

Comparison of a 2D laparoscopic system for surgical imaging of gastric cancer patients: laparoscopic efficacy and ease of use

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Abstract

The most frequently diagnosed cancer in Korea has been gastric cancer. Since then, the laparoscopic surgery for gastric cancer has become one of the standard treatments for early gastric cancer in Korea. Most of the hospitals in Korea use a brand laparoscopic system with a relatively high costs. Our study aims to evaluate the clinical applicability of locally made 2D laparoscopic system. A total of 40 patients with gastric cancer were recruited for this study. All surgical procedures and evaluations were done by three surgeons. Each surgeon was asked to score each patient using a set of questionnaire in accordance with the laparoscopic efficacy and ease of use. Image 1 HD rated superior in the categories of color saturation and image brightness. Image quality, focus, image distortion, field of view, direction of view, depth of field, fog prevention, image stability on bleeding, temperature change, manageability and convenience of use were rated similarly for both laparoscopes and showed no significant difference. Fencer-III seems to be a promising alternative to Image 1 HD in performing laparoscopic surgery, and this would economically help the hospitals in rural area to equip the laparoscopic system with much affordable price.

Keyword : Laparoscope, Diagnostic imaging, Gastric cancer, Minimally Invasive Surgical Procedures

1. Introduction

Gastric cancer has been the most commonly diagnosed cancer in Korea since 1999 [1]. This remarkable number of gastric cancer patients may have influenced the treatment method among surgeons.

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* This work was partly supported by Institute for Information & communications Technology Promotion(IITP) grant funded by the Korea government(MSIT) (2018-2-00861, Intelligent SW Technology Development for Medical Data Analysis), and a grant of the Korea Health Technology R&D Project through the Korea Health Industry Development Institute (KHIDI), funded by the Ministry of Health & Welfare, Republic of Korea (grant number : HI16C2319), and the Gachon University Gil Medical Center(FRD2019-08).

Received(January 23, 2020), Review Result(1st: February 17, 2020), Accepted(March 13, 2020), Published(March 31, 2020)



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Since 1994 [2], laparoscopic surgery for gastric cancer has become one of the standard treatments for early gastric cancer in Korea [3-5].

Minimally invasive surgery (MIS) in the abdomen yields significantly better results than traditional open surgery in that patients have fewer complications, less recovery time, have much better cosmetic results, and the treatment of the underlying condition is at least as good, if not better than open surgery [4]. MIS including laparoscopic and robotic surgery is now considered a standard operation in most surgical fields [5].

Laparoscope is one of the numerous instruments routinely used for laparoscopic surgery. According to the study done in [6], which surveyed 14 surgeons from major hospitals in Korea, most commonly used laparoscope used was Stryker System (43%), followed by Olympus (36%) and Karl Storz (14%), which are all imported products [6]. However, these devices from "multi-billion dollar" industries are too expensive for wide use despite their great efficiency and performance [7].

Currently, the essential components used for laparoscopic surgery are the camera, the light source device, and the insufflator. In Korea, each component is mostly imported from foreign companies such as Karl Storz and Olympus Medical. Every company's products have three elements that make up a system of independent products. A Korean company, MGB Endoscopy, has developed a unique new two-dimensional (2D) laparoscopic system named Fencer-III. Unlike the other 2D systems used in Korea, Fencer III is a laparoscopic integrated system that includes four components: camera, light source, insufflator and irrigation into one unit, which makes it unique. The high-resolution image sensors (1/3" complementary metal-oxide-semiconductor (CMOS), Progressive scanning) provide superior image quality of up to 1920x1080 pixels. The camera head includes USB storage capabilities in order to store images during the procedure. The light source provides a long lifetime with high-quality light emitting diode (LED) lighting that can replace Xenon 180W. Its estimated lifetime is approximately more than 50,000 hours. The gas insufflator provides a flow rate of 40 l/min, with an insufflation pressure of 1~30 mmHg, CO2 input pressure of 3~80 bar.

Using this new 2D system, we have evaluated the clinical applicability in terms of image quality, camera performance, and stereoscopic effect. It will be a promising alternative to those brand laparoscopes when the performance of locally made system is good enough, which could be a window of opportunity for the hospitals in rural areas.

2. Materials and methods

The study was conducted at the Department of Surgery in Gachon University Hospital between January 2018 and September 2018. A total of 40 patients with gastric cancer were recruited for this study. Only patients ≥ 19 years old were considered in this study. Informed consent was obtained from all the subjects, approved by our Institutional Review Board(GDIRB2018-006). Of these, 20 underwent laparoscopic high definition (HD) surgery using Fencer-III. This experimental group was compared to a control group of 20 patients who underwent the same surgical procedures but using Image 1 HD(Karl Storz, Tuttlingen, Germany). The patients were classified to the above 2 groups randomly. Before the operation, the demographic and clinical data were recorded, including age, sex, height, weight, past medical history, present illness, allergy, vital signs, ECG result, and physical examination findings.

The three surgeons, all experienced in laparoscopic gastric surgery within the hospital performed all surgical procedures and evaluations. The laparoscope used in the surgery were not being told to the operating surgeons. Each surgeon was asked to score each patient using a set of questionnaire in accordance with the laparoscopic efficacy and ease of use. Laparoscopic efficacy was subdivided into 5 categories namely color saturation, image quality, focus (possibility of distinguishing anatomical structure using laparoscope), image brightness and image distortion. Ease of use was assessed by the following 8 criteria: field of view, direction of view, depth of field, fog prevention, image stability on bleeding, temperature change, manageability and convenience of use. All categories were rated with the use of the visual analog scale (0-to-10) according to surgeon's satisfaction.

Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS) 20.0 for Windows. Comparison between Fencer-III and Image 1 HD in accordance with the laparoscopic efficacy and ease of use were studied using independent t-tests. To apply the independent t-tests, differences in the scores between the two laparoscopic systems were examined with the Levene's test for equality of variances. The results were stated as the mean values and standard deviation for each group based on different categories. A p-value of <0.05 was considered as the threshold for statistical significance.

3. Results

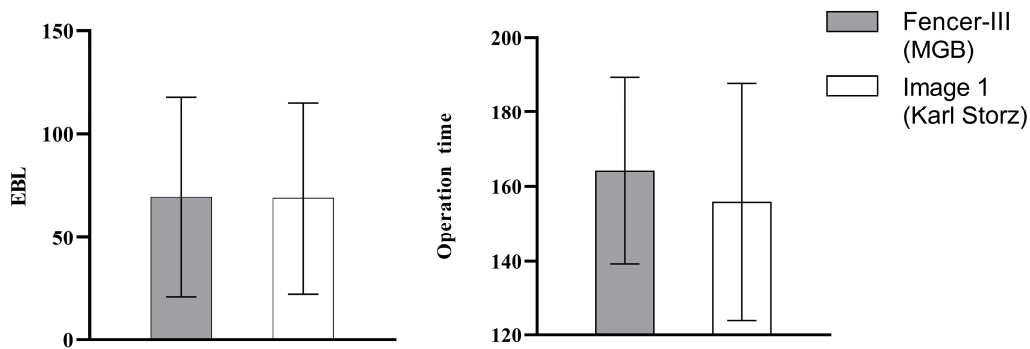
3.1 Demographic data

Patients under Fencer-III group was older than the Image 1 group (68.7 ± 13.0 vs 58.8 ± 15.8 years;

$p < 0.05$). No significant differences were found in the other demographic data between the two groups. The male-to-female ratio was 2:1 in the Fencer-III group and 9:11 in the Image 1 group ($p = 0.759$). The average weight was 62.9 ± 14.3 kg in the Fencer-III group and 67.1 ± 12.6 kg in the Image 1 group ($p = 0.745$). The average height was 157.9 ± 13.7 cm in the Fencer-III group and 162.1 ± 13.5 cm in the Image 1 group ($p = 0.337$). None of the patients showed any adverse events after the surgery.

3.2 Estimated blood loss and operation time

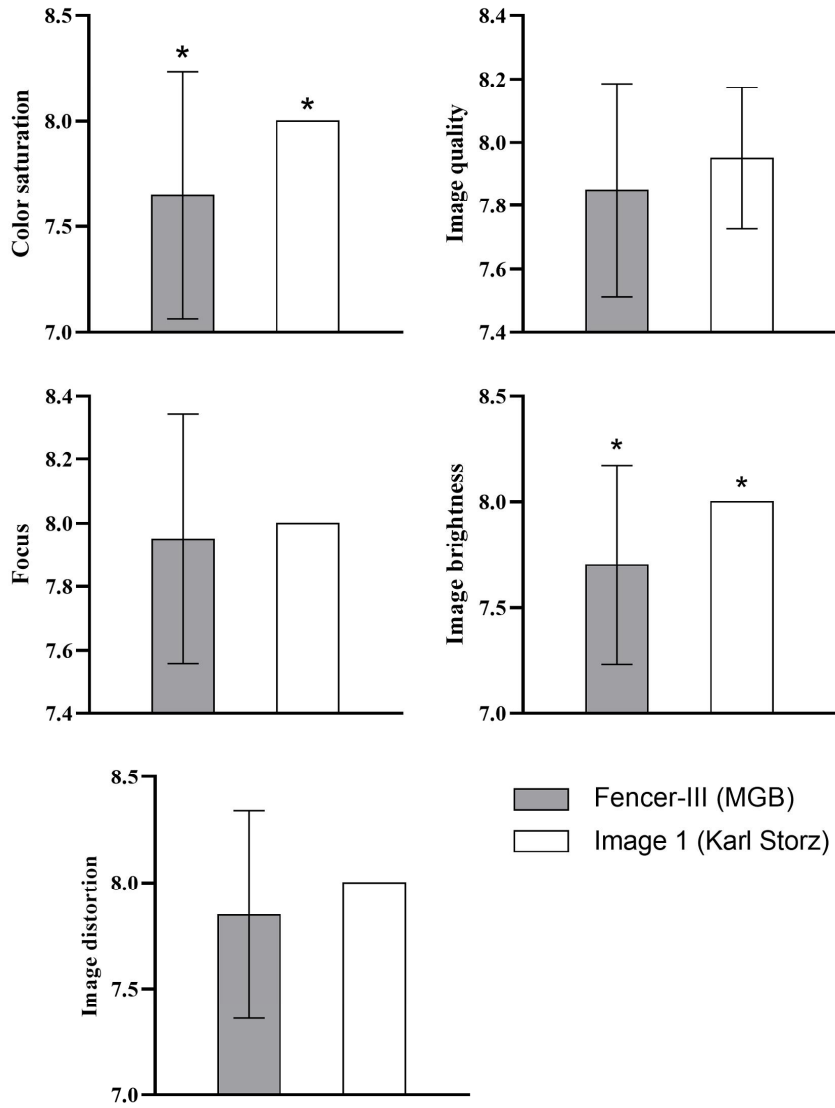
[Fig. 1] shows the average values for the estimated blood loss (EBL) and operation time between two laparoscopic systems. The EBL and operation time showed no significant difference between two groups. The mean EBL was 69.5 ± 48.4 ml in the Fencer-III group and 69.0 ± 46.2 ml in the Image 1 group ($p = 0.974$). The mean operation time was 164.3 ± 25.0 min in the Fencer-III group and 155.8 ± 31.9 min in the Image 1 group ($p = 0.355$).



[Fig. 1] Average values for estimated blood loss (EBL) and operation time between two laparoscopic systems

3.3 Laparoscopic efficacy

The efficacy parameters were color saturation, image quality, focus, image brightness and distortion. In terms of color saturation and image brightness respectively, the mean scores of Fencer-III system were significantly lower than the Image 1 HD (7.65 ± 0.59 vs 8.00 ± 0.22 , $p < 0.05$; 7.70 ± 0.47 vs 8.00 ± 0.00 , $p < 0.01$), as shown in [Fig. 2] There were no significant difference in the image quality ($p = 0.305$), focus ($p = 0.577$) and image distortion ($p = 0.186$).



[Fig. 2] Average ratings for laparoscopic efficacy parameters between two laparoscopic systems

3.4 Ease of use

The evaluation for the ease of use was done by comparing the parameters such as field of view, direction of view, depth of field, fog prevention, image stability on bleeding, temperature change, manageability and convenience of use. The result shown in [Table 1] confirmed that there are no significant differences among these variables between the two laparoscopic systems.

[Table 1] Ease of use evaluation data between the Fencer-III and Image 1 HD (n=40)

Variables	Image 1 HD		Fencer-III		p Value
	Mean	SD	Mean	SD	
Field of view	8.00	0.000	7.90	0.308	0.163
Direction of view	8.00	0.000	7.95	0.224	0.330
Depth of field	8.00	0.000	7.85	0.366	0.083
Fog prevention	7.60	0.754	7.90	0.308	0.112
Image stability on bleeding	7.95	0.224	7.65	0.671	0.070
Temperature change	7.90	0.308	7.90	0.718	1.000
Manageability	7.95	0.224	7.95	0.224	1.000
Convenience of use	7.95	0.224	7.95	0.394	1.000

SD, standard deviation

4. Discussion

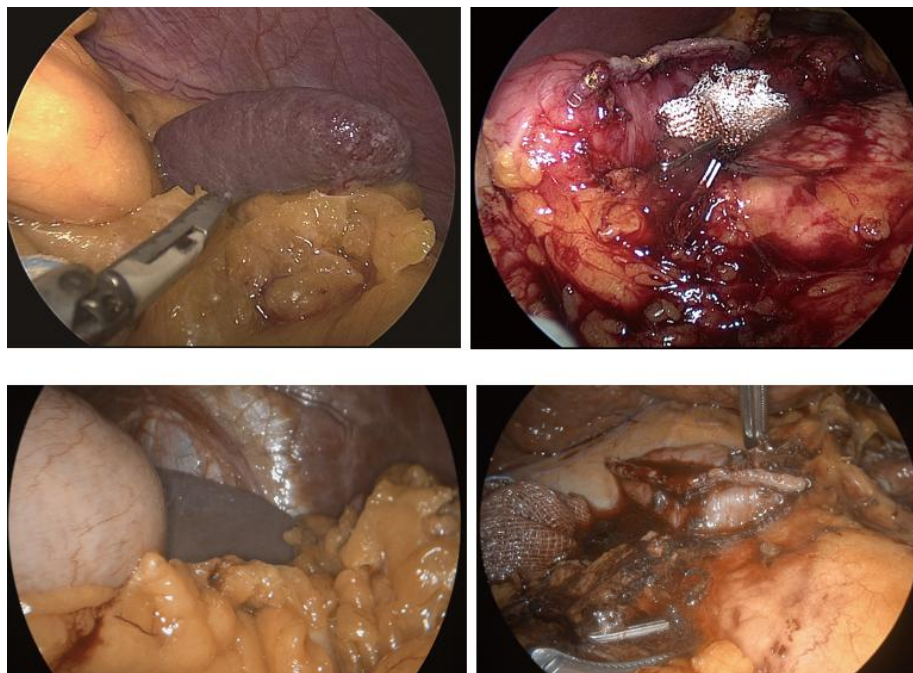
Accurate stereoscopic imaging is an important factor in laparoscopic surgery where surgeon can distinguish structures to be observed. This paper compares the Fencer-III system to the Image 1 system to evaluate its clinical applicability.

Fencer III system is a combined laparoscopic camera system, with endoscopic camera function, light output and insufflator. The endoscopic camera uses a 1-CMOS chip to obtain an optical image from the lens and convert the image into an electrical signal to display on a monitor. This system provides high-resolution HD quality, such as SDI and DVI, from low-resolution image outputs such as CVBS and S-Video. The light output uses an LED lamp and can control the amount of light in stages according to 10 levels. The insufflator, which controls the patient's abdominal pressure, is a suitable device for injecting CO₂ gas during surgery. The built-in microprocessor measures and controls the infusion pressure and the actual intraperitoneal pressure control system is operated on the basis of Monofilar-Bivalent System (MBS). This system intermittently measures the gas content and recharges the loss to maintain a constant input.

Our results demonstrated that there was no difference between scores of the post-surgical evaluation on the local laparoscope compared with the standard laparoscope system among all groups, with the exception of the color saturation and image brightness where Storz performed better with the average mean score of 7.65 and 8.00 respectively.

[Fig. 3] shows a laparoscopic image of gastric cancer surgery using Storz and Fencer. Fencer laparoscope shows more dull color compared to the Storz especially on bleeding site. Storz expressed

bright red color very much similar with the color of the blood while Fencer demonstrated dull brown color.



[Fig. 3] Laparoscopic image of gastric cancer surgery, Storz, normal surgical site (Top left); Storz, surgical bleeding site (Top right); Fencer, normal surgical site (Bottom left); Fencer, surgical bleeding site (Bottom right)

In addition, in terms of brightness, the test system showed inferior result than the control system ($p < 0.05$). Although statistically insignificant, the mean of image stability on bleeding of the test system also scored low compared with the control system. As stated above, this may be attributed to the difference in color and resolution of the surgical site during bleeding.

In contrast, Fencer scored higher in terms of fog prevention while performing a surgery. According to the study done by Lei Gu et al., lesser fog significantly improves the clarity of video images, reduces the surgeon's anxiety due to screen clarity, reduces operation time and time to fog care [8].

This study has several limitations. First, our survey did not cover general surgical practice, but rather laparoscopic gastric cancer surgery as performed by experts in the field. It means that these results do not essentially reflect general practice for laparoscopic gastric cancer surgery. Second, the number of surgeons was too small to analyze the overall efficacy and performance of the newly developed system.

Despite these limitations, our results on evaluating local laparoscopic system highlight the efficiency of its usage and similar evaluation outcomes as compared with the brand laparoscope. Fencer seems to

be a promising alternative to Storz in performing laparoscopic surgery and is worth for further high-quality evaluation with greater number of patients.

5. Conclusion

In conclusion, most of the urban hospitals in Korea were well-equip with those brand laparoscopic systems. However, due to the relatively high cost of surgical equipment, a large number of the local hospital in rural area fails to set up a facility. If the locally made laparoscopic system with much lower cost and easy accessibility, have similar outcomes in performing laparoscopic surgery, this would greatly help the rural hospital in terms of economics. Thus, our results can be used as an important reference tool on the current practice of laparoscopic gastric cancer surgery in Korea.

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