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Intraoperative fluorescence imaging in different surgical fields: Consensus among 140 intercontinental experts

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ABSTRACT

Background: Despite exponentially growing evidence supporting the use of intraoperative fluorescence imaging + indocyanine green dye, considerable variability exists in how and when it is used, and no published consensus guidelines exist. We have conducted Delphi surveys of international experts in the use of intraoperative fluorescence imaging covering 6 distinct surgical scenarios: laparoscopic cholecystectomy; colorectal, lymphedema, gastric cancer, and plastic surgery; and thyroid and parathyroid resections. Although each survey asked experts to vote on field-specific consensus statements, they also had 29 shared statements to permit some analysis spanning the 6 specialties. This article summarizes these results.

Methods: Data on the 29 shared statements from 6 two-round Delphi consensus surveys were compiled to identify areas of overall consensus and compare the different specialties. As with the individual surveys, consensus was defined as ≥70% intervoter agreement.

Results: Among 140 participating experts, overall consensus was achieved on 16 statements, including strong agreement that using indocyanine green is extremely safe, that it can be used even when informed written consent cannot be provided, that it significantly enhances anatomical visualization and impacts how procedures are performed, and that it significantly reduces overall procedural risk. However, indocyanine green dosing and timing are procedure-specific, with considerable variability persisting for some applications, and the overall consensus is that further research is necessary to optimize this facet of intraoperative fluorescence imaging.

Conclusion: Fluorescence imaging is gaining traction across multiple surgical specialties as an invaluable intraoperative tool. Its use in clinical practice and research seems destined to increase.

Introduction

Over a 2-year period, the International Society for Fluorescence-Guided Surgery (ISFGS)[1] has conducted 7 Delphi surveys. The first examined general issues on intraoperative fluorescence imaging (FI) among 19 attendees of the 2019 ISFGS Annual Scientific Meeting in Frankfurt, Germany, and it has already been published.[2] Among its many findings were 100% unanimity that the role of intraoperative FI is destined to increase over the coming decade, both in clinical practice and research; that both using fluorescence and administering indocyanine green (ICG) dye are very safe; that FI decreases overall costs; that it has the potential to dramatically facilitate surgical procedures and enhance patient outcomes; that it is an important tool for assessing tissue perfusion; and that it useful both for training surgical residents and for quality control.[2] Two highly reasonable criticisms of these results must be considered, however. The first is that because all voters were members of the ISFGS advisory board, the potential for bias is

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significant[3]; the second, that general results are less informative and practical than procedure-specific data.

Consequently, the current special issue reports the methodologies and results of the 6 next Delphi studies, which examined intraoperative FI in 6 distinct surgical scenarios: (1) laparoscopic cholecystectomy; (2) anastomosis assessments and sentinel lymph node (SLN) mapping during colorectal surgery; (3) lymphedema surgery; (4) SLN mapping during gastric cancer surgery; (5) tissue perfusion assessments during plastic surgery; and (6) parathyroid gland protection during thyroid and parathyroid resections. The overriding objectives of each survey were to identify the areas of consensus that might lead to the establishment of consensus guidelines and to isolate the areas of nonconsensus as springboards to new research. In addition, as opposed to the general survey, in which all participants were ISFGS advisory board members,[2] the 6 Delphi surveys described in this special issue and summarized in this article were conducted among many FI experts outside of the ISFGS.

Across these 6 surveys, by design, several specific statements and issues were shared to allow for the compilation of results spanning a larger, more specialty-diverse sample, consisting of experts in all 6 surgical procedures of interest, so that these compiled results might too be analyzed. This article summarizes these results. The article's specific objectives are to (1) identify the areas of general consensus that span multiple, if not all 6 surgical scenarios; (2) identify the differences between the different surgical scenarios and specialties (eg, pertaining to the dosing and timing of ICG and how frequently it is used); and (3) identify, among these common issues, the areas of nonconsensus and resultant essential needs for further research.

Methods

Details regarding the collection of data in the 6 individual Delphi studies have already been thoroughly described in the 6 preceding papers and will not be elaborated to any great extent here, other than to say that each survey was performed independent of all others, except that the same 3 principal investigators (F.D., E.L.M., R.J.R.) and the same MD-PhD level expert in Delphi survey design and orchestration (K.P.W.) assisted with every survey, from inception through final data analysis, with the goals of ensuring the inclusion of a subset of shared statements and issues and highly consistent methodology spanning the 6 surveys. Methodology also adhered to published guidelines.[4] All experts were required to meet strict inclusion criteria that included: (1) coauthorship of $\geq$1 published clinical study assessing the use of intraoperative FI *or* (2) $\geq$10 years in surgical practice *and* 5 years using intraoperative FI. They also had to be (3) acknowledged as an international expert by the ISFGS advisory board, (4) fluent in written English, (5) willing to participate, and (6) willing to review, comment on, and approve the manuscript corresponding to the survey they participated in before journal submission. Potential experts were identified not only by word of mouth, but also via a thorough review of all currently published studies on fluorescence-guided surgery in their respective field to identify senior and corresponding authors, and then invited to participate by e-mail. All agreeing to participate then were sent links to online surveys hosted on SurveyMonkey, the online survey platform.

Each survey had 2 rounds and was conducted over 2 to 4 months. Only statements not achieving consensus in the first round were presented again in the second.

Data compilation and analysis

To be included in the current analysis, the wording of statements had to be virtually identical between the different surveys, except for, at most, 2 to 3 words specifically referencing the targeted surgical scenario. Altogether, this resulted in the compilation of results from 29 statements: 19 with which voters were asked to agree or disagree, and 10 for which there were alternative response options, and sometimes several options from which to choose (eg, different doses of ICG). As with the individual surveys, percentage consensus was defined as agreement between responders, rather than as agreement with any given statement, and it was calculated as the number of voters selecting the most commonly selected response divided by the total number of experts voting on that particular statement, with $\geq$70% intervoter agreement considered "consensus." The percentage participation also was calculated for each statement, with $\geq$80% participation considered necessary for voting on any given statement to be considered valid. For quality control, data were analyzed using both SurveyMonkey's intrinsic data-analysis tool and Windows Excel 16.0 (Microsoft Corp, Redmond, WA).

Results

Data on the practice characteristics of the 140 experts spanning 6 surveys are summarized in Table I.

Among the 19 statements with which voting experts were asked to either agree or disagree (Tables II and III), $\geq$70% consensus was reached on 13. These 19 included 6 statements on patient preparation and contraindications to either FI in general or ICG specifically (Table II). Strong consensus (defined as $\geq$90%) was achieved agreeing with 2 of the statements, on allergic reactions to ICG being extremely rare and on the need to ask all patients about potential allergies to iodine, shellfish, or ICG before ICG administration. Moderate consensus (defined as 80%–89.9%) was achieved disagreeing with a patient's inability to provide informed written consent being an absolute contraindication to using ICG. Most agreed with known or suspected allergy to iodine or shellfish being an absolute contraindication to ICG, whereas most disagreed with pregnancy being an absolute contraindication for FI and with the need for patients to be provided with written information about FI before its use, but none of these 3 statements achieved consensus. Interestingly, the percentage of voters considering an allergy to iodine or shellfish an absolute contraindication against ICG ranged from a low of 27% among plastic surgeons to a high of 94.4% among surgeons performing lymphedema surgery (surgery to treat lymphedema). Similarly, the percentage of voters considering written information specific to FI necessary ranged from 9% among colorectal surgeons to 100% among lymphedema surgeons.

Moderate to strong consensus was observed with all 4 statements on ICG administration, pertaining to the importance of its dose, concentration, and time of administration and the need for further research (Table III). With respect to uses of FI, strong consensus was reached regarding its value enhancing anatomical visualization and training surgery residents, with moderate consensus achieved agreeing that it has a significant impact on how procedures are performed and on the need for both surgery and nonsurgery residents to learn about it. The percentage agreeing that FI was necessary for all procedures in their targeted surgical scenario ranged from 5% and 10% among plastic and endocrine surgeons, to 75% among surgeons performing laparoscopic cholecystectomies. By specialty, consensus was therefore reached that it is necessary for all laparoscopic cholecystectomies, but also that it is not always necessary in plastic surgery, gastric cancer surgery, or during thyroid or parathyroid resections.

Regarding the limitations of or obstacles to FI, consensus was reached agreeing with equipment unavailability being a limitation, but there was disagreement with regulatory issues being so. Most disagreed with inadequate empirical evidence being a limitation,

Table I
Practice characteristics of the sample

Practice characteristic	LC N = *28*	Colorectal surgery N = *35*	Lymphedema surgery N = *18*	Gastric cancer N = *27*	Plastic surgery N = *22*	T/PT surgery N = *10*	Totals N = *140*	%
Region of practice								
Asia-Pacific	2	3	3	9	4	1	22	15.7
Europe	12	16	9	9	9	4	59	42.1
Middle East	0	5	0	0	0	0	5	3.6
North America	11	11	2	8	9	3	44	31.4
South and Central America	3	0	4	1	0	2	10	7.1
Nature of practice								
Full or partial university affiliation	27	32	15	22	22	9	127	90.7
Nonacademic	1	3	3	5	0	1	13	9.3
Years performing thyroid/parathyroid surgery								
<10 y	3	10	2	2	9	0	26	18.6
10–20 y	10	13	7	14	9	5	58	41.4
>20 y	14	12	9	11	4	5	55	39.3
Years performing fluorescence-guided surgery								
<5 y	9	14	5	15	4	4	51	36.4
5–10 y	15	3	6	9	9	5	44	31.4
>10 y	4	8	7	3	9	2	33	23.6

LC, laparoscopic cholecystectomy; *T/PT*, thyroid and parathyroid surgery.

Table II
Patient preparation and contraindications to fluorescence imaging

Statement	*LC (%)*	*Colorectal surgery (%)*	*Lymphedema surgery (%)*	*Gastric cancer (%)*	*Plastic surgery (%)*	T/PT surgery (%)	*Overall agreement (%)*	Degree of consensus (%)
Allergic reactions to ICG are extremely rare.	100	100	100	100	95.5	100	99.1	**99.1**
All patients should be asked about possible allergies to iodine, shellfish, or ICG before receiving ICG.	95	95.8	100	94.7	95.5	90	95.6	**95.6**
Known or suspected allergy to iodine or shellfish is an absolute contraindication for ICG.	60.9	42.4	94.4	78.9	27.3	80	59.2	59.2
Inability to provide informed written consent is an absolute contraindication to using ICG.	20	20.8		5	9.1	20	14.6	**85.4**
Pregnancy is an absolute contraindication to FI	25	25		60	27.3	22.2	32.6	67.4
Prior to undergoing FI, patients should be provided with written information specifically addressing its use.	26.1	9.1	100	50	52.4	20	40	60

Bold = consensus.
FI, fluorescent imaging; *ICG*, indocyanine green; *LC*, laparoscopic cholecystectomy; *T/PT*, thyroid and parathyroid surgery.

but agreed with background fluorescence being so, though neither opinion reached consensus across the entire sample. Tremendous variability between the surgeon groups was observed for both statements (Table III).

Among the 10 statements with response options besides agree or disagree, overall consensus was reached on only 3, on FI with ICG decreasing overall procedural risk (84% agreed; Table IV) and on the increasing use of FI in both clinical practice and research over the upcoming decade, on which there was 100% and 99% agreement, respectively. Spanning the 29 statements, therefore, consensus was reached only on 16.

Comparing the specialties (Table V), 4 of the 5 specialties who voted on the issue (the lymphedema survey was the first survey completed, with some statements added to later surveys) reached consensus that ICG should be dosed on a milligram per kilogram basis; however, the dose and timing of ICG administration were highly procedure-specific. All participating specialties agreed that FI decreases overall procedural risk, but no such consistency between specialties was observed regarding its impact on operating time. Three specialties agreed that FI with ICG should be performed routinely (laparoscopic cholecystectomy, colorectal, and lymphedema surgeons), whereas the 3 others said that selective use was preferred. Every participating specialty reached consensus that the use of FI is destined to increase, both in clinical practice and research, over the next decade. Four of six reached consensus that exposure to FI should begin in residency, and 1 during medical school, with no consensus achieved among endocrine surgeons. Consensus was reached among colorectal surgeons that only 1 to 10 cases are necessary to overcome the learning curve, whereas gastric surgeons reached consensus on 11 to 25 cases being necessary. No consensus was reached in the other specialties, though 11 to 25 cases was the most frequently selected response option, albeit chosen by only half of the experts.

Discussion

In this survey of 140 intercontinental experts in intraoperative FI, unanimous consensus was reached for only 1 of the 29 statements presented, spanning patient preparation, contraindications, ICG administration, uses, limitations, impact, training, or future use. That one statement on which there was 100% agreement was that the use of FI was destined to increase over the next decade, with 99% predicting the same increase in research use. Nonetheless, several shared and differing opinions were made clear.

With respect to the former, ICG is virtually universally considered extremely safe to administer and use, not even contraindicated during pregnancy, if deemed necessary. In other words, with no data published documenting any risk to a mother or her unborn child, surgeons appear free to personally weigh the extremely low risk of an adverse reaction against the risks of performing surgery without ICG. Published empirical evidence has supported this option, including data from a prospectively recorded database of 1,414 endometrial cancer patients administered ICG for SLN mapping, among whom, despite 65 patients having

Table III
Performance, uses, and limitations of fluorescence imaging

Statement	*LC (%)*	*Colorectal surgery (%)*	*Lymphedema surgery (%)*	*Gastric cancer (%)*	*Plastic surgery (%)*	*T/PTsurgery (%)*	*Overall agreement (%)*	*Degree of consensus (%)*
Administration of ICG								
For FI with ICG, the timing of ICG administration (how long before the surgery) is very important.	100	78.8	88.2	100	95.5	100	95.6	**95.6**
For FI with ICG, the concentration of ICG administered is very important.	95.7	78.3	72.2	94.7	77.3	0	84	**84**
For FI with ICG, the dose of ICG administered is very important	85	87.5	60	100	81.8	0	81.8	**81.8**
Research is necessary to determine the optimum dose and concentration of ICG and timing of ICG administration.	85	0	0	100	81	0	89.7	**89.7**
Uses of fluorescence imaging								
FI significantly enhances visualization.	100		93.8	89.5	95.5	100	95.4	**95.4**
FI is necessary for all procedures.	75	36.4		23.8	4.8	10	32.4	67.6
FI with ICG significantly impacts the way that the procedure is performed.	90	83.3	94.1	61.1	90.9	100	85.6	**85.6**
FI with ICG is useful for training surgical residents.	100	100	94.1	90	100	100	97.3	**97.3**
Not just surgery residents but residents in other nonsurgical fields should learn about FI.	85	79.2	72.7	89.5	90.5	90	84.8	**84.8**
Limitations of fluorescence imaging								
Equipment unavailability is a major limitation to performing FI with ICG.	90	91.7	75	83.3	90.9	80	86.4	**86.4**
Inadequate empirical evidence supporting efficacy is a major limitation to performing FI with ICG.	20	18.2	75	85.7	19	22.2	32.7	67.3
Background fluorescence is a significant disadvantage of using FI with ICG.	80	29.2		68.4	76.2	90	64.9	64.9
Regulatory issues are a major limitation to performing FI with ICG.	26.1	33.3		26.3	18.2	10	25.2	**74.8**

Bold = consensus.
FI, fluorescent imaging; *ICG*, indocyanine green; *LC*, laparoscopic cholecystectomy; *T/PT*, thyroid and parathyroid surgery.

Table IV
Statements with response options other than agree/disagree

Statement	Most common Response	% Agreement
The dose of ICG to administer for FI should be determined on a mg per kg basis or as an absolute dose	mg per kg	68.6
The optimum timing of ICG administration before an LC is…	<1 min	54.4
The optimum dose of ICG to administer is…	2.5-5 mg	54
Relative to white light alone, FI with ICG increases, decreases, or has no impact on the overall risk of the procedure of interest	Decreases	**83.7**
Relative to white light alone, FI with ICG increases, decreases, or has no impact on the overall time required to perform LC	No impact	54.8
For the procedure of interest, FI with ICG should be used routinely or selectively*	Selectively	50.4
Exposure of physician trainees to fluorescent imaging should begin during medical school or residency training	Residency	57.3
The number of cases of FI with ICG that needs to be completed to overcome the learning curve is approximately	11–25 cases	50.5

Bold = consensus.
FI, fluorescent imaging; *ICG*, indocyanine green; *LC*, laparoscopic cholecystectomy.
* Average of 4 different procedures for colorectal surgery (left-sided and right-sided anastomosis, proctosigmoidoscopy, rectal stump).

Table V
Comparing specialties on technical specifics, current use, training, and future use of fluorescence imaging

Statement	LC	Colorectal surgery	Lymphedema surgery	Gastric cancer	Plastic surgery	T/PT surgery
ICG administration						
How dose of ICG is determined	mg/kg	mg/kg		(Absolute dose)*	mg/kg	mg/kg
Optimum timing for ICG before fluorescence imaging	>30 min	30–60 s	<60 s	(11–30 min)*	20–60 s	<60 s
Optimum dose of ICG	2.5–5 mg	(5–10 mg)*	1–2 mg	5–25 mg	2.5–5 mg	<5 mg
Impact and use						
Impact on overall risk	Decrease	Decrease	Decrease		Decrease	Decrease
Impact on surgical time	Decrease	No impact		No impact	(Decrease)*	No impact
Routine or selective use.	Routine	R/S†	(Routine)*	Selective	Selective	Selective
Training and learning						
When trainee exposure to FI should begin	Medical school	Residency	Residency	Residency	Residency	(Residency)*
Number of cases to overcome the learning curve	(11–25)*	1–10	(11–25)*	11–25	(11–25)*	(20–30)*

FI, fluorescent imaging; *ICG*, indocyanine green; *LC*, laparoscopic cholecystectomy; *T/PT*, thyroid and parathyroid.
* Parentheses indicate failure to achieve consensus.
† Routine use to assess perfusion for left-sided anastomosis; selective use for postanastomosis proctosigmoidoscopy; no consensus reached on extent of use (routine versus selective) for right-sided anastomoses or rectal stump perfusion.

documented iodine or contrast allergy, only 3 experienced any allergic reaction after ICG administration, none of them anaphylactic, and none attributed to ICG; this said, 63 of these 65 patients received a single dose of corticosteroid, with/without diphenhydramine, before ICG administration.[5] In another published series of 1,923 ICG video-angiography procedures performed by ophthalmologists, only 1 instance of anaphylaxis occurred (incidence 0.05%), and this was treated easily.[6] Despite this apparent very low risk, almost every one of our 140 experts considered it essential that patients be asked about known or suspected allergies.

With respect to ICG dosing and time of administration, there was strong and consistent consensus across all 6 specialties that the timing of ICG administration is very important. Opinions were less consistent for ICG dose and concentration, with no endocrine surgeon considering either important. In addition, the opinions among lymphedema surgeons were mixed: although weak (72%) consensus was reached for concentration, only 60% agreed about the dose. This contrasts starkly against the opinions of surgeons performing laparoscopic cholecystectomy and gastric cancer SLN mapping, with 100%, 96%, and 85% consensus reached among the former for the importance of ICG timing, concentration, and dose, respectively, and corresponding percentages of 100%, 95%, and 100% among the latter. Why this is so likely relates to the clearly distinct ways in which ICG is administered—by peripheral vein for cholecystectomy followed by a wait of ≥30 minutes,[7] and submucosally around the tumor for SLN mapping during gastric cancer surgery, followed by a wait of >10 minutes for gastric surgery[8]—as opposed to the direct injection of ICG into local vessels and waiting mere seconds during assessments of tissue perfusion and vascular, including lymphatic, flow.[9,10] Interestingly, cholecystectomy and gastric cancer experts also agreed strongly (with 85% and 100% consensus, respectively) that further research on ICG dose, concentration, and/or timing is necessary to optimize its use, whereas this opinion was expressed by no colorectal, lymphedema, or thyroid/parathyroid surgeons—again consistent with the differences in where and how long before visualization that ICG is introduced.

More than 95% of the experts agreed that FI enhances visualization, whereas roughly 86% agreed that FI with ICG significantly impacts the way in which procedures are performed, and all 5 specialties asked to vote on this agreed that FI with ICG decreases overall procedural risks. However, there was considerable variability in how often FI was deemed necessary, with only laparoscopic cholecystectomy experts reaching consensus that it was necessary for all cholecystectomy procedures, whereas only between 5% and 36% of the experts said so among the other specialties. Surgeons performing laparoscopic cholecystectomies, along with colorectal and lymphedema surgeons, also said that FI should be routinely performed (among colorectal surgeons, consensus was reached only for its routine use with left-sided anastomoses), whereas selective use was the choice of surgeons performing gastric cancer SLN mapping, plastic surgery, postanastomosis proctosigmoidoscopy, or thyroid and parathyroid resections. The confidence of cholecystectomy surgeons in FI seems well founded, supported by both a large ($N = 639$) international randomized clinical trial (RCT)[11] and a meta-analysis of 16 studies (5 using near-infrared fluorescence cholangiography with ICG and 11 not ($n = 5{,}070$).[12] In the RCT, which compared 321 patients who underwent laparoscopic cholecystectomy with near-infrared fluorescence cholangiography against 318 in whom it was not used, the visualization of biliary structures deemed essential to performing the procedure and preventing complications was 2.3- to 3.6-fold as high in the former group; anatomical visualization also was much less affected by obesity and surgical field inflammation.[11] In the meta-analysis, the rate of bile duct injuries and conversions to open surgery were only 1/4 and 1/17 as high among patients whose surgery was conducted with near-infrared fluorescence cholangiography versus those in whom it was not, with differences noted both with laparoscopic and robotic surgery.[12]

To date, the only other published RCT examining complication rates in patients undergoing surgery with versus without FI is one that examined hypercalcemia rates in patients undergoing thyroidectomies, and, in this RCT, only parathyroid autofluorescence (ie, without ICG) was examined.[12] Recently, 4 large comparative studies have been published examining the use of ICG fluorescence for SLN detection in gastric cancer patients, 3 retrospective[13–15] and 1 RCT.[16] In each, the number of SLNs identified per patient was statistically greater among patients with injected versus no injected ICG; however, the sensitivity detecting cancer-positive nodes ranged widely with ICG, from 52.6%[13] to 100%.[15] Moreover, none of these studies assessed patient survival. This said, numerous meta-analyses have been published supporting the use of FI in gastric surgery,[17–19] as well as in colorectal surgery for assessing anastomoses,[20–23] plastic surgery for assessing perfusion in various tissue flaps,[9,24–29] and thyroid resections.[30]

A final issue of particular importance is that 86% of the experts said that equipment unavailability is an obstacle to performing intraoperative fluorescence imaging—the only obstacle they agreed upon, which is at considerable odds with the virtually unanimous consensus that FI is destined to increase, both in clinical practice and research, over the coming decade. Interestingly, despite obvious reservations in some specialties regarding the routine use of this technology, fewer than one-third of our experts considered inadequate empirical evidence a significant barrier, supporting their prediction that this technology's use will increase.

As indicated at the end of every article in this special issue, each individual study and the current analysis of compiled data has limitations, which also have been discussed extensively in the Introduction to this issue. Foremost among them is that every Delphi study, by its very nature, reports on opinions, not empirical evidence. If an expert panel is selected carefully and appropriately, the opinions reported are based primarily on extensive knowledge of the empirical evidence, as well as on considerable experience in the field for which opinions are being sought. But they are opinions, nonetheless.

This sometimes raises concerns about the potential for professional bias because those who are considered experts due to considerable experience using a particular diagnostic or therapeutic approach must believe in its value or they would not use it. The potential for such bias must be considered when examining the opinions of any expert panel, which is why such opinions must never replace readers' reliance on well-designed, well-orchestrated clinical trials to ultimately decide whether a given therapeutic or diagnostic approach is effective and/or safe. That said, selecting nonusers of an approach for an expert panel creates the potential for similar but directionally opposite bias, which may be based largely on voters being less informed.

Delphi studies also have uses and advantages that even well-designed RCTs and meta-analyses lack, including the capacity to evaluate different technical aspects of procedures, such as different ICG doses and administration times or different imaging equipment and how it is used, including different camera angles and distances. Expert panels also can identify the potential advantages and, perhaps even more importantly, limitations of given approaches and areas that require further improvement and research, which is exactly what occurred in all 6 Delphi surveys reported in this special issue. For example, although colorectal surgeons appreciated the value of FI for anastomosis perfusion, they were unconvinced about its value with SLN detection—both conclusions

backed by several recently published meta-analyses.[20–23,31–34] Similarly, the gastric cancer surgery panel of experts reached consensus that FI with ICG facilitates SLN detection (also supported by the literature, including 1 randomized clinical trial[16]), but also that its use remains experimental to date because the impact of such SLN detection on surgical planning and outcomes remains uncertain. Such results suggested that these experts were not globally biased to favor the use of fluorescence imaging.

What is, therefore, clear from our data and from the results of the countless studies and meta-analyses that have been published is both that FI has numerous diverse applications spanning multiple surgical fields, and that considerable research remains to be done to both verify and optimize the effectiveness of this novel intraoperative tool.

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