproduced on screen. Therefore, to minimize these discrepancies, LG developed Pathology Mode which particularly adjusts colors on the red spectrum in order to provide the most accurate image reproduction possible. As this mode allows specimens such as blood, bodily fluids, and tissue cells to be displayed onscreen without color distortion, it helps to ensure that no details are overlooked for a reliable and accurate diagnosis. In addition, the LG Diagnostics Monitor also provides high quality imagery even at high resolutions, color expression that clearly expresses black density, and IPS technology for undistorted viewing at any angle. This makes it the ideal monitor for use in pathology and diagnostics.

Therefore, this study, entitled an "Experiment to determine the efficacy of Pathology Mode in LG Diagnostic Monitor", was conducted in order to verify whether the 8MP Diagnostic Monitor (32HL512D) in Pathology Mode delivers sufficiently high color reproduction rates and image accuracy to conduct diagnostic pathology.

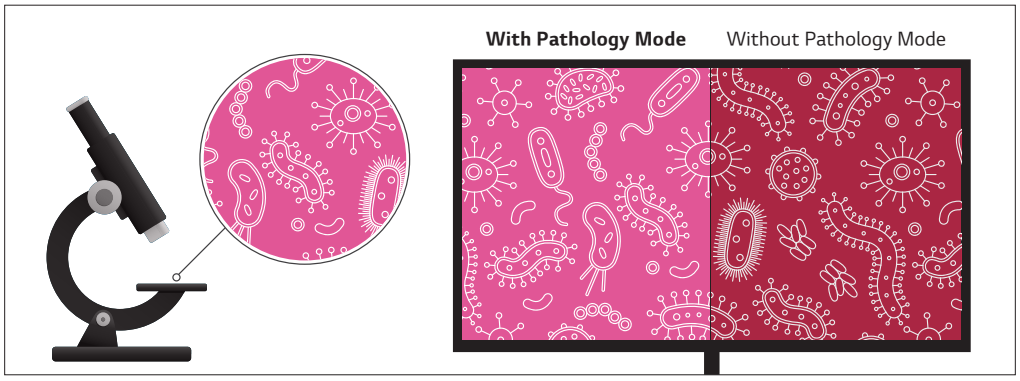

Figure 3) LG Medical Display - Pathology Mode

3. Method

The test to determine the efficacy of the Diagnostic Monitor in Pathology Mode was conducted over a period of 9 days between February 4 and March 3, 2020 at Seoul National University Hospital. The test was conducted by comparing the performance of two products, the control – a 32UK550 non-medical grade monitor, and the test product – the 32HL512D 8MP Diagnostic Monitor in Pathology Mode. Both monitors had the same resolution and were set up identically with the exception of Pathology Mode.

A total of 8 pathologists from Seoul National University Hospital were randomly selected to participate in the study. They had an average of 17.17 years of medical experience across 12 different specializations including digestive pathology and kidney pathology. Six of the eight participants reported using monitors for diagnostic pathology at least three times a week, as doing so made research and deciphering fine details easier.

The 32HL512D in Pathology Mode (hereinafter, the test monitor) and the 32UK550 (hereinafter, the control monitor) were installed side-by-side at a workstation and the participants were asked to compare the use of both monitors in analyzing 30 sample slides (Figure 4-1 and 4-2). The 30 samples consisted of 10 hematoxylin and eosin(HE) tissue slides, 10 papanicolaou(Pap) cytology slides, and 10 immunohistochemistry slides. The results were collected directly through an evaluation questionnaire. The evaluation was divided into two sections: the first being the comparison in performance of the two monitors in reviewing the 30 test slides, and the second, a survey measuring participant's overall levels of satisfaction with the test product. The comparative section measured performance across three common test types; papanicolaou stain, hematoxylin stain and immunohistochemistry test. The survey section measured participants overall satisfaction with Pathology Mode and their intension to either purchase or recommend monitors with Pathology Mode to others.

Division	Test Monitor	Control Monitor
	Medical grade	Non-medical grade
Model	32HL512D	32UK550
Size	31.5-inch	
Resolution	8MP (3840x2160)	
Panel	IPS	VA
Color Gamut	DCI-P3 98%(Typ.)	DCI-P3 95%(Typ.)
HDR	HDR 10, HDR Effect	HDR 10
Color Calibration	HW Calibration	Color Calibrated
Display Mode	Multi-resolution Mode, **Pathology Mode**	-

Table 1) Main specifications for products

Figure 4-1) Test set-up with the control and test monitor

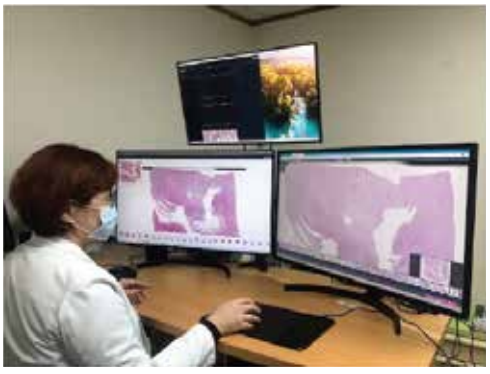

Figure 4-2) Performance comparison of the test and control monitor

4. Results

The comparative test measured participants satisfaction with the monitors performance across several indicators on a 4 point scale, with possible responses ranging from 1 (very poor) to 4 (very good). The difference between the average score each monitor received for the four indicators was calculated and the results were as follows.

4-1. Comparative test

The comparative test revealed higher levels of satisfaction with the test monitor in terms of image color, shape, clearness, and brightness across all three test types (papnicolaou stain, hemaotoxylin stain, and immunohistochemistry test).

For papnicolaou stain tests, the test monitor was rated higher than the control monitor by an average of 0.09 (color), 0.09 (shape), 0.73 (clearness), and 0.41 (brightness). Thus, the biggest improvement was in image clearness, followed by brightness. Image color and shape showed similar levels of improvement when viewed on the test monitor.

In hemaotoxylin stain, the test monitor was rated higher than the control monitor by an average of 0.08 (color), 0.17 (shape), 0.67 (clearness), and 0.42 (brightness). Thus, as with the papincolaou stain test, the biggest improvement was in image clearness, followed by brightness. In hemaotoxylin stain tests however, there was a greater improvement in image shape than in image color when viewed on the test monitor.

In immunohistochemistry tests, the test monitor was rated higher than the control monitor by an average of 0.14 (color), 0.15 (shape), 0.3 (clearness), and 0.29 (brightness). Thus, image clearness and brightness showed similar levels of improvement when viewed on the test monitor, followed by image shape and color.

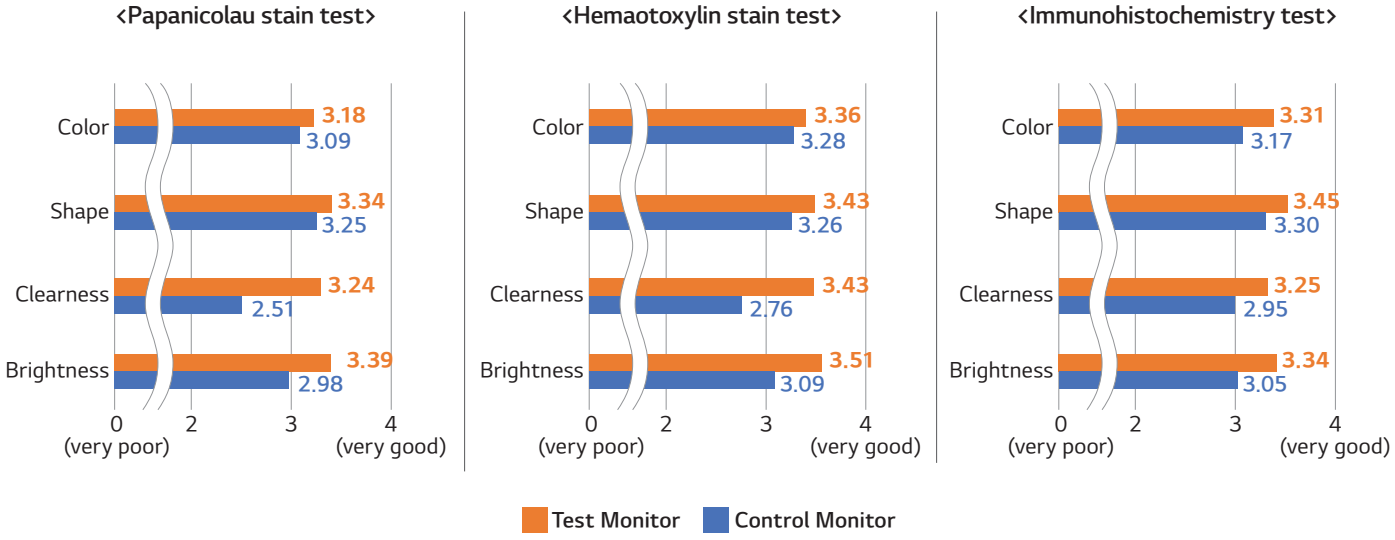

Figure 5) Results of Comparative test by test type

In summary, of the three test types (Pap, HE, immunohistochemistry), HE stains showed the greatest increase in utility when conducted on the test monitor versus the control monitor, with an average of 0.335 points difference (Pap 0.33, immunohistochemistry 0.22). With an average increase of roughly 0.57, image clearness showed the greatest improvement when reviewed on the test monitor in Pathology Mode, followed by brightness(0.37), shape(0.14), and color(0.1).

4-2. Test Monitor Satisfaction

The satisfaction survey measured participants overall satisfaction with the test monitor on a 4 point scale, with possible responses ranging from 1 (very low) to 4 (very high).

The results showed a high level of overall satisfaction with the test monitor with an average score of 3.38 out of 4. The test product also received an average score of 3.38 out of 4 for the question of participants willingness to purchase or recommend the 8MP Diagnostic Monitor (32HL512D) in Pathology Mode following the study.

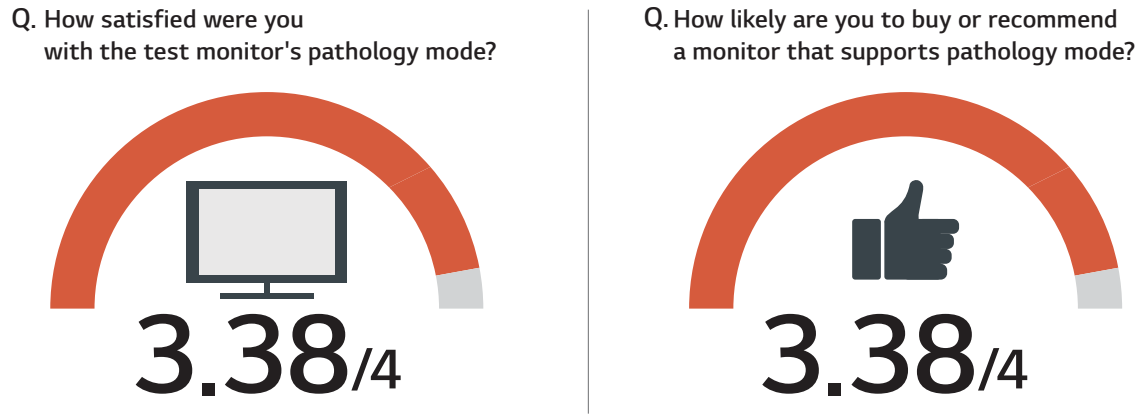

Figure 6) Results of test monitor satisfaction

In conclusion, when compared with a standard monitor of the same resolution, the 8MP Diagnostic Monitor in Pathology Mode provided an optimized environment for diagnostic pathology. Improved image color, shape, clearness, and brightness provided by the test monitor help to ensure diagnostic accuracy and lead to higher satisfaction among pathologists. Additionally, participants were sufficiently impressed with the test monitor to express a willingness to purchase or recommend the monitor to others.

Therefore, the results of this study have revealed that the LG Diagnostic Monitor with Pathology Mode has sufficient color reproduction rates and image accuracy to satisfy the demands of pathologists. In addition, the monitor is ergonomically designed with a large 31.5-inch screen, 4-side virtually borderless design, and 2PBP and dual controller functionality for easier multi-tasking, making this the ideal monitor for use in digital pathology.

5. Report from Dr. Kyoungbun Lee, Seoul National Univ. Hospital

Comparison of pathology-specified medical-grade monitor versus non-medical monitor
Comment by Professor Kyoungbun Lee, Department of Pathology, Seoul National University.

Digital pathology is a new platform to investigate the cells and tissues under the microscopic level. A whole slide images (WSI) is giga-pixel image file composed of high power images of microscopic tissue images and made by digital scanner. Digital pathology workflow is replacing traditional pathology workflow in anatomic pathology laboratory and the monitor is a main equipment in digital pathology. As pathology images are colorful, not like gray-scale radiologic images, color composition and calibration of monitor may affect the pathologists' perception and interpretation. Pink (eosin) and violet (hematoxylin) are the main two colors of pathology images which influence the pathologists' sense and color composition of display may affect the pathologist. Since various magnification are used during pathology examination for one slide, contrasts and resolution of display may affect the detection ability of lesion.

There is some progress in developing standards for digital scanner and viewer systems, but color calibration of monitor for pathology images is not present. Before diagnosis, it is necessary to evaluate and adjust whether the monitor reproduces the color of the glass slides.

Pathology mode of LG diagnostic monitor is the customized color composition to pathology images, especially hematoxylin and eosin staining (HE) and papanicolaou (Pap) staining slides. It enhanced clearness of digital images at low power level and reproduced color of glass slides at high power level.

1-1. Evaluation of Pathology mode in LG diagnostic monitor.

Eight pathologists who are using digital pathology for diagnosis or conference at normal workflow graded quality of 30 WSIs using the pathology mode implemented medical grade monitor and general monitor without pathology mode. Except the pathology mode, other device specification were set identically (eg. size, resolution). Ten HE tissue slide, ten Pap cytology slides, and 10 immunohistochemistry slides were enrolled. Pathologists assessed color, shape, clearness, and brightness by four tiered system (1, 2, 3, 4; very poor, poor, good, very good). Scores of pathology mode were generally higher than those of the general monitor in all evaluation (figure 1). Contrast between tissue and background were better in pathology mode than general mode and this strength was more different in low power field (less than x100). It may be helpful to quickly find the lesion at low magnification. The contrast and clearness of tissue and background at low magnification are important to quickly detect the abnormal area which need high power inspection. The preference for the pathology mode did not differ depending on the type of slide, but there was a problem that decalcified bone tissue was excessively pink.

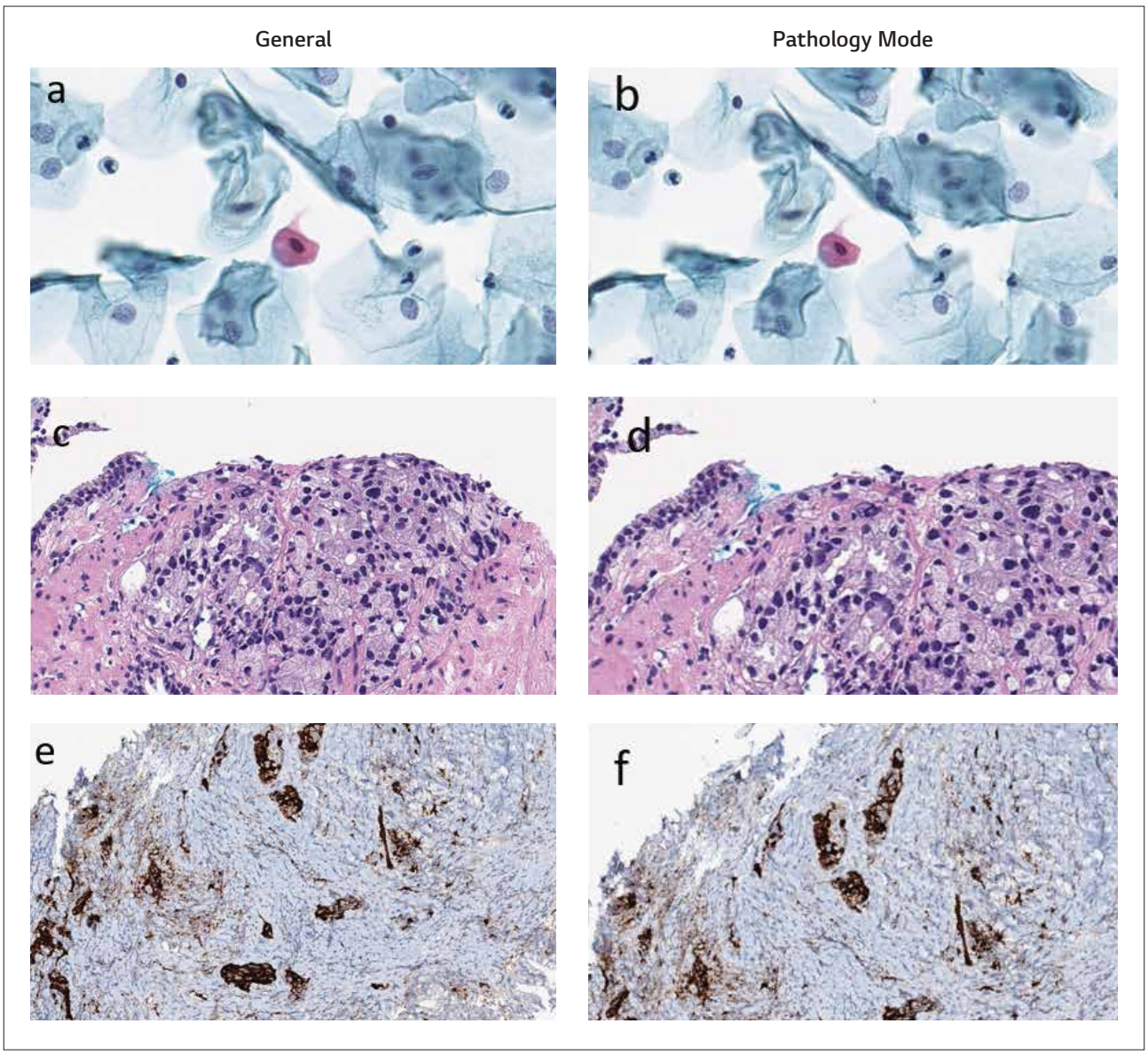

Figure 1) Representative cases of each monitor, a,b) cytology, pap staining x500, c,d) prostate, HE stain x300, e,f) PDL1, immunohistochemistry, x150

1-2 . Other ergonomic features

It was the first time to use a 31.5-inch monitor and multitasking is much easier with 2PBP and dual controller feature. Also, when it comes to multi-monitor setup, thin bezel did not interfere the view.

Kyoungbun Lee
Department of Pathology, Seoul National University Hospital.

6. Specifications (32HL512D)

Model		31.5-inch 8MP Diagnostic Monitor 32HL512D 
Panel	Panel Type	IPS
	Inch (Aspect Ratio)	31.5-inch (16.9)
	Resolution	8MP (3840 x 2160)
	Color Gamut (Typ.)	DCI-P3 98% (CIE1976)
	Viewing Angles (CR≥10)	178° (Right/Left), 178° (Up/Down)
	Brightness (Typ.)	450 cd/m^2
	Contrast Ratio (Typ.)	1300:1
	Response Time	GTG 14ms (Off- setting), GTG 5ms (Faster- setting)
Feature	DICOM Compliant	Yes
	HW Calibration	Yes (PerfectLum)
	HDR	HDR 10, HDR Effect
	Display Mode	Multi-resolution Mode(8/6/4MP), Pathology Mode
Video Signals	Input Terminals	HDMI x1, DisplayPort x2
Connectivity	USB	1 upstream, 2 downstream
Power	AC Input	100-240Vac, 50-60Hz
	Power Consumption (Max.)	65W
	Power Consumption (DC Off)	Less than 0.3W
Certifications & Standards		IEC (IEC 60601-1 / IEC 60601-1-2), EN (EN 60601-1 / EN 60601-1-2), IEC (IEC 60950-1 / IEC 55032, 55024), EN (EN 60950-1 / EN 55032, 55024), cUL (ANSI/AAMI ES 60601-1, CSA CAN/CSA-C22.2 NO. 60601-1), FCC (FCC part 15 Class A), FDA (510(k) Class ||), RoHS, REACH, WEEE
User Convenience	PBP	Yes (2PBP)
	Reader Mode / Flicker Safe	Yes / Yes
Physical Specifications	Weight (with stand)	7.0 kg (15.4 lb)
	Borderless Design	4-Side Virtually Borderless Design
	Adjustable Stand	Tilt : -5~20°, Height Range : 110mm, Pivot : ±90°