

Three-dimensional versus two-dimensional laparoscopy for ovarian cystectomy: a prospective randomised study

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ABSTRACT

Introduction: Three-dimensional (3D) laparoscopy is now available as an alternative to conventional two-dimensional (2D) laparoscopy for ovarian cystectomy. However, the clinical value of 3D laparoscopy in benign gynaecological surgery remains uncertain. This study evaluated whether 3D laparoscopy had any advantages over 2D laparoscopy for ovarian cystectomy for apparently benign ovarian cysts.

Methods: This prospective randomised study involved patients undergoing laparoscopic ovarian cystectomy. The primary outcomes were the duration of cystectomy and surgeon's Global Operative Assessment of Laparoscopic Skills (GOALS) score. The secondary outcomes were the preferences, perceptions, and adverse effects reported by the participating surgeons.

Results: There were 38 patients assigned to the 2D laparoscopy group and 37 patients assigned to the 3D laparoscopy group. Participating surgeons in the 2D group reported more efficient tissue handling than did those in the 3D group (mean

[standard deviation] rating score, 4.2 [0.8] vs 3.8 [0.8]; $P=0.033$). Duration of cystectomy (47.6 [32.0] min vs 51.6 [36.2] min; $P=0.198$) and overall GOALS score (20.8 [3.9] vs 20.1 [3.3]; $P=0.393$) were similar between both groups. Participating surgeons in the 2D group reported nausea, dizziness, ocular fatigue, and blurring of vision less frequently than did those in the 3D group (5.3% vs 45.9%; $P<0.001$).

Conclusion: There were no significant benefits to using 3D laparoscopy compared with conventional 2D laparoscopy for ovarian cystectomy, and 3D laparoscopy may cause more frequent adverse effects in surgeons.

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New knowledge added by this study

- For ovarian cystectomy, there is no significant benefit to using three-dimensional laparoscopy rather than conventional two-dimensional laparoscopy.
- Three-dimensional laparoscopy permits binocular vision and depth perception; however, surgeons using three-dimensional laparoscopy more frequently reported adverse effects such as ocular fatigue, nausea, dizziness, and blurring of vision.

Implications for clinical practice or policy

- Clinical use of three-dimensional laparoscopy in more complex surgical procedures, such as laparoscopic suturing, or with more experienced surgeons may be beneficial; therefore, further investigation is worthwhile.

Introduction

Laparoscopy has replaced laparotomy in most gynaecological procedures, and laparoscopic cystectomy is currently the mainstay of treatment for apparently benign ovarian cysts. However, the absence of depth perception and limited instrument dexterity are major drawbacks of laparoscopy. Advances in three-dimensional (3D) video imaging technology allow 3D laparoscopy to provide better precision than conventional two-dimensional (2D) laparoscopy, especially in depth perception and spatial orientation. This increased precision may help improve surgeons' performance during laparoscopic

surgery.

Studies have shown that 3D laparoscopy objectively^{1,2} and subjectively^{3,4} improves surgical performance, especially during complex tasks.⁵ In addition, 3D laparoscopy lessens the learning curve for beginners.⁶ The durations of laparoscopic cholecystectomy and pelvic lymphadenectomy have also been shortened when performed using 3D technologies.^{7,8} However, the clinical value of 3D laparoscopy in benign gynaecological surgery remains uncertain. This study aimed to evaluate any advantages of using 3D laparoscopy over 2D laparoscopy for ovarian cystectomy.

三維與二維腹腔鏡卵巢囊腫切除術：前瞻性隨機研究

雷雯華、張煜棠

引言：三維（3D）腹腔鏡可替代傳統的二維（2D）腹腔鏡手術進行卵巢囊腫切除術。然而，3D腹腔鏡在良性婦科手術中的臨床價值仍不確定。本研究評估3D腹腔鏡與2D腹腔鏡檢查相比對於明顯良性卵巢囊腫切除術是否有優勢。

方法：這項前瞻性隨機研究涉及接受腹腔鏡卵巢囊腫切除術的患者。主要研究結果是卵巢囊腫切除術的手術時間和外科醫生的整體腹腔鏡技術（GOALS）評分。次要結果是參與研究的外科醫生報告的偏好、認知和不良反應。

結果：38例患者分配到2D腹腔鏡組，37例患者分配到3D腹腔鏡組。2D組的參與外科醫生相比3D組報告更有效的組織處理（平均〔標準差〕評分：4.2〔0.8〕比3.8〔0.8〕； $P=0.033$ ）。兩組患者的手術時間（47.6〔32.0〕分鐘比51.6〔36.2〕分鐘； $P=0.198$ ）和GOALS總評分（20.8〔3.9〕比20.1〔3.3〕； $P=0.393$ ）相若。2D組的參與外科醫生報告噁心、頭暈、眼疲勞和視力模糊較3D組為低（5.3%比45.9%； $P<0.001$ ）。

結論：與常規2D腹腔鏡手術相比，使用3D腹腔鏡手術對於卵巢囊腫切除術沒有明顯益處。3D腹腔鏡手術可能會對外科醫生造成更多不良反應。

Methods

This prospective randomised study was conducted from May 2014 to May 2016 at the Queen Mary Hospital, Hong Kong, a teaching hospital affiliated with The University of Hong Kong. Women with apparently benign ovarian cysts who were scheduled for elective laparoscopic ovarian cystectomy and who were eligible for the study were invited at the pre-admission clinic to enrol in the study. Inclusion criteria were being older than 18 years; ability to understand Cantonese, Putonghua, or English; and ability to understand the study information during the consent process. Patients who were intra-operatively found to have no ovarian cyst were excluded from further analysis.

Patients were allocated by block randomisation to undergo surgery with 2D laparoscopy (2D group) or 3D laparoscopy (3D group) according to a computer-generated random sequence, in blocks of five. The group allocation for each patient was disclosed to the surgeon on the day before the surgery using a consecutively numbered, opaque, sealed envelope. Demographic data of patients and duration of surgeries were collected by a research nurse.

A pneumoperitoneum was created using a Veress needle to provide visually guided closed access. For 3D laparoscopy, a 10-mm 3D telescopic

videoscope was used (Endoeye Flex 3D; Olympus, Center Valley [PA], US). All surgeons were trained for 3D laparoscopy using a pelvic trainer with standardised tasks including peg transfer, precision cutting, duct cannulation, and suturing with knot tying. The 3D laparoscopy training was continued until the surgeons could confidently operate using 3D images. All non-specialist surgeons were supervised by a laparoscopist accredited at the advanced level in gynaecological laparoscopic surgery, according to the Hong Kong College of Obstetricians and Gynaecologists.⁹ At their discretion, surgeons were allowed to switch from 3D laparoscopy to traditional 2D laparoscopy if difficulty was encountered during surgery. All 2D laparoscopies were performed using a 10-mm laparoscope (26033AP; Karl Storz Endoscopy-America Inc, Culver City [CA], US). The same 32-inch high-definition monitor (LMD-3215MT; Sony Corporation, Tokyo, Japan) was used for all operations. In the 2D and 3D groups, cystectomy was performed in the usual manner, using two or three 5-mm accessory ports inserted in the lower abdomen under direct vision. The start time of the operation (first skin incision), insertion of primary trocar, completion of cystectomy, and end of operation (final skin closure) were recorded by the research nurse.

After the operation, all surgeons were required to self-evaluate their performance by using the Global Operative Assessment of Laparoscopic Skills (GOALS) assessment tool.¹⁰ The five-item GOALS score includes assessment of depth perception, bimanual dexterity, efficiency, tissue handling, and autonomy. Any operator discomfort encountered during the surgery, any need to convert to 2D laparoscopy, and the surgeon's preference for the type of laparoscopy based on experience were also recorded. Demographic data and operative findings, such as size and laterality of cysts, operative duration, and presence of adhesions, were analysed. Duration of cystectomy was defined as the time from completion of primary port insertion to separation of the cyst from the ovary and completion of haemostasis. The time spent on specimen retrieval was not included, owing to variations in the specimen retrieval method with or without use of a specimen bag.

The primary outcome of the present study was the difference between the GOALS score of 2D and 3D groups. The secondary outcomes were the duration of cystectomy and surgeons' preferences and reported adverse effects. Subgroup analysis was performed to compare the outcomes for different experience levels among the surgeons. The surgeons were categorised according to their experience in performing laparoscopic surgery (≤ 5 years or >5 years). Surgeons with more than 5 years of experience had achieved competency in gynaecological laparoscopic surgery to at least an

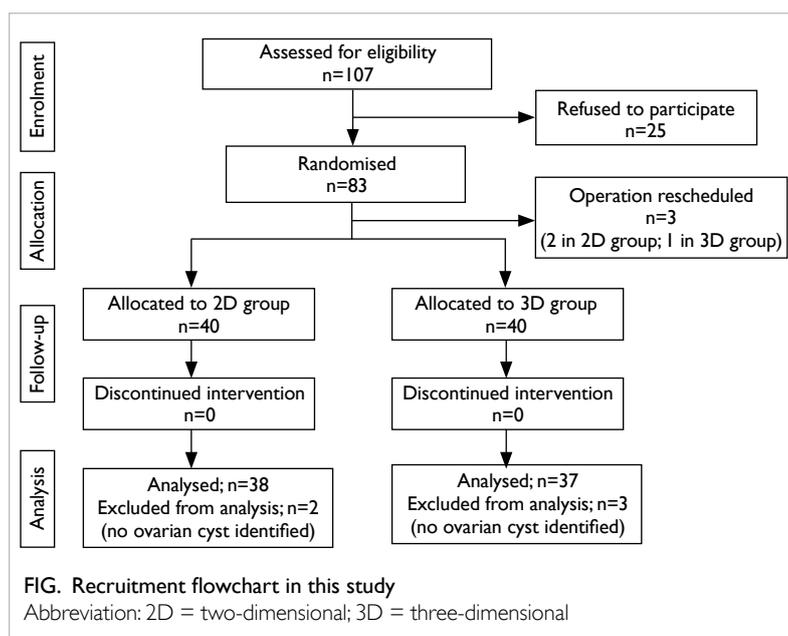
intermediate level, according to the Hong Kong College of Obstetricians and Gynaecologists, and had completed a required number of laparoscopic operations as requested by the College.⁹

A sample size of 36 patients was required in each group, as calculated using an alpha of 0.05 and a beta of 0.2 for detection of a difference in the sum of four items of the GOALS score (excluding tissue handling) of 13 (interquartile range [IQR], 11-16) in the 2D group and 16 (IQR, 12-18) in the 3D group, as based on a previous study,¹¹ using a two-sided test. To allow for a 10% dropout rate, 40 patients were recruited into each group. For randomised patients whose operations were subsequently rescheduled outside the study period, treatment assignment numbers were reallocated to subsequent eligible patients who provided consent. Statistical analysis was performed using IBM SPSS Statistics for Windows, Version 21.0 (IBM Corp., Armonk [NY], US). Data were presented as proportions or mean and standard deviation. Student's t test and Chi squared test were used for statistical analyses. A P value of <0.05 was considered statistically significant.

Results

Of the 83 patients recruited into the study from May 2014 to May 2016, operations were rescheduled for three patients who were therefore withdrawn from the study; 80 patients completed the trial (Fig). Of these 80 patients, two from the 2D group and three from the 3D group were excluded from analysis because no cysts were identified. Finally, 38 patients in the 2D group and 37 patients in the 3D group were included for analysis. Patient characteristics and surgical outcomes are presented in Table 1. There were no significant differences between the 2D and 3D groups in terms of patient age, laterality of the ovarian cyst, histological diagnosis of the cyst, presence of severe adhesions, volume of blood loss, and experience level of the surgeon. Three accessory ports were used in four patients in the 2D group and in five patients in the 3D group. In all other patients, two accessory ports were used. The mean (standard deviation) diameter of the ovarian cyst was smaller in the 3D group than that in the 2D group (5.1 [2.1] cm vs 6.1 cm [2.1] cm; $P=0.031$). Body mass index in the 2D group was significantly higher than that in the 3D group (23.4 [4.4] kg/m² vs 21.3 [2.6] kg/m²; $P=0.011$). Severe adhesion was defined as a score of >20 for adnexal adhesion unilaterally¹² or a score of >40 for endometriosis,¹³ according to the American Society for Reproductive Medicine classifications.

The differences between 2D and 3D groups in terms of GOALS score and duration of cystectomy are presented in Table 2. A total of 15 surgeons participated in the study and there were 13 in each group: 11 in both, while two for each were involved in 2D and 3D groups, respectively. Participating



surgeons in the 2D group reported more efficient tissue handling than did those in the 3D group. Adverse effects, including nausea, dizziness, ocular fatigue, and blurring of vision were reported less frequently by participating surgeons in 2D group than those in 3D group (Table 3). However, none of the participating surgeons requested intra-operative conversion from 3D to 2D laparoscopy. At the end of surgery, more participating surgeons in the 3D group expressed a preference for 2D laparoscopy (43.3%) than for 3D laparoscopy (18.9%), whereas 37.8% had no preference. A subgroup analysis of participating surgeons in the two groups did not show statistically significant differences in terms of GOALS score (2D vs 3D; 28.9 [5.1] vs 28.2 [46.0]; $P=0.585$), tissue handling (4.2 [0.8] vs 3.9 [0.8]; $P=0.060$), and duration of cystectomy (93.7 [46.1] minutes vs 97.7 [52.2] minutes; $P=0.737$).

Subgroup analyses according to the experience level of the surgeon and the presence of dense adhesions are shown in Tables 4 and 5, respectively. Two of the surgeons in the 3D group and three of the surgeons in the 2D laparoscopy are accredited at the advanced level in gynaecological laparoscopic surgery by the Hong Kong College of Obstetricians and Gynaecologists. Surgeons with more than 5 years of laparoscopic experience reported lower scores in tissue handling and efficiency when using 3D laparoscopy. There were no differences in terms of GOALS score and duration of cystectomy in the subgroup with dense adhesions.

Discussion

Three-dimensional laparoscopy is gaining popularity

TABLE 1. Patient characteristics and surgical outcomes*

	Two-dimensional group (n=38)	Three-dimensional group (n=37)	P value
Age, y	36.6 (7.1)	35.6 (7.0)	0.538
Body mass index, kg/m ²	23.4 (4.4)	21.3 (2.6)	0.011
Laterality of cysts			0.891
Unilateral	22 (57.9%)	22 (59.5%)	
Bilateral	16 (42.1%)	15 (40.5%)	
Size (longest diameter) of cyst, cm	6.1 (2.1)	5.1 (2.1)	0.031
Presence of severe adhesions	14 (36.8%)	13 (35.1%)	0.878
Blood loss, mL	55.1 (64.8)	58.2 (56.2)	0.825
Duration of hospital stay, d	2.6 (1.2)	2.4 (1.3)	0.489
Surgeon's experience			0.725
≤5 Years	19 (50.0%)	17 (45.9%)	
>5 Years	19 (50.0%)	20 (54.1%)	
Histology			0.054
Dermoid cyst	9 (23.7%)	14 (37.8%)	
Endometriotic cyst	25 (65.8%)	16 (43.2%)	
Others†	4 (10.5%)	7 (18.9%)	

* Data are shown as mean (standard deviation) or No. (%) of subjects

† Other histologies included five cases of serous cystadenoma, two cases of mucinous cystadenoma, one case of mucinous borderline ovarian tumour, and three cases of follicular cysts

TABLE 2. Differences between the 2D and 3D laparoscopy groups in terms of surgeon's GOALS score and duration of cystectomy*

	2D group (n=38)	3D group (n=37)	P value
Overall GOALS score	20.8 (3.9)	20.1 (3.3)	0.393
Component of GOALS score			
Depth perception	4.1 (1.0)	4.1 (0.8)	0.888
Bimanual dexterity	4.1 (0.8)	4.1 (0.8)	0.782
Efficiency	4.2 (1.0)	4.1 (0.7)	0.503
Tissue handling	4.2 (0.8)	3.8 (0.8)	0.033
Autonomy	4.2 (0.9)	4.1 (0.8)	0.434
Duration of cystectomy, min	47.6 (32.0)	51.6 (36.2)	0.198

Abbreviations: 2D = two-dimensional; 3D = three-dimensional; GOALS = Global Operative Assessment of Laparoscopic Skills

* Data are presented as mean (standard deviation)

TABLE 3. Adverse effects reported by participating surgeons

	Two-dimensional group (n=38)	Three-dimensional group (n=37)	P value
No. of operations that surgeons reported adverse effects	2 (5.3%)	17† (45.9%)	<0.001
Nausea	1	8	
Dizziness	0	8	
Ocular fatigue	1	9	
Blurring of vision	0	2	

† Some surgeons experienced more than one adverse effect

TABLE 4. Comparison between the 2D and 3D groups in terms of surgeon's GOALS score and duration of cystectomy according to the experience level of the surgeon*

	Surgeon's experience ≤5 years			Surgeon's experience >5 years		
	2D group (n=19)	3D group (n=17)	P value	2D group (n=19)	3D group (n=20)	P value
Age of patient, y	34.1 (6.8)	36.1 (7.4)	0.391	39.1 (6.7)	35.1 (6.9)	0.073
Body mass index, kg/m ²	22.7 (3.4)	20.9 (2.3)	0.068	24.2 (5.3)	21.5 (2.8)	0.065
Size of ovarian cyst, cm	6.3 (1.9)	5.3 (2.2)	0.170	6.0 (2.3)	4.8 (2.1)	0.116
Bilateral cysts	9 (47.4%)	9 (52.9%)	0.738	7 (36.8%)	6 (30.0%)	0.651
Presence of severe adhesions	7 (36.8%)	7 (41.2%)	0.790	7 (36.8%)	6 (30.0%)	0.651
Blood loss, mL	64.0 (64.3)	72.9 (60.5)	0.668	46.3 (65.7)	45.8 (0.4)	0.976
Overall GOALS score	18.9 (3.5)	18.2 (3.1)	0.551	22.8 (3.2)	21.8 (2.5)	0.268
Depth perception	3.8 (0.9)	3.7 (0.8)	0.768	4.4 (1.0)	4.5 (0.6)	0.764
Bimanual dexterity	3.7 (0.7)	3.7 (0.8)	0.726	4.5 (0.6)	4.5 (0.6)	0.698
Efficiency	3.7 (1.0)	3.8 (0.7)	0.634	4.7 (0.6)	4.2 (0.6)	0.033
Tissue handling	3.9 (0.7)	3.5 (0.8)	0.165	4.6 (0.6)	4.1 (0.8)	0.040
Autonomy	3.8 (0.9)	3.5 (0.5)	0.272	4.6 (0.8)	4.5 (0.8)	0.593
Duration of cystectomy, min	60.7 (37.7)	64.7 (39.0)	0.756	34.5 (18.0)	40.5 (30.3)	0.457
Presence of adverse effects	2 (10.5%)	8 (47.1%)	0.015	0	9 (45.0%)	0.001

Abbreviations: 2D = two-dimensional; 3D = three-dimensional; GOALS = Global Operative Assessment of Laparoscopic Skills

* Data are shown as mean (standard deviation) or No. (%) of subjects

TABLE 5. Comparison between the 2D and 3D groups in terms of surgeon's GOALS score and duration of cystectomy according to presence of severe adhesions*

	With severe adhesions			No severe adhesions†		
	2D group (n=24)	3D group (n=24)	P value	2D group (n=14)	3D group (n=13)	P value
Age of patient, y	36.0 (7.5)	35.4 (7.0)	0.751	37.5 (6.7)	35.9 (7.4)	0.566
Body mass index, kg/m ²	23.5 (4.4)	21.1 (2.4)	0.023	23.3 (4.5)	21.6 (2.8)	0.262
Size of ovarian cyst, cm	6.1 (2.4)	4.7 (2.0)	0.029	6.1 (1.4)	5.7 (2.3)	0.615
Bilateral cysts	7 (29.2%)	6 (25.0%)	0.745	9 (64.3%)	9 (69.2%)	0.785
Surgeons' experience >5 years	12 (50.0%)	15 (58.3%)	0.562	7 (50.0%)	6 (46.2%)	0.842
Blood loss, mL	43.8 (42.0)	44.4 (56.6)	0.966	74.6 (90.3)	83.9 (47.4)	0.741
Overall GOALS score	29.7 (5.1)	27.6 (4.9)	0.146	28.1 (5.1)	29.6 (3.7)	0.374
Depth perception	4.3 (0.8)	4.0 (0.8)	0.159	3.7 (1.2)	4.4 (0.7)	
Bimanual dexterity	4.1 (0.7)	4.0 (0.9)	0.721	4.1 (0.9)	4.2 (0.7)	
Efficiency	4.3 (1.0)	4.0 (0.8)	0.186	4.0 (1.0)	4.2 (0.6)	
Tissue handling	4.4 (0.8)	3.7 (0.8)	0.003	4.0 (0.7)	4.2 (0.8)	
Autonomy	4.3 (0.9)	4.1 (0.9)	0.503	4.1 (0.7)	3.9 (0.8)	
Duration of cystectomy, min	90.3 (43.1)	77.0 (32.1)	0.233	93.9 (52.0)	127.4 (66.6)	0.162

Abbreviations: 2D = two-dimensional; 3D = three-dimensional; GOALS = Global Operative Assessment of Laparoscopic Skills

* Data are shown as mean (standard deviation) or No. (%) of subjects

in modern gynaecological surgery owing to improved depth perception and spatial orientation compared with 2D laparoscopy. Improved effectiveness using 3D laparoscopy has been shown extensively in training models, especially when performing complex tasks⁵ and in beginners.^{6,8,14} However,

our study was unable to show an improvement in terms of GOALS score and duration of operation (Table 2) despite the 3D laparoscopy group having a smaller mean ovarian cyst diameter (Table 1). This finding contradicts a recent meta-analysis that 3D laparoscopy was associated with shortened surgical

time and hospital study, less blood loss, and fewer perioperative complications.¹⁵

The addition of binocular vision and depth perception in 3D laparoscopy is associated with more frequent adverse effects such as ocular fatigue, nausea, and dizziness.¹⁶ In the present study, participating surgeons in the 3D group more frequently reported nausea, dizziness, ocular fatigue, and blurring of vision than did those in the 2D group. However, this result may be because the participating surgeons were unfamiliar with 3D images; with experience, this discomfort may be lessened. Maintaining stability of the telescope is of utmost importance during 3D laparoscopy; therefore, familiarity with 3D images is important for assistants to mitigate adverse effects. Furthermore, maintaining an appropriate distance between the screen and the surgeon also alleviates nausea and ocular fatigue.¹⁶

Previous studies have shown that 3D laparoscopy is beneficial for less experienced surgeons^{6,8,14} and for any surgeon performing complex tasks.⁵ However, in our subgroup analysis, we were unable to confirm any benefits of 3D laparoscopy in relation to the experience level of the surgeons. All participating surgeons were much more familiar with 2D laparoscopy and, thus, the difference between groups might simply reflect the surgeons' assessment of what they are used to. This familiarity effect may explain the lower scores in tissue handling and efficiency with 3D laparoscopy attained by the more experienced surgeons.

The surgeons' preference for 2D laparoscopy and the heterogeneity of the participating surgeons and patients make the subgroup analyses underpowered and represents a constitute limitation of the present study. The differences in mean diameter of the ovarian cysts and body mass index between the two groups also suggest ineffective randomisation. This ineffective randomisation, the withdrawal of patients after randomisation, and the surgeons' lack of experience with 3D laparoscopy were also limitations. During data analysis, there were also no controls for possible confounding factors, such as experience of each surgeon with 3D laparoscopy or significant differences in patient characteristics between the groups.

In conclusion, the results show that there is no significant benefit to using 3D laparoscopy for ovarian cystectomy compared with conventional 2D laparoscopy. Moreover, 3D laparoscopy is associated with more frequent adverse effects for surgeons. However, it is possible that more complex procedures, such as those involving laparoscopic suturing and knot tying, might be easier to perform with 3D laparoscopy than with 2D laparoscopy. Therefore, further evaluation is required of the clinical performance of 3D laparoscopy in operations

of different complexities and of surgeons with different experience levels.

Author contributions

All authors have made substantial contributions to the concept of this study; acquisition of data; analysis or interpretation of data; drafting of the article; and critical revision for important intellectual content.

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Declaration

The authors have no conflicts of interest to disclose. All authors had full access to the data, contributed to the study, approved the final version for publication, and take responsibility for its accuracy and integrity. The study was presented as oral presentation in the 25th Asian and Oceanic Congress of Obstetrics and Gynaecology, 16 June 2017, Hong Kong.

Ethical approval

Ethical approval was obtained from the Institutional Review Board of the University of Hong Kong/Hospital Authority Hong Kong West Cluster. Written informed consent was obtained from all participating patients and surgeons. The study was registered with ClinicalTrials.gov (NCT02775344).

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