Advanced optical imaging for surgical vision

Sylvain Gioux

Follow this and additional works at: https://dc.engconfintl.org/optics_2023
Advanced Optical Imaging for Surgical Vision

Sylvain Gioux

Engineering Conference International
Advances in Optics for Biotechnology, Medicine and Surgery
Tomar, Portugal, October 15-19, 2023
Disclosure

I am a full-time employee of Intuitive Surgical
Robotic-Assisted Surgery (RAS)

Number of da Vinci Procedures

Still, much improvement needed:
- Morbidity / complications
- Surgical margins
- Reoperation rate

Source: Intuitive data
An enabling platform...

- Think of the robotic-assisted platform as
  - collecting information from many sources
  - digitizing information
  - turning information into something actionable

- Think of the surgeon as
  - visualizing and interpreting information
  - making decision for best patient outcome
  - using the platform to put it into action

Modified from Weissleder et al, Nature 452, 2008
Augment surgeon capabilities to go beyond what is innately human

Precision

Guidance

Safety

Learning

Organizational Insight

© 2023 Intuitive Surgical Operations, Inc. All rights reserved
Intelligent instruments
Da Vinci SP surgical system:

enabling a shift to less invasive approaches

40+ da Vinci SP systems installed globally

3100+ clinical cases completed across 5 specialties

50+ peer-reviewed publications

Source: Intuitive data

The Da Vinci SP surgical system is not CE Marked and cannot be placed on the market nor put into service.
Smart systems & instruments augment surgeon capabilities to go beyond what is innately human
Enhancing Surgeon’s perception
Imaging agents, such as indocyanine green (ICG), should be administered per the manufacturer's instructions for use. Surgery should only be performed when the vision system provides sufficient visualization to safely perform surgical tasks.

Spignolio et al, Surgical Endoscopy, 2013
New endoscope design on da Vinci since 2020

da Vinci X/Xi Endoscope
Imaging agents, such as indocyanine green (ICG), should be administered per the manufacturer’s instructions for use. Surgery should only be performed when the vision system provides sufficient visualization to safely perform surgical tasks.
What else?
New imaging methods to identify sensitive structures - IS001

**WHITE LIGHT**

**FIREFLY**

**SENSITIVE FIREFLY**

~ 1 mm depth

~ 2-3 mm depth

The technology presented is not CE Marked and cannot be placed on the market nor put into service.

Credit: Rick Farnam, Las Palmas Medical Center
Focusing on better oncologic outcomes - IS002

PSMA binding agent – primary tumor identification

WHITE LIGHT IMAGING

NEAR-INFRARED FLUORESCENT IMAGING

The technology presented is not CE Marked and cannot be placed on the market nor put into service.

Credit: Peter Carroll & Hao Nguyen, UCSF – presented at SPIE Photonics West
Focusing on better oncologic outcomes - IS002

PSMA binding agent – residual disease identification

WHITE LIGHT IMAGING

NEAR-INFRARED FLUORESCENT IMAGING

The technology presented is not CE Marked and cannot be placed on the market nor put into service.

Credit: Peter Carroll & Hao Nguyen, UCSF – presented at SPIE Photonics West
And reducing morbidities - nerve imaging

90 MINUTES POST-INJECTION

The technology presented is not CE Marked and cannot be placed on the market nor put into service.

Credit: Summer Gibbs, OHSU
And reducing morbidities - nerve imaging

WHITE LIGHT IMAGING

NEAR-INFRARED FLUORESCENT IMAGING

The technology presented is not CE Marked and cannot be placed on the market nor put into service.

Credit: Summer Gibbs, OHSU
And reducing morbidities - nerve imaging

WHITE LIGHT IMAGING

NEAR-INFRARED FLUORESCENT IMAGING

The technology presented is not CE Marked and cannot be placed on the market nor put into service.

Credit: Summer Gibbs, OHSU
Advanced fluorescence imaging - FLIM

The technology presented is not CE Marked and cannot be placed on the market nor put into service.

D. Gorpas et al. Scientific Reports, 2019

Credit: Laura Marcu, UC Davis
Advanced fluorescence imaging - FLIM

*In vivo* pre-resection  

*Ex vivo* tissue specimen

The technology presented is not CE Marked and cannot be placed on the market nor put into service.

Credit: Laura Marcu, UC Davis
Directly looking at optical properties

Absorption  Scattering

Quantitative Endogenous Imaging

Hemoglobin ⇔ Oxygen saturation
Lipids ⇔ Metabolism
Water ⇔ Hydration
Scattering ⇔ Subcellular content
Imaging optical properties in real-time

Aguénounon et al, Biomed Opt Exp, 11(10), 2020
Aguénounon et al, Biomed Opt Exp, 11(10), 2020

18ms processing time for 1Mp images (including 3D profile correction)
Trident imaging platform

Two imaging modes:
- Color + Fluorescence (800nm)
- Color + Oxygenation

Ségaud et al, Front. Photonics, 3:1032776, 2022
Trident imaging platform

Ségaud et al, Front. Photonics, 3:1032776, 2022
Trident: fluorescence imaging

Ségaud et al, Front. Photonics, 3:1032776, 2022
Trident: endogenous imaging

Ségaud et al, Front. Photonics, 3:1032776, 2022
The technology presented is not CE Marked and cannot be placed on the market nor put into service.

This work is being funded by the European Research Council under grant agreement 715737 (QuantSURG) © 2023 Intuitive Surgical Operations, Inc. All rights reserved
Product Information
The Intuitive Surgical Endoscopic Instrument Control Systems (da Vinci X and da Vinci Xi Surgical Systems) are intended to assist in the accurate control of Intuitive Surgical Endoscopic Instruments during urologic surgical procedures, general laparoscopic surgical procedures, gynecologic laparoscopic surgical procedures, general thoracoscopic surgical procedures, and trans-oral otolaryngology surgical procedures restricted to benign tumors and malignant tumors classified as T1 and T2, and for benign base of tongue resection procedures. The systems are indicated for adult and pediatric use (except for trans-oral otolaryngology surgical procedures). They are intended to be used by trained physicians in an operating room environment.

The da Vinci X and da Vinci Xi Surgical Systems are class IIb medical devices CE marked (CE 2460) under the European Medical Devices Directive (93/42/EEC), manufactured by Intuitive Surgical, Inc. Refer to Instructions For Use before use.

The da Vinci Firefly Imaging System is intended to provide real-time endoscopic visible and near-infrared fluorescence imaging. The da Vinci Firefly Imaging System enables surgeons to perform minimally invasive surgery using standard endoscopic visible light as well as visual assessment of vessels, blood flow and related tissue perfusion, and at least one of the major extra-hepatic bile ducts (cystic duct, common bile duct or common hepatic duct), using near infrared imaging.

Imaging agents, such as indocyanine green (ICG), should be administered per the manufacturer's instructions for use. Surgery should only be performed when the vision system provides sufficient visualization to safely perform surgical tasks.

Da Vinci SP Surgical System is not CE Marked and cannot be placed on the market nor put into service.

The endoscope is intended to provide real-time, 3D, high-definition imaging enabling surgeons to perform minimally invasive surgery. The endoscope supports two modes: standard visible light imaging mode and a near-infrared fluorescence imaging mode consisting of a black and white surgical image with the near-infrared fluorescence depicted in a color overlay.

The endoscope is a class Ila medical device CE marked (CE 2460) under the European Medical Devices Directive (93/42/EEC), manufactured by Intuitive Surgical, Inc. Refer to Instructions For Use before use.

EndoWrist Instruments, including blunt and sharp endoscopic dissectors, scissors, scalpels, forceps / pick-ups, needle holders, endoscopic retractors, electrocautery and accessories are intended for endoscopic manipulation of tissue, including grasping, cutting, blunt and sharp dissection, approximation, ligation, electrocautery, suturing, and delivery and placement of microwave and cryogenic ablation probes and accessories.

EndoWrist Instruments are class Ila and class Ilib medical device CE marked (CE 2460) under the European Medical Devices Directive (93/42/EEC) manufactured by Intuitive Surgical, Inc. Refer to Instructions For Use before use.

The Vessel Sealer Extend is a bipolar electrosurgical sealing and cutting instrument for use with the da Vinci Xi and da Vinci X Surgical Systems and the compatible electrosurgical generator. It is intended for grasping and blunt dissection of tissue and for bipolar coagulation and mechanical transection of vessels up to 7 mm in diameter and tissue bundles that fit in the jaws of the instrument. The Vessel Sealer Extend has not been shown to be effective for tubal sterilization or tubal coagulation for sterilization procedures, and should not be used for these procedures.

The Vessel Sealer Extend is a class Iib medical device CE marked (CE 2460) under the European Medical Devices Directive (93/42/EEC), manufactured by Intuitive Surgical, Inc. Refer to Instructions For Use before use.

Legal Notices
Some products, features or technologies may not be available in all countries. Please contact your local Intuitive representative for product availability in your region.

Refer to the product specific User Manual for indications, contraindications, warnings and other product information.

Individuals’ outcomes may depend on a number of factors, including but not limited to patient characteristics, disease characteristics and/or surgeon experience.

The information contained in this presentation has been checked and compiled with the greatest care. However, no responsibility is taken for its correctness, completeness and topicality. It is the sole responsibility of the recipient to check all information before using it in the individual case.

In order to provide benefit and risk information, Intuitive reviews the highest available level of evidence on representative procedures. Intuitive strives to provide a complete, fair and balanced view of the clinical literature. However, our materials should not be seen as a substitute for a comprehensive scientific review. We encourage patients and physicians to review the original publications and all available literature in order to make an informed decision.

Privacy Notice
Intuitive’s Privacy Notice is available at www.intuitive.com/privacy.

© 2023 Intuitive Surgical Operations, Inc. All rights reserved. Product and brand names/logos are trademarks or registered trademarks of Intuitive Surgical or their respective owner.