Application of Individual Surgical Image Guidance with Holographic Technology (inSIGHT) in Pelvic Exenteration (PE) of Surgically Refractory Rectal Cancer

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CONTENTS

PART 01

Current Challenges of PE

Definition of PE

Pelvic Exenteration (PE) is the radical multivisceral resection of locally advanced or recurrent pelvic tumors.

PE was originally described by Alexander Brunschwig in 1948 as a palliative procedure for recurrent cervical cancer and has since evolved into one of the most important surgical procedures for locally progressive and recurrent rectal cancer.

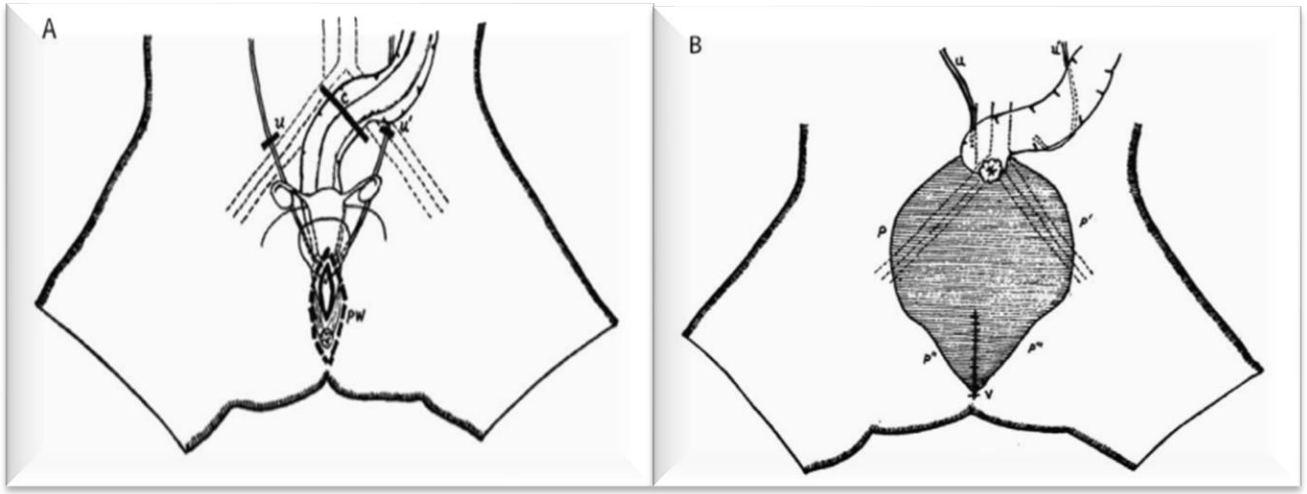
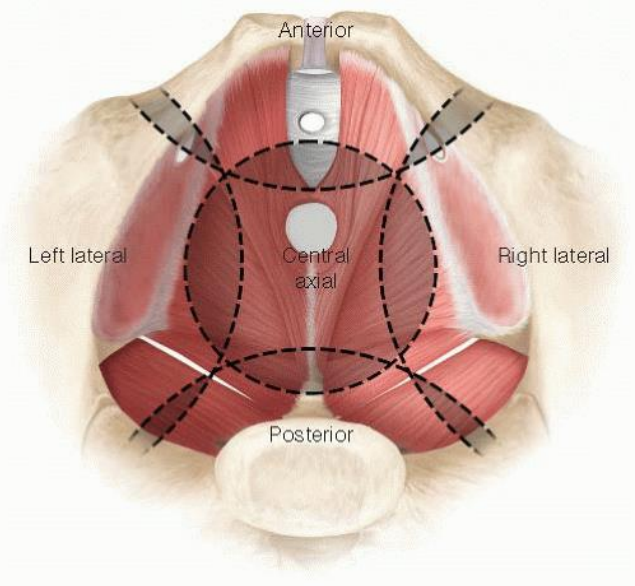


FIGURE 1. A, Diagram showing levels of transection of the ureters (U) and colon (C) and incision encompassing the vulva and anus (PW) from Brunschwig's original article.[7] B, Diagram showing conditions at end of operation indicating areas of peritonectomy (shaded area, P, P′, PI′, and PI″). The midline colostomy is shown with both ureters (U and U′) implanted into the colon a short distance above colostomy. Copyright © 1948 American Cancer Society. Reproduced with permission from John Wiley & Sons Ltd.

Cancer. 1948;1(2):177-183.

Definition of PE



Resection of rectal tumors with rectum, as well as resection of 2 or more pelvic organs for >50% and/or bone and neurovascular resection. (International)

Removal of pelvic organs or structures in two or more anatomical divisions. Pelvic anatomical divisions include the anterior, middle, lateral, and posterior pelvic cavities. (Chinese Expert Consensus 2023)

- Ultra TME
- en Bloc resection
- R0 resection

Current status of PE research

TABLE 1. Selected series reporting outcomes of pelvic exenteration surgery over 7 decades

Author, reference	*Year*	*Location*	*Patients*	*R0, %*	*Mortality, %*	*Morbidity, %*	*5-year OS, %*
Brunschwig[7]	1948	New York	22	–	23	–	–
Brunschwig[34]	1965	New York	430	–	18	–	22
Ketcham et al[35]	1970	Maryland	162	–	17	–	38
Symmonds et al[36]	1975	Minnesota	198	–	8	92 (early) 88 (late)	33
Averette et al[37]	1984	Miami, FL	92	69	24	67	37
Lawhead et al[38]	1989	New York	65	54	9	–	23
Robertson et al[39]	1994	Tyne, United Kingdom	83	–	4	47	41
Salo et al[40]	1999	New York	103	69	1	24[a]	31
Heriot et al[41]	2008	Sydney (New South Wales) and Melbourne (Victoria), Australia Christchurch, New Zealand	160	61	1	27	37
You et al[1]	2012	Houston, TX	46	80	0	50	58
Bhangu et al[42]	2014	London, United Kingdom	100	78	0	53	84 (PRC)[b] 72 (RRC)[b]
Harris et al[2]	2016	Multicenter	533	59	–	–	28

R0 resection and overall survival rates gradually increased, and perioperative mortality and complication rates decreased.

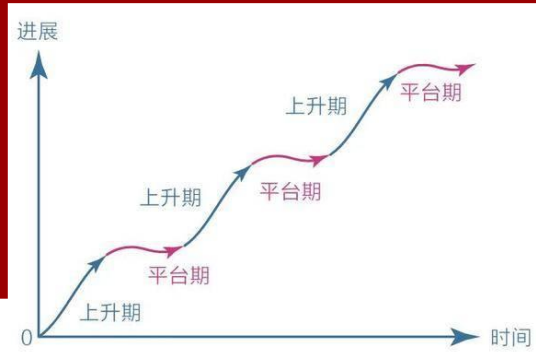
Dis Colon Rectum 2017; 60: 745–754

Current restrictions in PE

Complex local anatomy

High-volume medical centers

Long learning curve

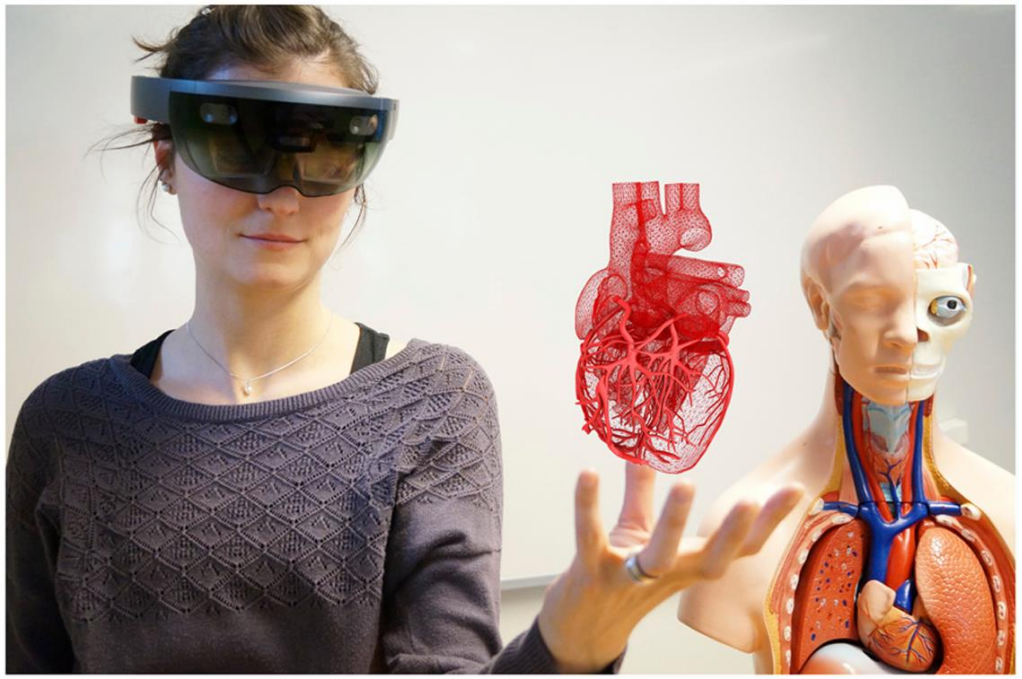


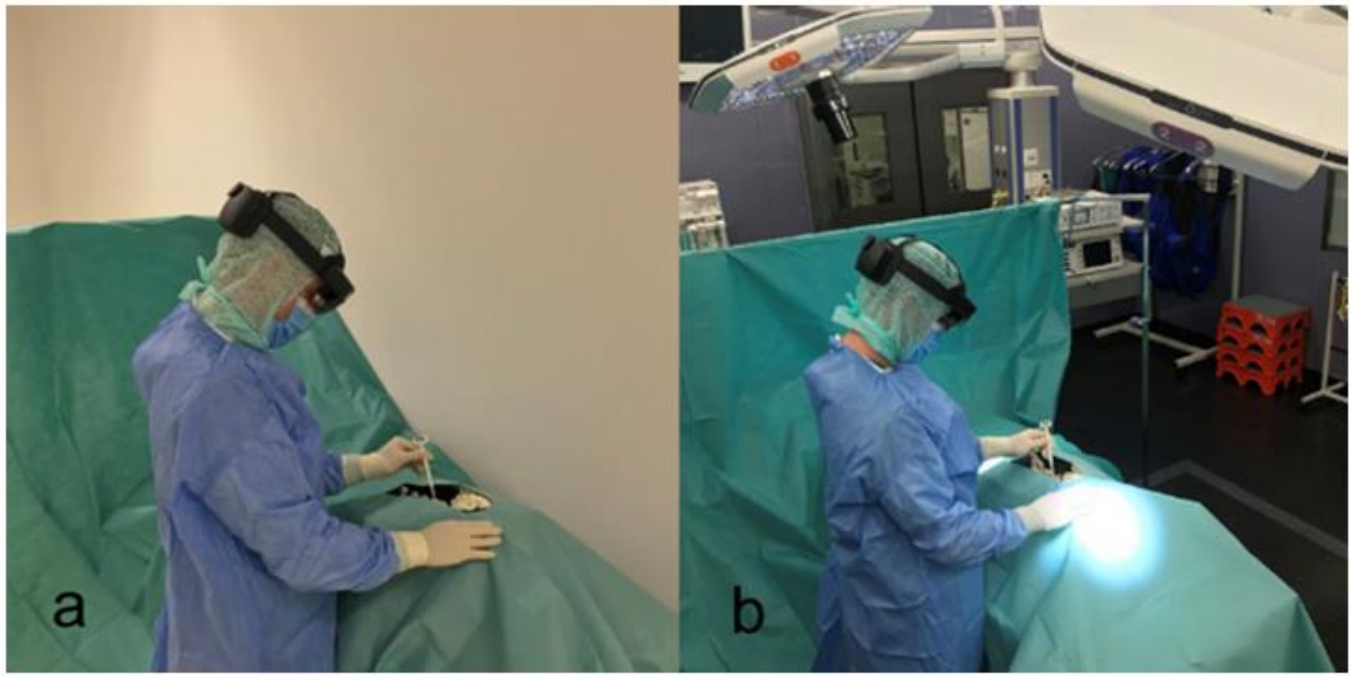
Med J Aust. Mar 18;220(5):222-224.

PART 02

Application of holo-imaging in PE

Holo-imaging Emerge in Surgery





Holo-imaging, a highly accurate 3D image based on a patient's CT or MRI data, can be presented in a mixed-reality manner, stereoscopically and accurately presenting the patient's lesions and surrounding anatomical structures, and is emerging in a number of surgical-related fields, such as **telemedicine, simulation training, pre-surgical planning, patient education, intra-operative navigation,** and so on.

Surg Innov. 2024 Feb;31(1):82-91.

Intraoperative holo-imaging to guide laparoscopic CRC surgery

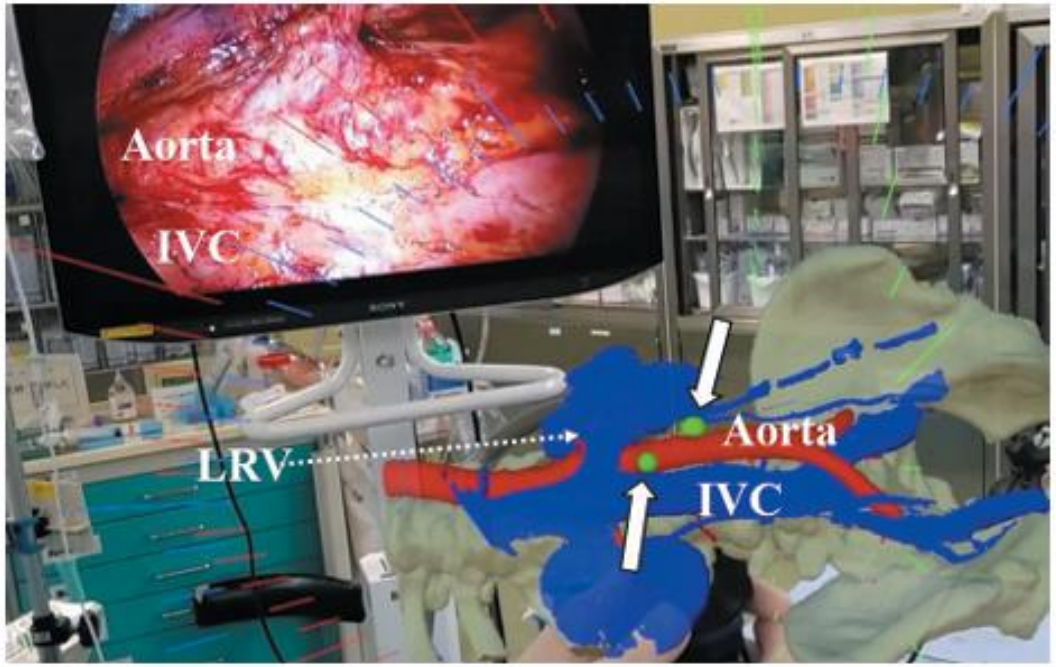
2.0 > Anticancer Res. 2022 Oct;42(10):4849-4856. doi: 10.21873/anticanres.15990.

Intraoperative Holographic Guidance Using Virtual Reality and Mixed Reality Technology During Laparoscopic Colorectal Cancer Surgery

Shunjin Ryu [1], Takahiro Kitagawa [2], Keisuke Goto [2], Atsuko Okamoto [2], Rui Marukuchi [2], Keigo Hara [2], Ryusuke Ito [2], Yukio Nakabayashi [2]

Purpose: Exploring the feasibility of intraoperative holo-imaging to guide laparoscopic colorectal cancer surgery

- **2 ileocaecal resections, 6 right hemicolectomies, 1 partial colectomy, 4 lateral lymph node dissection and 1 para-aortic lymph node dissection;**
- **Assessment: operative time, blood loss, length of postoperative hospitalization, NASA Task Load Index (TLX)**



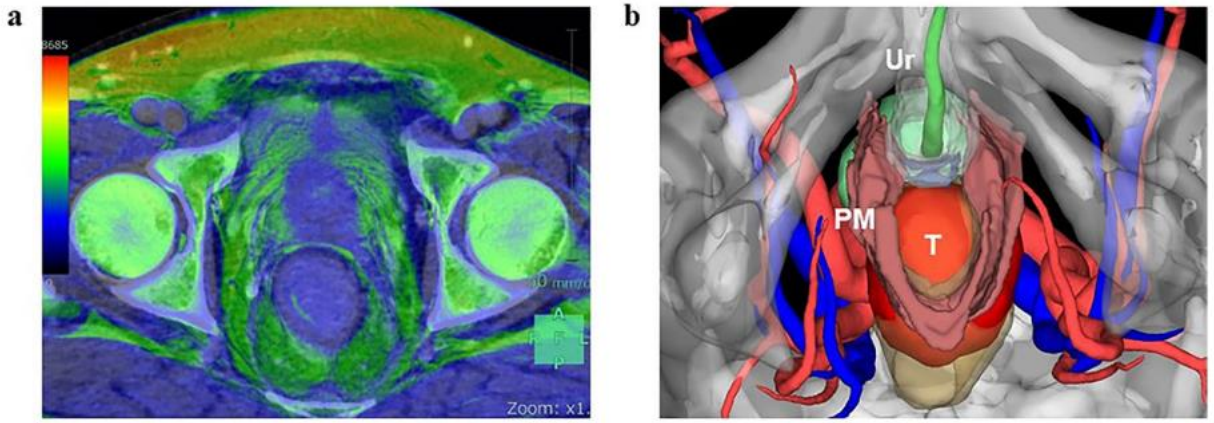
Intraoperative holo-imaging to guide TaTME surgery

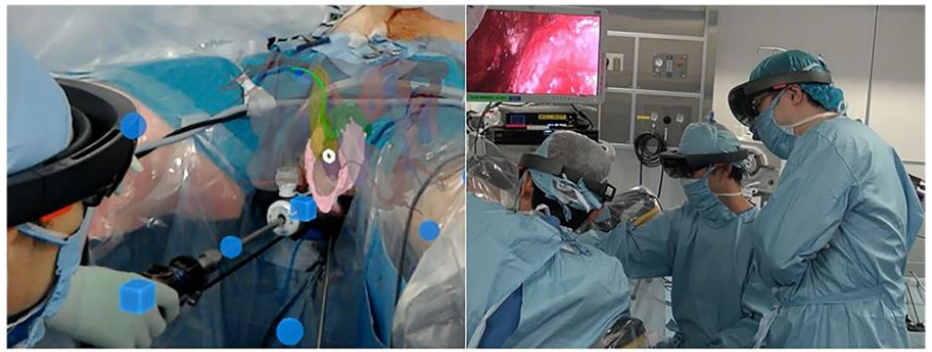
2.3 > Langenbecks Arch Surg. 2022 Sep;407(6):2579-2584. doi: 10.1007/s00423-022-02607-4. Epub 2022 Jul 15.

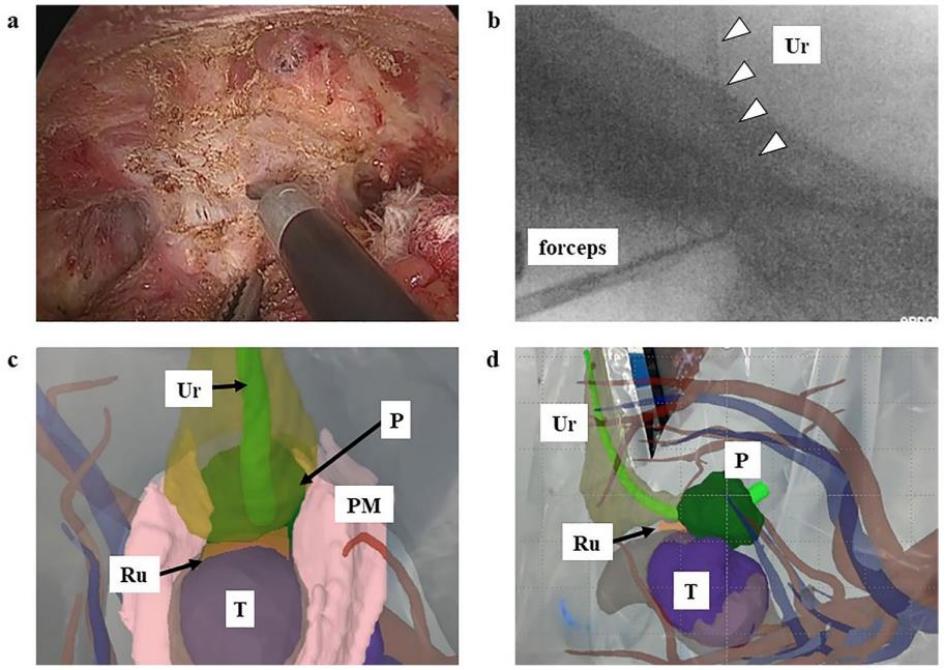
Intraoperative holographic image-guided surgery in a transanal approach for rectal cancer

Takuya Tokunaga [1], Maki Sugimoto [2], Yu Saito [3], Hideya Kashihara [3], Kozo Yoshikawa [3], Toshihiro Nakao [3], Masaaki Nishi [3], Chie Takasu [3], Yuma Wada [3], Toshiaki Yoshimoto [3], Shoko Yamashita [3], Yosuke Iwakawa [3], Noriko Yokota [3], Mitsuo Shimada [3]

Purpose: to avoid urethral injury during TaTME





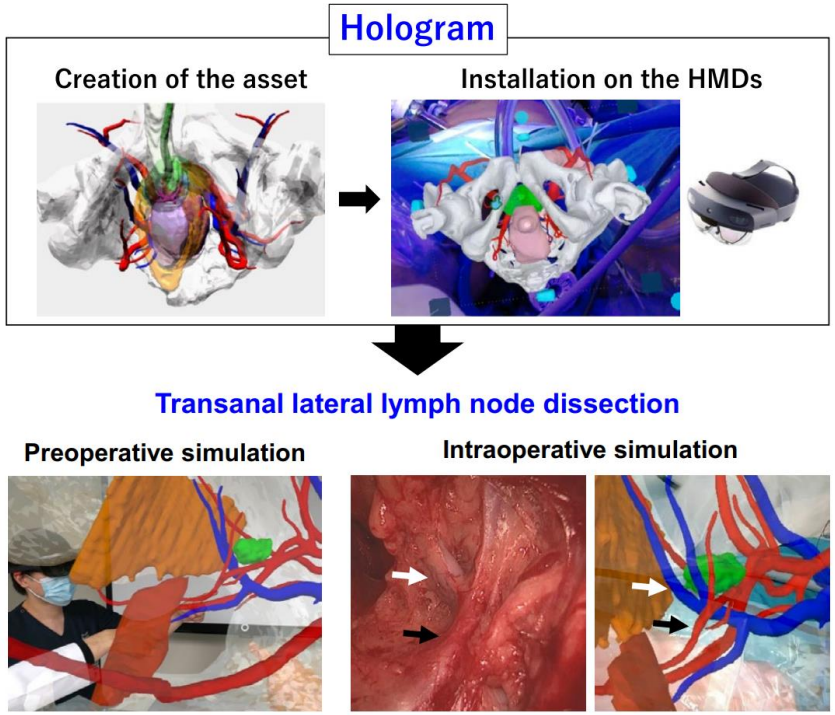


Intraoperative holo-imaging to guide transanal lateral lymph node dissection

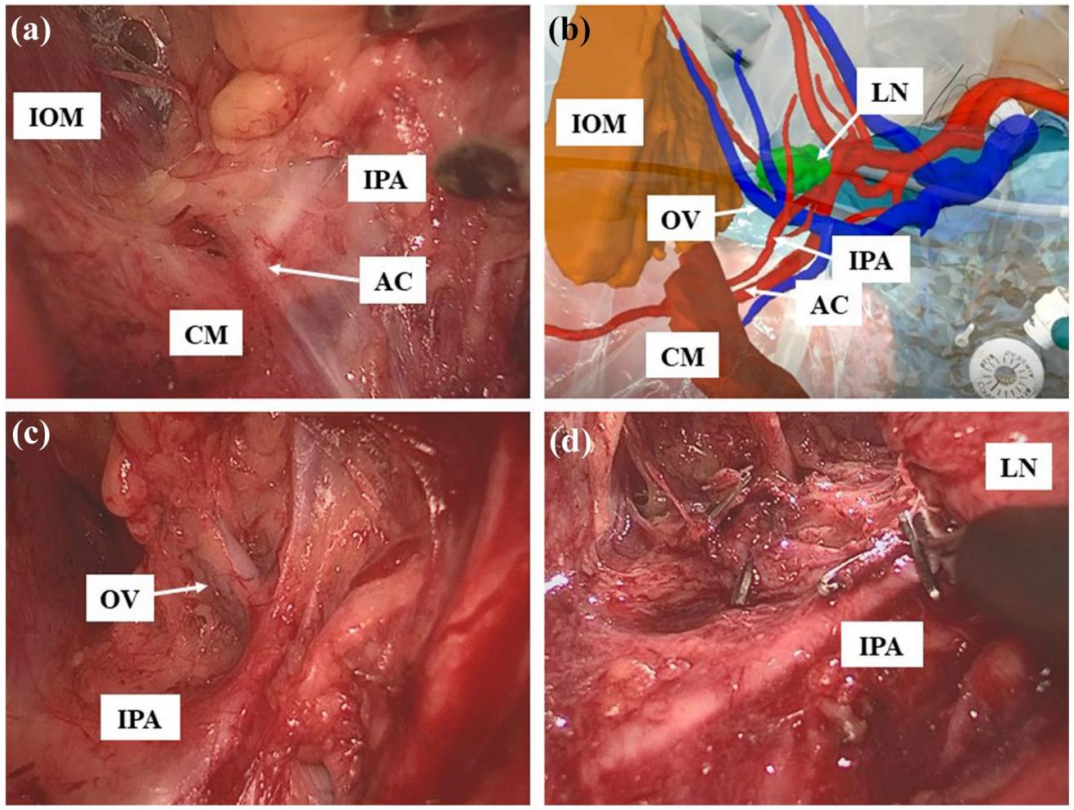
3.1 > Surg Endosc. 2023 Jul;37(7):5414-5420. doi: 10.1007/s00464-023-09977-w. Epub 2023 Apr 5.

Transanal lateral lymph node dissection with intraoperative hologram support in low rectal cancer

Takuya Tokunaga [1], Maki Sugimoto [2], Yu Saito [3], Hideya Kashihara [3], Kozo Yoshikawa [3], Toshihiro Nakao [3], Masaaki Nishi [3], Chie Takasu [3], Yuma Wada [3], Yuhei Waki [3], Toshiaki Yoshimoto [3], Takayuki Noma [3], Mitsuo Shimada [3]



➢ **Purpose：to investigate whether intraoperative holographic imaging can be used as a tool to assess complex pelvic anatomical structures**

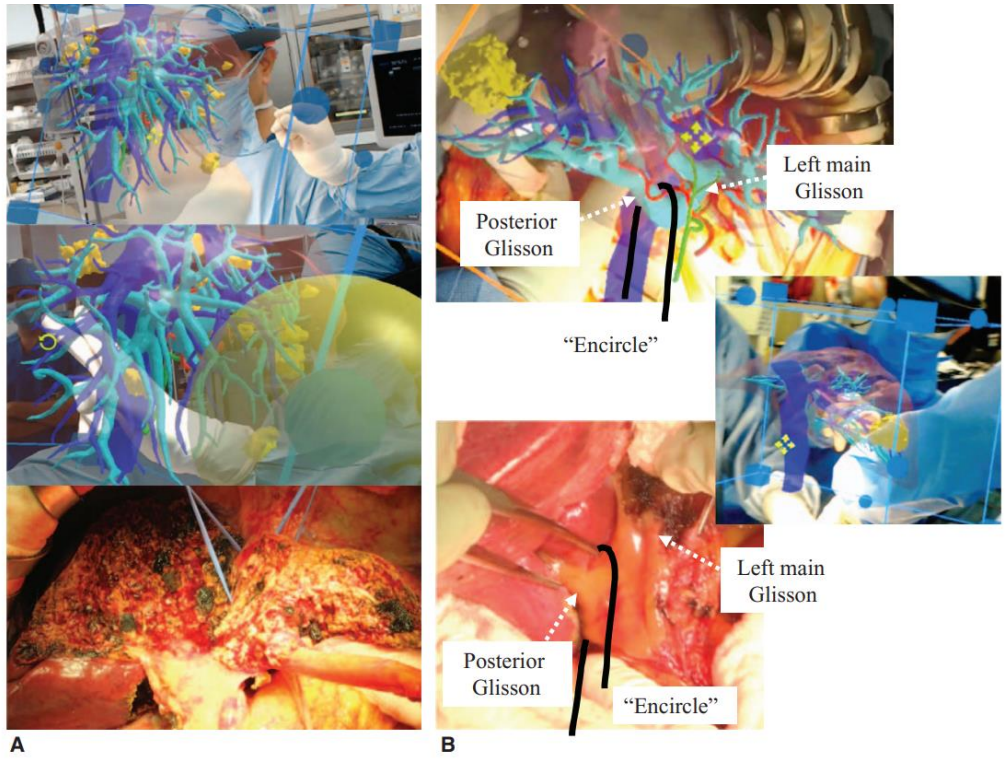


Intraoperative holo-imaging for CRC liver metastases and HCC

10.1 > Ann Surg. 2020 Jan;271(1):e4-e7. doi: 10.1097/SLA.0000000000003552.

Intraoperative 3D Hologram Support With Mixed Reality Techniques in Liver Surgery

Yu Saito [1], Maki Sugimoto [1 2], Satoru Imura [1], Yuji Morine [1], Tetsuya Ikemoto [1], Shuichi Iwahashi [1], Shinichiro Yamada [1], Mitsuo Shimada [1]



- **Purpose: Exploring the potential of holo-imaging for liver surgery**
- **Reconstruction method: CT**
- **Assessment: NASA Task Load Index (TLX)**

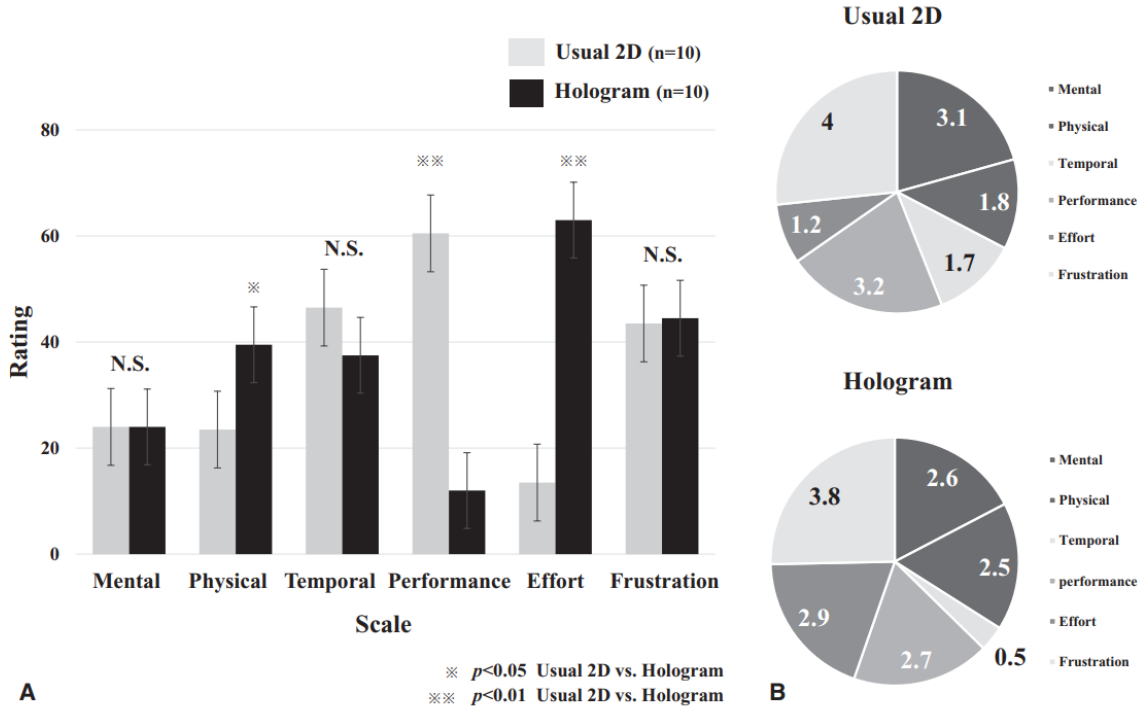
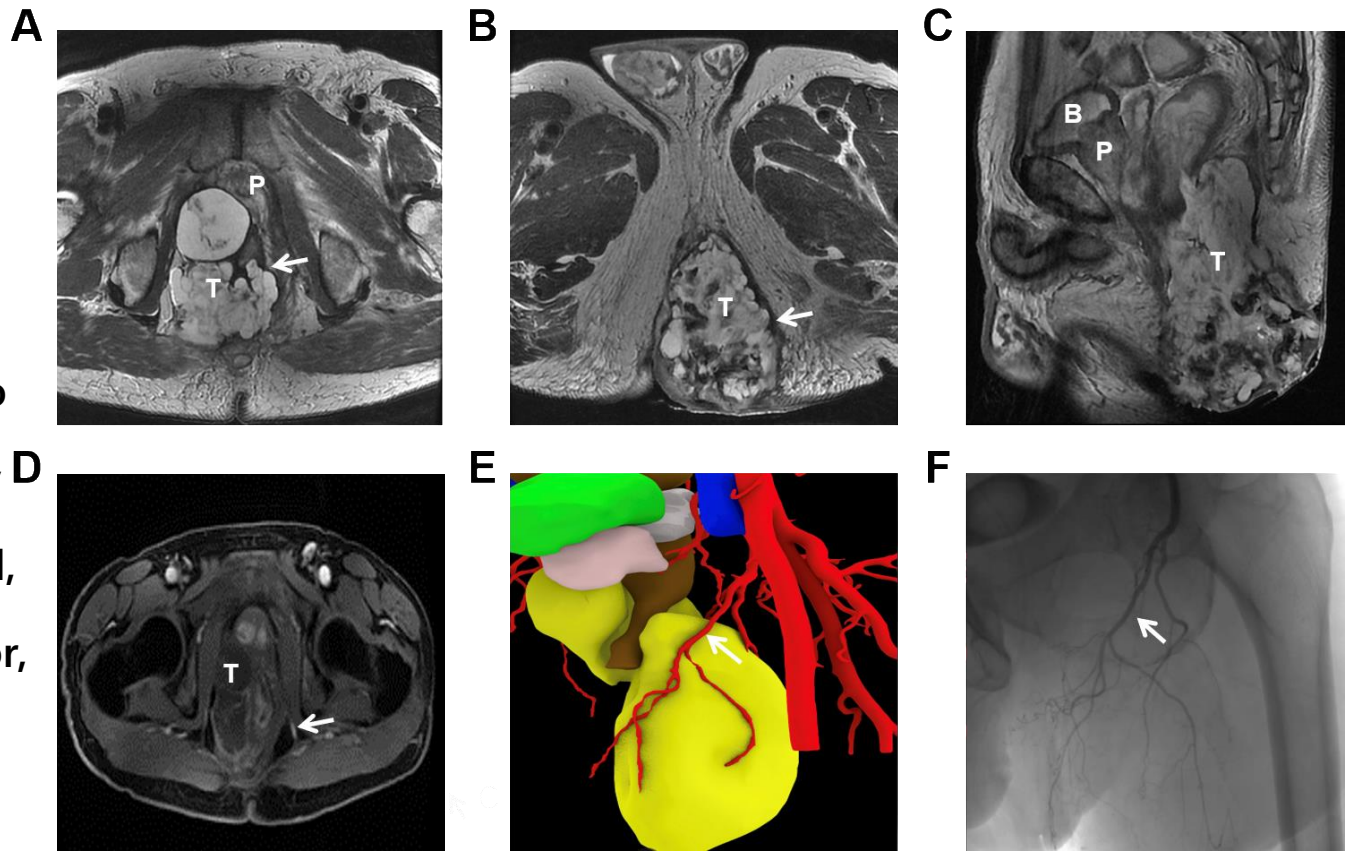


FIGURE 2. NASA-Task load index workload. A, Mean rating for each subscale. Hologram scored significantly higher ''physical demand,'' ''effort,'' and lower ''performance'' than usual 2D support. B, Weighting of each scale. ''Frustration'' was the most important factor in both intraoperative supports. ''Effort (2.9)'' and ''physical demand (2.5)'' were recognized as important sources in hologram support.

How does the application of holo-imaging in PE ???

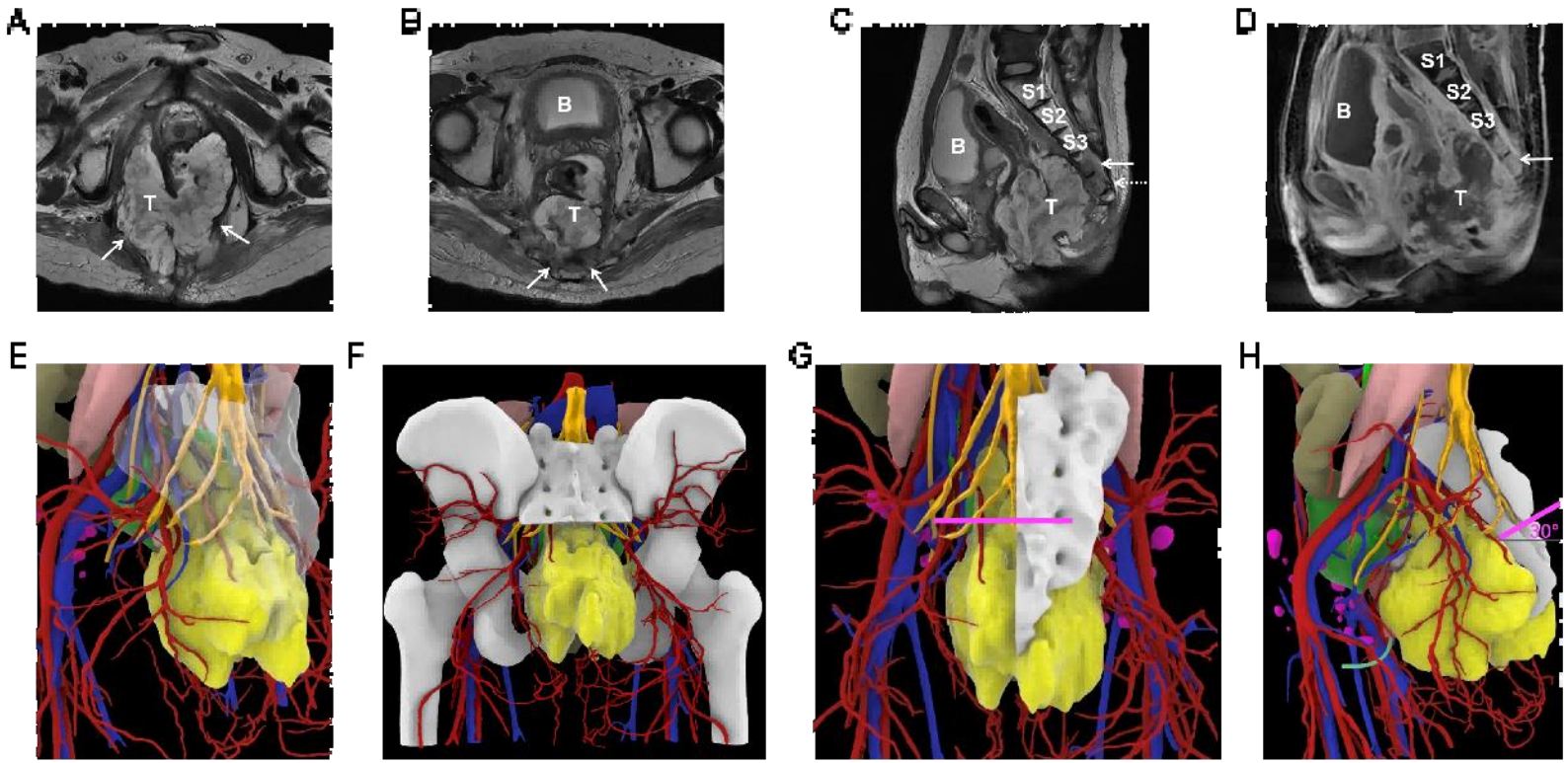
Holo-imaging technology assisted surgeons in localizing the 3D structure of giant tumors and identifying key nourishing vessels

- Male, 73y, with huge tumor and rich blood supply of recurrent rectal cancer,
- with the help of holo-imaging to initially determine the blood vessel to be subjected to interventional embolization, which effectively blocked the tumor's main blood supply vessel, and led to a significant shrinkage of the tumor, and guided the successful completion of the surgery.



Unpublished data

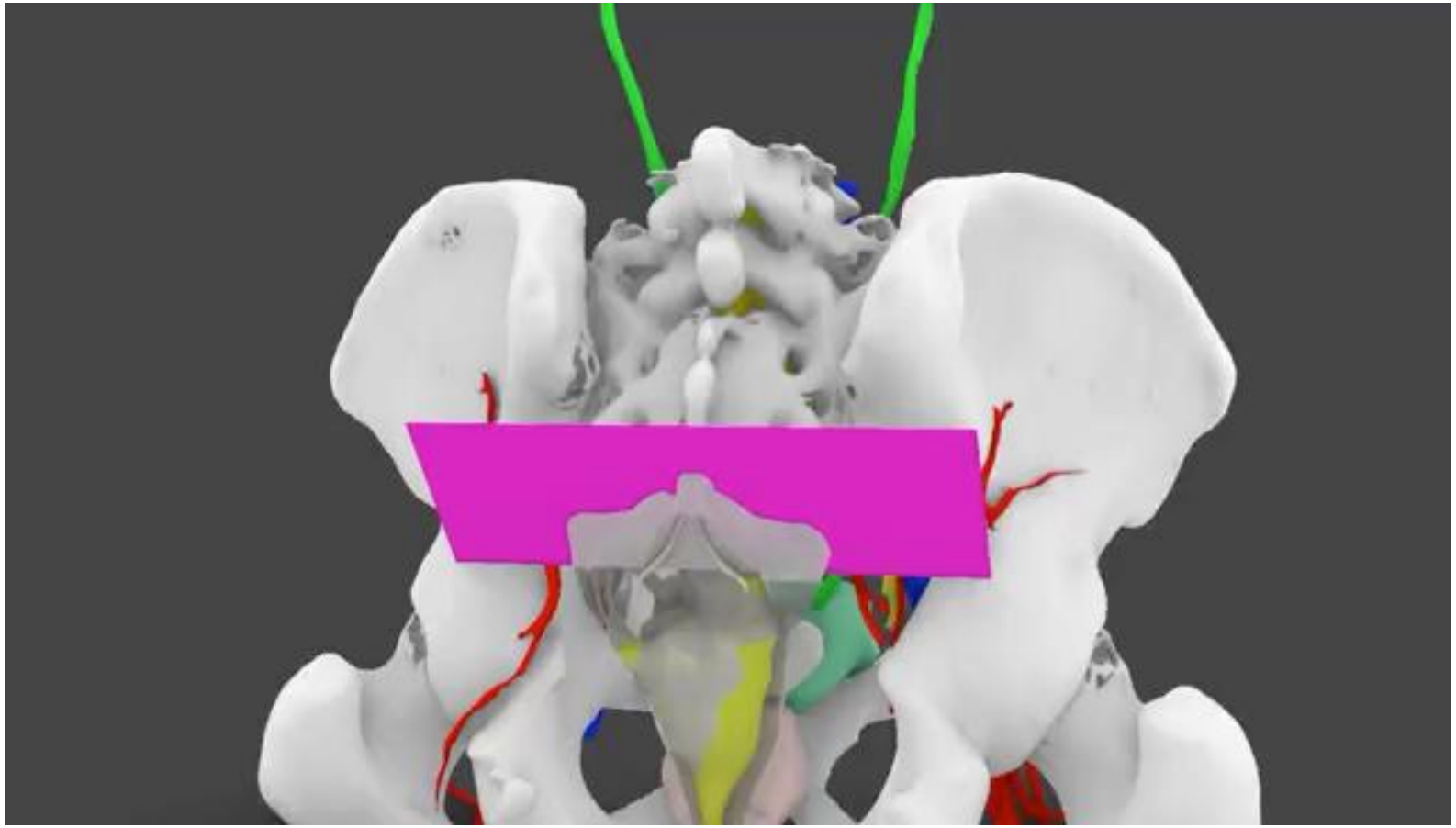
Application of holo-imaging in combined sacrectomy



Male, 38y. The holo-imaging shows the relationship between the tumor and the sacrum and sacral nerves from a S3 level, and more intuitively shows the involvement of the tumor on the bilateral sacral 4 nerves.

Unpublished data

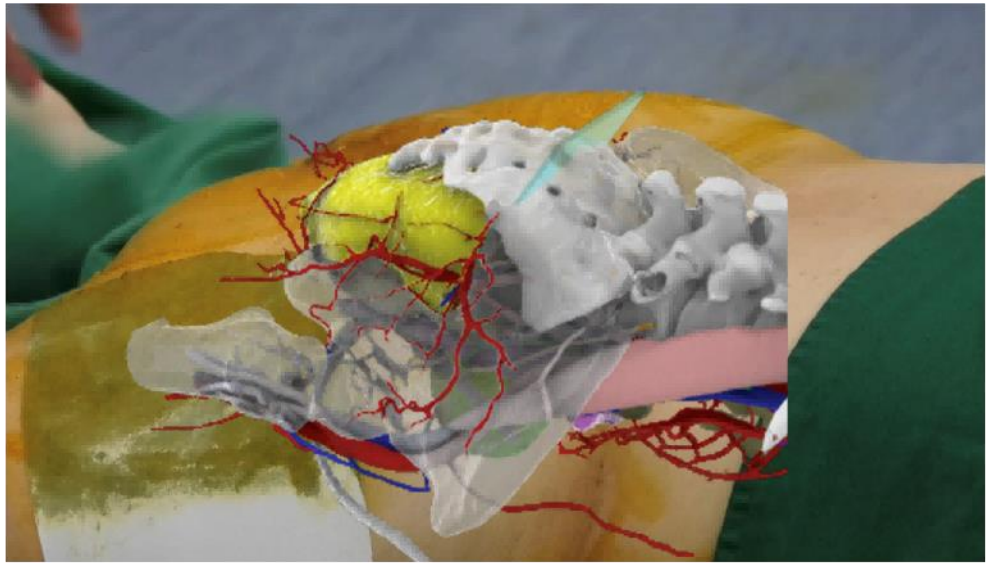
Application of holo-imaging in combined sacrectomy

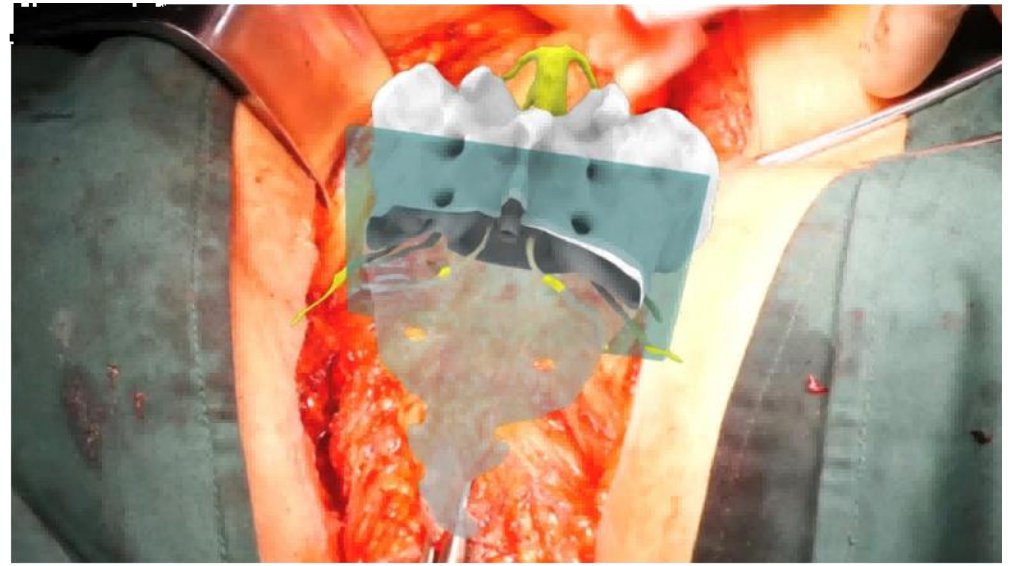


The pink plane is the sacral resection plane and Angle determined based on the holo-imaging

Unpublished data

Application of holo-imaging in combined sacrectomy





When the surgeon uses the head-mounted holo-imaging device (HoloLens2), in addition to seeing the real surgical field of view, and the holographic image (the green plane on the sacrum in the figure),

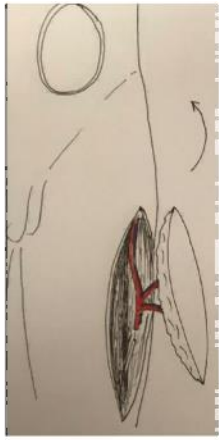
The surgeon performs the sacrectomy with reference to the planes and angles shown on the hologram.

Unpublished data

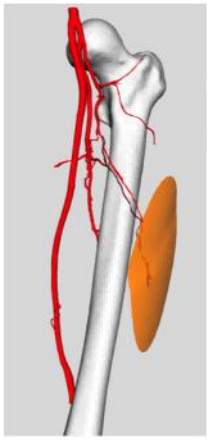
Production of holo-imaging

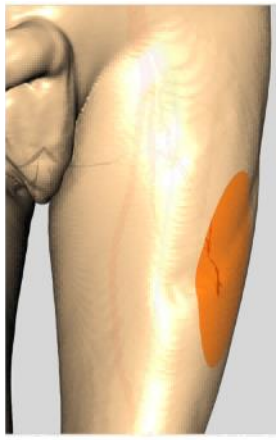
Unpublished data

Holo-imaging assists in plastic surgery and reconstruction of the perineal area

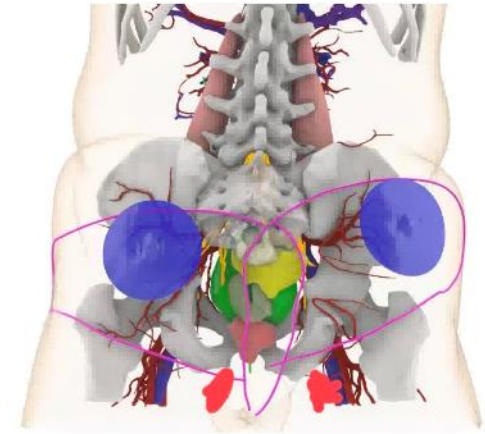


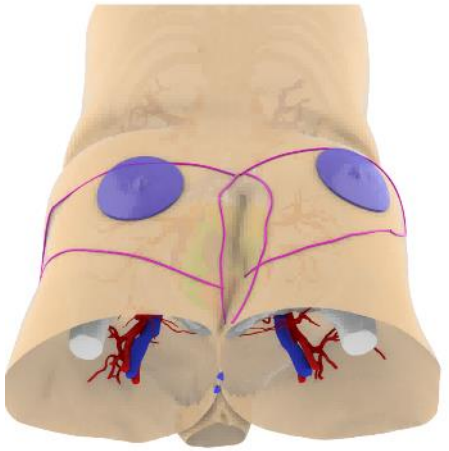
Schematic design of a conventional lateral thigh flap





Holo-imaging assisted development of flaps and perforating vessels by surgeons and engineers





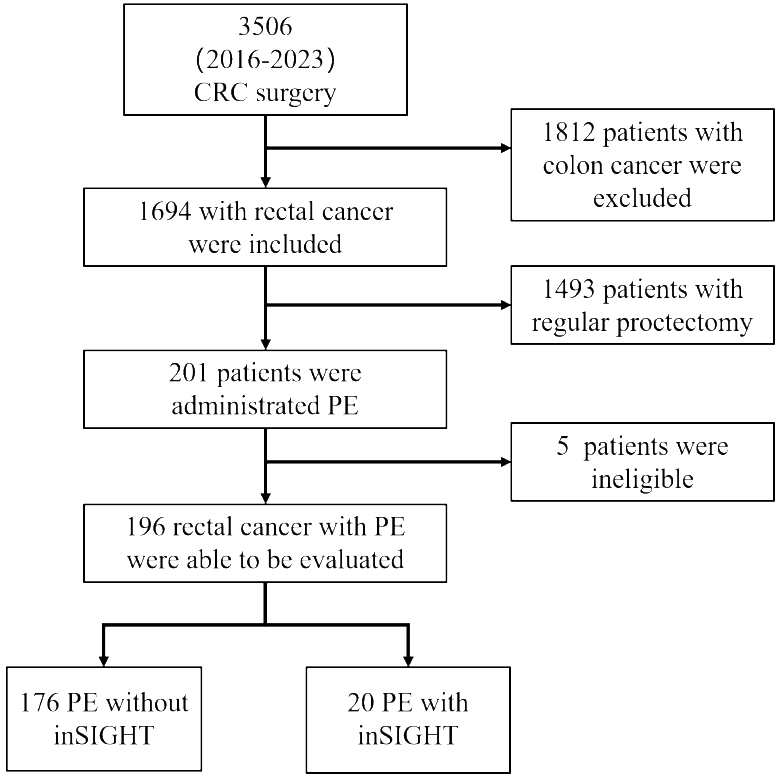
Flap design and surgical planning by engineers and plastic surgeons on holo-imaging and patient models with skin based on vascular alignment and lesion extent in holo-imaging

Holo-imaging facilitates selection of perforating vessels with thicker diameters

Unpublished data

A retrospective cohort of Peking University Shougang Hospital

Application of inSIGHT in PE of surgically refractory rectal cancer



Surgically refractory rectal cancer

Inclusion Criteria:

1. AJCC stage T4b tumor confirmed by preoperative MRI staging;
2. Pathologically confirmed primary (recurrent) colorectal tumor;
3. Deemed fit by MDT for local R0 resection;
4. Older, critically ill patients with multiple organ dysfunction but deemed able to tolerate surgery based on MDT assessment

Exclusion Criteria:

1. Primary or recurrent rectal cancer with extensive metastasis;
2. Multiple organ dysfunction and deemed unable to tolerate surgery based on MDT assessment;
3. Concurrent primary tumors of other organs;
4. Poor compliance and unwilling to attend follow-ups;
5. Refused MDT assessment and preoperative neoadjuvant therapy;
6. Lesions invading sacral 1 and 2 vertebrae.

Patients screening flowchart

Individual Surgical Image Guidance with Holographic Technology (inSIGHT)

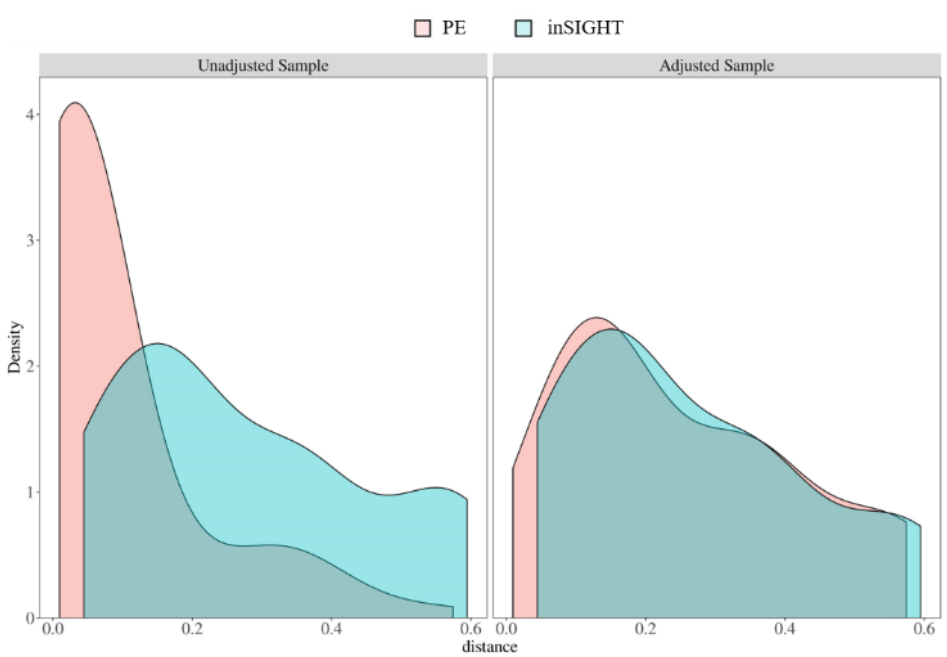
Unpublished data

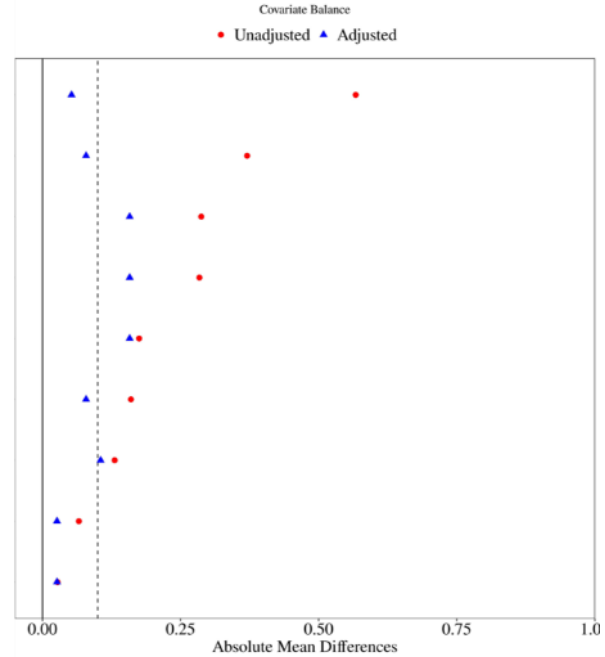
Patient outcomes for PE with/without inSIGHT

A 1:2 propensity score matching of PE with and without inSIGHT

was performed based on 6 clinical characteristics

- Sex;
- Age;
- Primary/recurrent tumor;
- Whether metastasized;
- Whether neoadjuvant therapy was performed;
- Whether reconstruction was performed





No significant difference in baseline information between the two groups after matching

Unpublished data

Patient outcomes for PE with/without inSIGHT

Variables		Total (n=50)	PE (n=31)	inSIGHT (n=19)	P value
Age, Mean±SD (years)		54.69±12.85	53.57±12.23	56.53±13.61	0.44
Hight (cm)		166.54±7.68	168.00±6.73	164.16±8.51	0.09
Weight (kg)		61.88±12.97	61.23±12.50	62.95±13.64	0.66
ECOG, M (Q_1, Q_3)		1 (1, 1.50)	1 (1, 1)	1 (1, 1)	0.92
ASA, M (Q_1, Q_3)		2 (2, 3)	2 (2, 2.50)	2 (2, 3)	0.53
Operative duration (minutes), M (Q_1, Q_3)		380 (291.25, 562.50)	375 (285, 510)	450 (335, 649.90)	0.09
Bleeding (ml), M (Q_1, Q_3)		600 (400, 1200)	600 (300, 1000)	800 (500, 1750)	0.4
Blood infusion, M (Q_1, Q_3)		800 (400, 1200)	600 (400, 1000)	1200 (500, 1500)	0.3
Resected organ number, M (Q_1, Q_3)		3 (2, 3)	3 (2, 3)	3 (2, 3)	0.85
PE, n (%)					0.11
	APE	10 (20)	9 (29.03)	1 (5.26)	
	PPE	32 (64)	17 (54.84)	15 (78.95)	
	TPE	8 (16)	5 (16.13)	3 (15.79)	
Surgery, n (%)					0.63
	R0	29 (58)	17 (54.84)	12 (63.16)	
	R1	17 (34)	12 (38.71)	5 (26.32)	
	R2	4 (8)	2 (6.45)	2 (10.53)	
Postoperative complication, n (%)					0.66
	No	27 (54)	18 (58.06)	9 (47.37)	
	Yes	23 (46)	13 (41.94)	10 (52.63)	
Postoperative hospital stay (days), M (Q_1, Q_3)		25.04 (14.64, 30.01)	27.42 (14.89, 34.91)	25.00 (14.61, 26.52)	0.11
Postoperative therapy, n (%)		15 (30)	10 (32.26)	5 (26.32)	0.9

Unpublished data

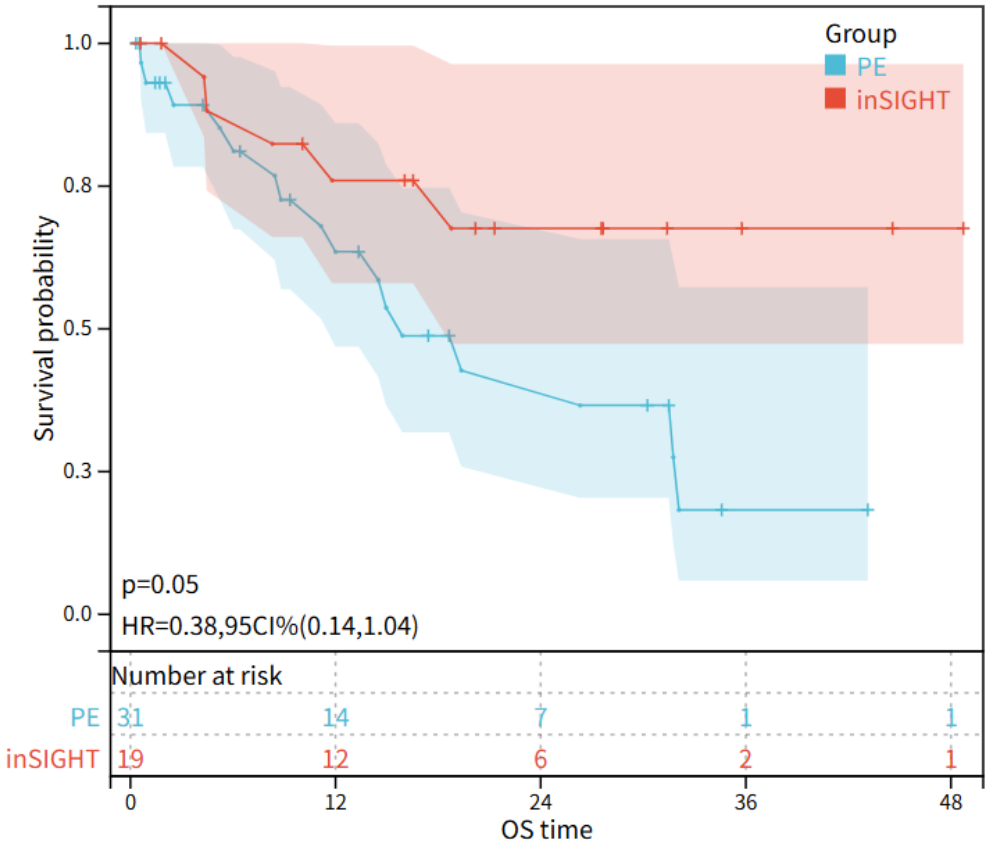
Patient outcomes for PE with/without inSIGHT

Variables		Total (n=50)	PE (n=31)	inSIGHT (n=19)	P value
Age, Mean±SD (years)		54.69±12.85	53.57±12.23	56.53±13.61	0.44
Hight (cm)		166.54±7.68	168.00±6.73	164.16±8.51	0.09
Weight (kg)		61.88±12.97	61.23±12.50	62.95±13.64	0.66
ECOG, M (Q_1, Q_3)		1 (1, 1.50)	1 (1, 1)	1 (1, 1)	0.92
ASA, M (Q_1, Q_3)		2 (2, 3)	2 (2, 2.50)	2 (2, 3)	0.53
Operative duration (minutes), M (Q_1, Q_3)		380 (291.25, 562.50)	375 (285, 510)	450 (335, 649.90)	0.09
Bleeding (ml), M (Q_1, Q_3)		600 (400, 1200)	600 (300, 1000)	800 (500, 1750)	0.4
Blood infusion, M (Q_1, Q_3)		800 (400, 1200)	600 (400, 1000)	1200 (500, 1500)	0.3
Resected organ number, M (Q_1, Q_3)		3 (2, 3)	3 (2, 3)	3 (2, 3)	0.85
PE, n (%)					0.11
	APE	10 (20)	9 (29.03)	1 (5.26)	
	PPE	32 (64)	17 (54.84)	15 (78.95)	
	TPE	8 (16)	5 (16.13)	3 (15.79)	
Surgery, n (%)					0.63
	R0	29 (58)	17 (54.84)	12 (63.16)	
	R1	17 (34)	12 (38.71)	5 (26.32)	
	No	27 (54)	18 (58.06)	9 (47.37)	
	Yes	23 (46)	13 (41.94)	10 (52.63)	
Postoperative hospital stay (days), M (Q_1, Q_3)		25.04 (14.64, 30.01)	27.42 (14.89, 34.91)	25.00 (14.61, 26.52)	0.11
Postoperative therapy, n (%)		15 (30)	10 (32.26)	5 (26.32)	0.9

No significant difference in R0 rate, complications, operation time, bleeding, hospital stay.

Unpublished data

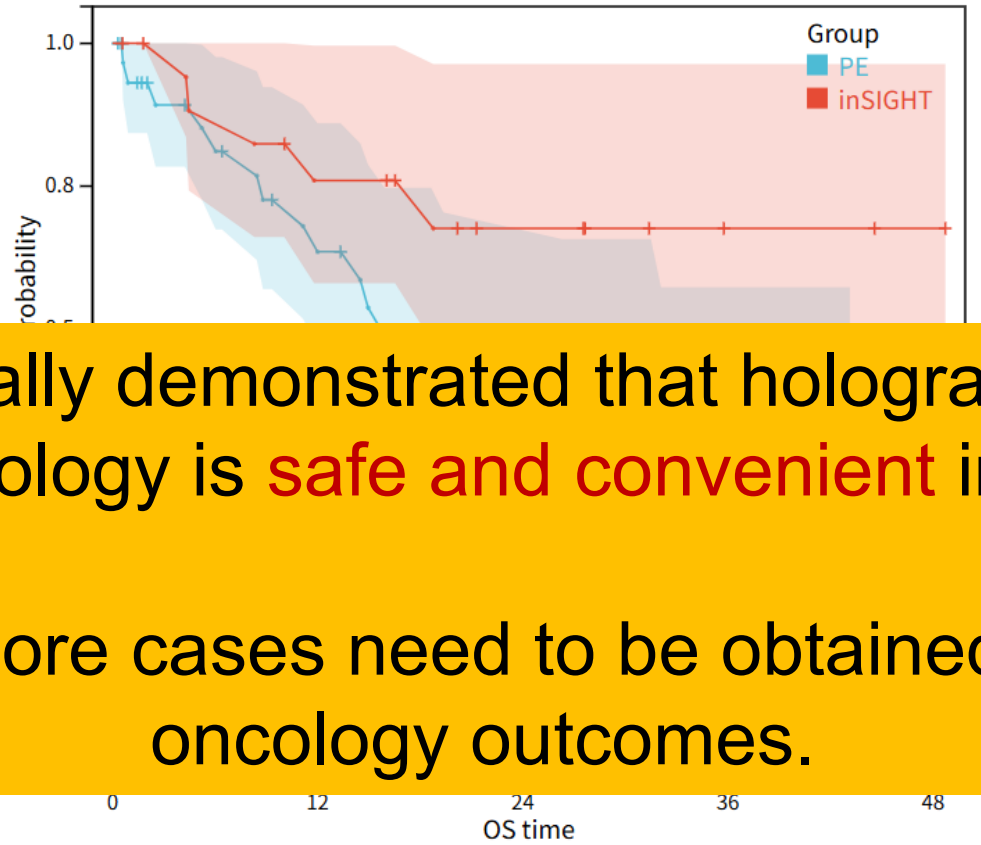
Patient outcomes for PE with/without inSIGHT



No significant difference in OS between the two groups after matching

Unpublished data

Patient outcomes for PE with/without inSIGHT



We have initially demonstrated that holographic imaging technology is safe and convenient in PE.

However, more cases need to be obtained in terms of oncology outcomes.

No significant difference in OS between the two groups after matching

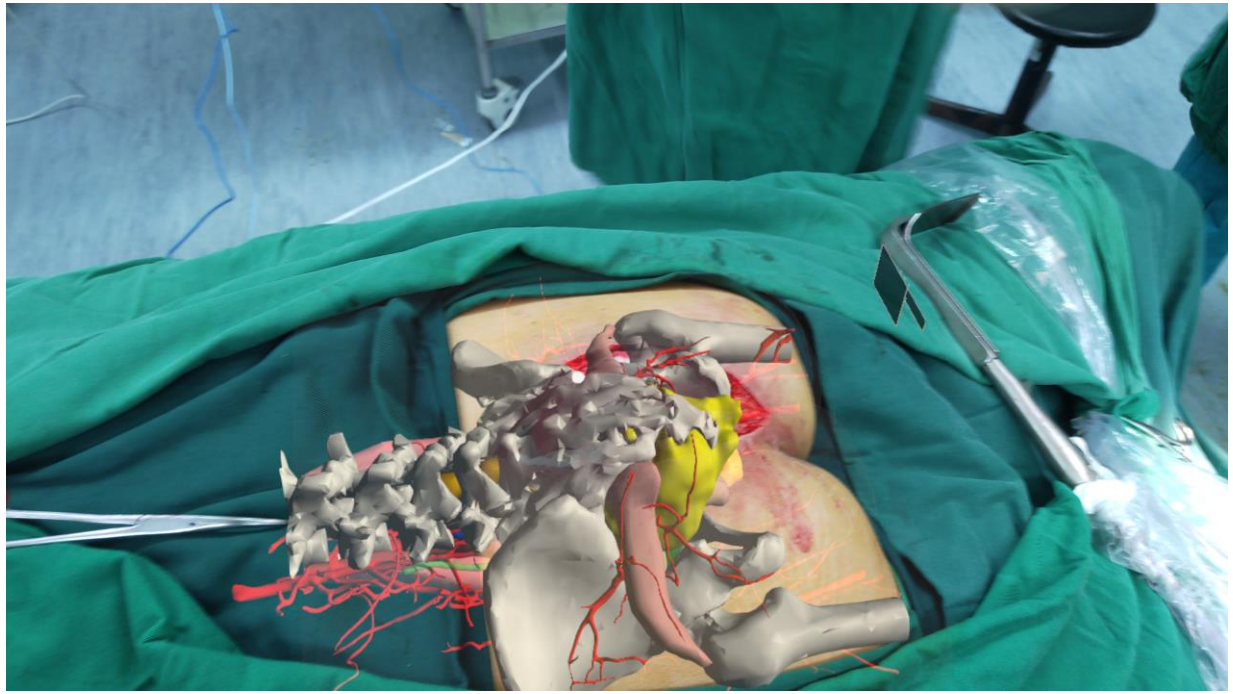
Unpublished data

PART 03

Conclusion and Limitation

Conclusion

- **Preoperative evaluation of PE**, determining the key nourishing vessels of huge tumors.
- **Intropeative navigation of PE,** judging the safe cutting edge of dorsal sacral dissection during combined sacrectomy, effectively avoiding the damage of important vessels and nerves.
- **Postoperative reconstruction of PE**, the selection of skin flaps.



Limitation

- Holo-imaging is generated on CT and MRI technology, and accuracy cannot exceed that
- Holo-imaging is currently unable to improve OS in patients undergoing PE surgery





THANK YOU & MY TEAM