

Makoto® Intravascular Imaging System
User's Guide



makoto®
INTRAVASCULAR IMAGING SYSTEM

User's Guide

Use with **REF** TVC-MC10

Makoto® Intravascular Imaging System User's Guide



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1 Introduction to the Makoto® Intravascular Imaging System

1.1 Indications for Use

The Makoto® Intravascular Imaging System is intended for the near-infrared examination of coronary arteries in patients undergoing invasive coronary angiography.

- a) The System is intended for the detection of lipid-core-containing plaques of interest.
- b) The System is intended for the assessment of coronary artery lipid core burden.
- c) The System is intended for the identification of patients and plaques at increased risk of major adverse cardiac events.

The System is intended for ultrasound examination of coronary intravascular pathology.

- a) Intravascular ultrasound imaging is indicated in patients who are candidates for transluminal coronary interventional procedures.

1.2 Additional Indications for Use – USA Only

The Makoto® Intravascular Imaging System is intended for ultrasound examination of peripheral intravascular pathology.

- a) Intravascular ultrasound imaging is indicated in patients who are candidates for transluminal peripheral interventional procedures. The System is not indicated for use in the cerebral vessels.



WARNING

The effectiveness of NIRS in the peripheral vasculature has not been established.

1.3 Clinical Benefit

The clinical benefit provided by the Makoto® Intravascular Imaging System is in the identification of the lipid core plaques (LCPs). By identifying LCP, the Makoto® Intravascular Imaging System provides information that is not as easily available from other technologies. The potential benefits of NIRS-IVUS-guided management are: 1) determination of the length of artery to stent, 2) selection of intensity of medical management, 3) identification and mitigation of the risk of embolic peri-stenting infarction, and 4) identification of patients and plaques at increased risk of future major adverse cardiac events (MACE).

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1.4 Training

The Makoto® Intravascular Imaging System is to be used exclusively by trained physicians and catheterization laboratory personnel.

Onsite training by Infraredx® personnel or certified trainers on the use of the Makoto® Intravascular Imaging System is available at the time of installation and available upon request. Please contact Infraredx® Customer Service or your local service provider to schedule onsite training and periodic training competency reviews.

1.5 Infraredx Contact Information

Infraredx® can be contacted at:

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28 Crosby Drive, Suite 100
Bedford, MA 01730
USA

www.infraredx.com

Phone (International): +1-800-596-3104

The Instructions for Use can be accessed in electronic form at the above website.

1.6 Patents

The Makoto® Intravascular Imaging System, catheters, and associated accessories are protected by one or more patents. For a complete listing of issued patents please consult:

<http://www.infraredx.com/infraredx-intellectual-property/>

1.7 Registered Trademarks

Infraredx®, Makoto®, Dualpro®, DualproPlus®, Infraredx Clarispro®, HD IVUS®, TVC®, and Extended Bandwidth® are registered trademarks of Infraredx, Inc. The name “Infraredx Dualpro” is a registered trademark in China. The name “Infraredx” is a registered trademark of Infraredx, Inc. in the USA, European Union, Australia, China, South Korea and Japan.

1.8 Trademarks

SmartImaging™ and DualproNIRS™ are trademarks of Infraredx, Inc.

All other brand names and product names used and referenced in this document are trademarks, registered trademarks, or trade names of their respective holders.



2 How to Interpret this Manual

This manual contains important information for operating the Makoto® Intravascular Imaging System. Carefully read and review the manual before attempting to operate the product.

2.1 Symbols and Icons

Throughout this manual there may be alerts. These alerts are indicated as Warnings, Cautions, and Notes.



WARNING

Hazardous situations, including injury to the patient or operator, may occur if display warnings are ignored.



CAUTION

Failure to heed written cautions can result in damage to the Makoto® Intravascular Imaging System or may result in degradation of system performance.

NOTE:

Notes provide helpful reminders and tips for using advanced features.

2.2 Abbreviations

AC	Alternating Current
ANSI	American National Standards Institute
AS	Area Stenosis
AVI	Audio Video Interleave
CABG	Coronary Artery Bypass Graft
CUI	Console User Interface
CPU	Central Processing Unit
DICOM	Digital Imaging and Communications in Medicine standard

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DVD	Digital Video Disc
EEM	External Elastic Membrane
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EO	Ethylene Oxide
EtO	Ethylene Oxide
FDA	Food and Drug Administration
FHD	Full High Definition display, 1920x1080 pixels
HD	High Definition display
IEC	International Electrotechnical Commission
IP	Internet Protocol
ISO	International Organization for Standardization
IVUS	Intravascular Ultrasound
JPEG	Joint Photographic Experts Group
LCBI	Lipid Core Burden Index
LCP	Lipid Core Containing Plaque of Interest
mxLCBI	max LCBI of a specified window width
NIR	Near-infrared
NIRS	Near-infrared Spectroscopy
PA	Plaque Area
PB	Plaque Burden
PACS	Picture Archiving and Communication System
PTCA	Percutaneous transluminal coronary angioplasty
PTA	Percutaneous transluminal angioplasty
RF	Radio Frequency

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RFID	Radio Frequency Identification
UL	Underwriters Laboratories
USB	Universal Serial Bus

2.3 Actions

The Makoto® Intravascular Imaging System is primarily designed for touch screen interaction. In addition to the touch screen monitor, the system is equipped with a mouse. Remembering the following actions and gestures will assist you when interacting with the Makoto® Intravascular Imaging System:

Touch	A momentary contact with the touch screen or depress and release of a physical button
Press	Depress and release of a physical button
Right click	A single right button click using the mouse
Left click or Click	A single left button click using the mouse
Double-click	Two left button clicks in rapid succession using the mouse
Scroll Up/Down	A roll of the scroll wheel on the mouse toward the user for down, away from the user for up
Drag	While the finger is in contact with a movable icon, move finger to another location. Lift finger off of the screen to release the icon.

3 Warnings, Safety, and Precautions

3.1 Contraindications

Use of the Makoto® Intravascular Imaging System catheter is contraindicated where introduction of any catheter would constitute a threat to patient safety. Contraindications include:

- Bacteremia or sepsis
- Major coagulation system abnormalities
- Severe hemodynamic instability or shock
- Patients diagnosed with coronary artery spasm
- Patients disqualified for CABG surgery
- Total occlusion
- Patients disqualified for PTCA
- Patients disqualified for PTA
- Patients who are not suitable for IVUS procedures

3.2 Complications

The following complications may occur as a consequence of intravascular examination:

- Allergic reaction
- Angina
- Cardiac arrest
- Cardiac arrhythmias including, but not limited to ventricular tachycardia, atrial/ventricular fibrillation and complete heart block.
- Cardiac tamponade/Pericardial effusion
- Death
- Device entrapment requiring surgical intervention
- Embolism (air, foreign body, tissue, or thrombus)
- Hemorrhage/hematoma
- Hypotension
- Infection
- Myocardial infarction
- Myocardial ischemia
- Stroke and transient ischemic attack
- Thrombosis
- Vessel occlusion and abrupt closure
- Vessel trauma including, but not limited to dissection and perforation

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3.3 Safety

The Makoto® Intravascular Imaging System, or Makoto®, has been designed for the safest possible operation and maintenance. However, any medical instrument can cause injury if it is improperly installed, operated, moved, or serviced and this system is no exception.

The potential hazards are:

- ocular (vision) damage resulting from exposure to direct or reflected laser radiation
- electrical shock from contact with electrical components inside the system
- physical injury incurred while operating or moving the system

Serious incidents involving the Makoto® Intravascular Imaging System should immediately be reported to Infraredx and the Competent Authority of the Member State in which the user and/or patient is established. Infraredx or your local service provider contact information may be found in Sections 1.5 Infraredx Contact Information or 14.1 About.

NOTE: Information related to the safety and clinical performance (SSCP) of the Makoto® Intravascular Imaging System is available at <https://infraredx.com/SSCP>.

After the launch of the European Database on Medical Devices (EUDAMED), refer to <https://ec.europa.eu/tools/eudamed> for a SSCP for this medical device, where it is linked to the Basic UDI-DI for the Makoto® Intravascular Imaging System:
0857595006SNUEQ

The Makoto® is equipped with features designed specifically to provide safe operation to users. All catheter laboratory personnel should become familiar with the location and operation of the safety features discussed below. During imaging, moving components are completely contained so that the user is not exposed to mechanical hazards.

Anyone using the Makoto® for human procedures of any kind should thoroughly understand the implications of such use. The AIUM (American Institute of Ultrasound in Medicine) has published a document titled Medical Ultrasound Safety (AIUM 2009). ALARA is an acronym for the principle of prudent use of diagnostic ultrasound by obtaining the diagnostic information at a power output that is As Low As Reasonably Achievable. To obtain a copy of this document, please contact the AIUM.









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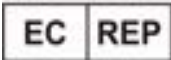
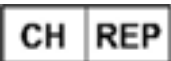




WARNING

Adherence to the precautions discussed in this section must be observed when installing, operating, moving, or servicing the system to avoid potentially hazardous situations.










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<i>SYMBOL</i>	<i>EXPLANATION</i>
	Warning
	Caution
	Refer to instruction manual
	Consult instructions for use
	Product meets applicable U.S., European, and Canadian Standards as evaluated by TUV Rheinland.
<p>100-120 V~ 50/60 Hz 5A 220-240 V~ 50/60 Hz 3A</p>	<p>Product operates from a power source that supplies nominally 100VAC, 120VAC, 220VAC, or 240VAC, 50/60 Hertz</p> <p>Maximum current is 5 Amperes at 100-120 VAC, 3 Amperes at 220-240 VAC.</p>
	Manufacturer
	Date of Manufacture
	Catalog number


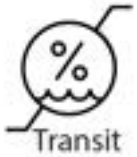





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	Serial number
	Batch Code
	Medical Device
	Use-by date
	Mass
	Authorized representative in the European Community
	Authorized representative in Switzerland
	Importer
	Protective earth (ground)
	Defibrillation-proof direct cardiac application (type CF applied part)
	Quantity contained in package.



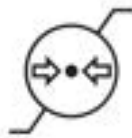
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	Packaging Unit
	Compatible guide catheter inner diameter
	Compatible guidewire outer diameter
	Laser Beam
	Keep away from sunlight
	Non-pyrogenic
	Keep dry
	Temperature limit
	Temperature limit during transportation

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	Humidity Limitation
	Humidity limit during transportation
R_x Only	This device for sale by or for use on the order of a physician
	Do not use if package is damaged
	Do not re-use
	Do not resterilize
	Sterilized using ethylene oxide.
	Not evaluated for safety when used with MRI
CE	CE Mark, indicates product complies with European Union law; number denotes specific notified body performing conformity assessment.

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	INMETRO symbol, indicates product has met the safety requirements to enter the Brazilian market; OCP number denotes the product certification body.
	Compatible with
	Atmospheric pressure limitation

There are no user serviceable parts in the Makoto® Console or Makoto® Controller. All adjustments are made at the factory before shipment to customers or on site by trained Infraredx personnel or service provider.



Tampering with or any attempt to modify the Makoto® Intravascular Imaging System will void the product warranty and may also result in improper operation of the system.
Device degradation or product failure may result.

3.4 Optical Precautions



Product contains a Class 1M laser product that emits invisible laser radiation. Do not view directly with optical instruments.



Never look directly into the laser beam coming from the system or reflected from a surface.

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WARNING

Do not look into the laser beam through lenses, binoculars, magnifiers, camera viewfinders, telescopes, or any optical element or instrument that may focus the light into the eye.



WARNING

Never permit reflective objects such as jewelry, watches, metal instruments, or mirrors to intercept and reflect the laser beam.

The Makoto® Intravascular Imaging System contains a laser system and is classified as a "Class-1M Laser Product" under a U.S. Department of Health and Human Services (DHHS) Radiation Performance standard according to the Radiation Control for Health and Safety Act of 1968 and per IEC 60825-1, Safety of Laser products.

Light energy emitted by this system lies in the invisible, near-infrared region of the electromagnetic spectrum at wavelengths between 1 and 2 microns. This fact should be remembered when taking precautions to avoid inadvertent exposure.

NOTE: Laser safety eyewear is NOT required during use of the Makoto® Intravascular Imaging System.

3.5 Electrical Precautions



WARNING

Failure to follow the information in this section may cause equipment damage, bodily injury, even death.

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WARNING

Use of this equipment adjacent to or stacked with other equipment should be avoided because it could result in improper operation. If such use is necessary, this equipment and the other equipment should be observed to verify that they are operating normally.



CAUTION

Medical electrical equipment needs special precautions regarding EMC and needs to be installed according to the EMC information provided in Appendix H: Electromagnetic Compliance.



CAUTION

DO NOT position the Makoto® Intravascular Imaging System close to other equipment as electrical interference may result.



CAUTION

A Live IVUS or pullback scan may be interrupted if the system is exposed to an Electrostatic Discharge (ESD). If a Live IVUS or pullback scan is interrupted, the scan may be restarted immediately.

The Makoto® Intravascular Imaging System uses AC line voltage inside the console. Disconnecting the Makoto® power cord plug from the outlet will interrupt power to the system causing an abrupt stop to all operations.

No part of the exterior housing should be displaced except by a trained and authorized technician.

To reduce the risk of electric shock, do not connect the system's input power connection to equipment that is not protectively earth grounded. Do not connect the system to Class II equipment.

Radio frequency (RF) communications equipment can affect the performance of the Makoto® Intravascular Imaging System. This type of equipment should be located as far

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from the Makoto® as possible. Either radiated or conducted RF emissions may cause image distortion or other artifacts in the IVUS display.



The Makoto® system is not intended for use with high frequency (HF) / radio frequency (RF) surgical equipment.



Radiated or conducted RF emissions may cause image distortion or artifacts on the Makoto® Intravascular Imaging System display.

Infraredx® recommends the use of an uninterruptible power supply in any facility in which voltage dips or interrupts may occur.

The Makoto® system is intended to function in either “offline” or be connected via network cable to a protected and secure hospital information system. When a network cable is connected to the Makoto® Intravascular Imaging System to transfer data to a hospital information system, then the cable should be a shielded Cat 5e ethernet cable (see Section 3.9). Use of a nonconforming cable may result in increased RF emissions or decreased RF immunity.

3.6 Mechanical Precautions



DO NOT position Makoto® Intravascular Imaging System mobile console operator between the Makoto® system console and other moving equipment in the catheterization lab due to the risk of bodily injury.



The procedure table should be kept level during use of the Makoto® system or at any time when the Makoto® Controller is in the sterile field. DO NOT utilize table pitch or roll controls, if available.

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WARNING

DO NOT position the Makoto® Intravascular Imaging System within the range of motion of pieces of the X-ray system.



WARNING

Ensure that cables originating from or connecting to the Makoto® Intravascular Imaging System lay flat on the floor.

In typical usage, the Makoto® Intravascular Imaging System mobile console is positioned near the foot of the examination table or to the right of the X-ray system monitors. A tip hazard may be created if the Makoto® system mobile console is contacted by moving equipment in the catheterization lab (examination table, C-arm, etc.). When positioned within the movement range of this equipment do not engage the locking casters on the Makoto® Console.

During normal use of the Makoto® Intravascular Imaging System mobile console various cables may be connected to or originating from the console. Ensure that the cables lay flat on the floor to minimize tripping hazards. Wherever it is possible, avoid laying cables across high foot traffic areas in the room.

The Makoto® Controller should be placed on a flat surface during the course of the procedure, especially during data acquisition. The Makoto® Controller should be positioned in the storage cradle of the console when the console is being moved or the controller is not in use.

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3.7 Fire Precautions



WARNING

This equipment is not intended for use with flammable anesthetics or liquids, or oxygen rich (>25%) environments.



WARNING

STATE OF CALIFORNIA (USA ONLY)

This product contains bisphenol-A (BPA), a chemical known to the state of California to cause birth defects, or other reproductive harm.

For information go to www.P65warnings.ca.gov

There are no known chemical or fire hazards associated with the Makoto® Intravascular Imaging System.

3.8 Catheter & Accessory Precautions



WARNING

STATE OF CALIFORNIA (USA ONLY)

The compatible disposable products and its packaging have been sterilized with ethylene oxide. The packaging may expose you to ethylene oxide, a chemical known to the State of California to cause cancer or birth defects or other reproductive harm.

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WARNING

Catheters and catheter accessories (Makoto® Controller Sterile Barrier, Priming Accessories) are supplied sterile and are designed for single patient use only. For single use only. Do not reuse, reprocess, or resterilize. Reuse, reprocessing, or resterilization may compromise the structural integrity and result in poor image quality or patient injury, illness, or death. Reuse, reprocessing, or resterilization may also contaminate the device and result in patient infection which may lead to patient illness or death. Infraredx makes no performance claim for product that is reused, reprocessed, or resterilized.



WARNING

DO NOT use the catheter if the inner package is open or damaged.



WARNING

When connected to the Makoto® Controller, DO NOT stare at the distal tip of the catheter or view directly with optical instruments.



WARNING

Medical waste can cause infection and/or disease. After use, dispose of product and packaging in accordance with hospital, administrative, and/or local government policy.



WARNING

Care should be taken when a guidewire is exposed in a stented vessel. Catheters that do not encapsulate the guidewire may engage the stent between the junction of the catheter and guidewire.

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WARNING

Care should be taken when advancing a guidewire after stent deployment. When crossing a stent, the wire may exit between stent struts that are not fully apposed. Subsequent advancement of the catheter could cause entanglement between the catheter and the deployed stent.



WARNING

If resistance is met upon withdrawal of the catheter, verify resistance using fluoroscopy, and then remove the entire system of catheter, guide catheter, and guidewire using fluoroscopic guidance.

The Makoto® Intravascular Imaging System emits near infrared laser radiation from the laser located in the console through the Makoto® Controller and to the connected catheter. Near infrared light is invisible to the human eye. Staring at or focusing near infrared light through the cornea and onto the retina may cause vision damage.

The Makoto® Intravascular Imaging System designed for use only with the compatible catheters. The compatible catheters are listed in Section 17.1 System Information.

Prior to use, carefully examine all equipment to be used during the procedure to ensure proper performance. The catheter has been inspected and sterilized using Ethylene Oxide (EtO) gas prior to shipment. Prior to use, inspect the catheter and its packaging for damage or breach of the sterile packaging seal(s).



CAUTION

DO NOT kink or sharply bend (>45 degrees) the catheter at any time. This can result in drive cable failure.

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3.9 Compliance with Safety Standards



WARNING

Use of unapproved accessories may result in noncompliance of the Makoto® Intravascular Imaging System with one or more of the standards listed in this section of the manual.

The Makoto® Intravascular Imaging System was designed to conform to all applicable standards (IEC, ANSI, ISO, UL, etc.) for the safe use of lasers, ultrasound and electrical equipment in healthcare facilities.

The following accessories have been tested to be compatible with the Makoto® Intravascular Imaging System: Integrated Data and Video Cable (TVC-10PMC), DVI-D cable (PN2665), and shielded Cat5e cable (PN2690). Contact your sales representative to order.

Specific standards include, but are not limited to, the following:

Standard	Description
IEC 60601-1 ANSI/AAMI ES60601-1 Canada: CAN/CSA 22.2 No. 60601-1 KS C IEC 60601-1	Medical electrical equipment -- Part 1: General requirements for safety and essential performance
IEC 60601-1-2	Medical electrical equipment -- Part 1-2: General requirements for basic safety and essential performance - Collateral standard: Electromagnetic compatibility - Requirements and tests
IEC 60601-1-6 CAN/CSA 22.2 No. 60601-1-6	Medical electrical equipment – Part 1-6: General requirements for basic safety and essential performance – Collateral standard: Usability

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Standard	Description
IEC 60601-2-37 CAN/CSA 22.2 No. 60601-2-37 KS C IEC 60601-2-37	Medical electrical equipment -- Part 2-37: Particular requirements for the basic safety and essential performance of ultrasonic medical diagnostic and monitoring equipment
IEC 60825-1 CFR Title 21 part 1040.10 and 1040.11	Safety of laser products – Part 1: Equipment classification and requirements
IEC 62304 CAN/CSA-CEI/IEC 62304	Medical device software – Software life cycle processes
IEC 81001-5-1	Health software and health IT systems safety, effectiveness, and security – Part 5-1: Security – Activities in the product life cycle.
ISO 10555-1	Intravascular catheters - Sterile and single-use catheters - Part 1: General requirements
ISO 10993	Biological evaluation of medical devices
ISO 11135	Sterilization of health care products – Ethylene Oxide
IEC 62366 CAN/CSA-IEC 62366	Medical devices – Application of usability engineering to medical devices
ISO 15223-1	Medical device – Symbols to be used with medical device labels, labeling and information to be supplied-Part 1: General Requirements.

4 System Description



WARNING

The Makoto® Intravascular Imaging System is designed to be used exclusively by trained physicians and catheterization laboratory personnel.

The Makoto® Intravascular Imaging System provides catheter based intravascular imaging using both IVUS and NIRS technologies. The system uses both sound and light to characterize intravascular features.

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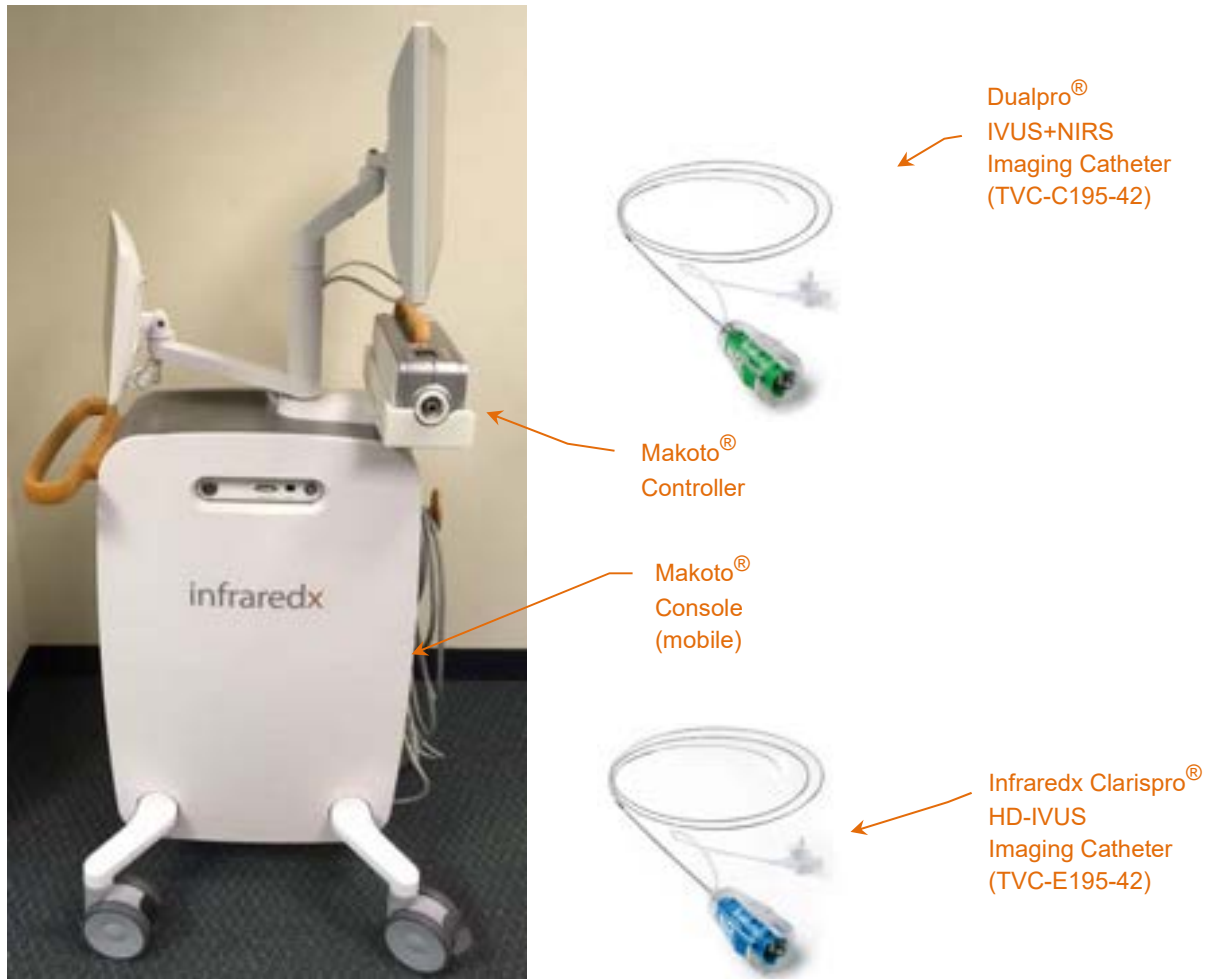


Figure 4-1: Makoto® Intravascular Imaging System and Dualpro® IVUS+NIRS Imaging Catheter (REF: TVC-C195-42), and Infraredx Clarispro® HD-IVUS Catheter (REF: TVC-E195-42).

The system consists of three major components:

- *Makoto® Intravascular Imaging System Mobile Console*
- *Makoto® Controller*
- Catheter (see catheter instructions for use):

Dualpro® IVUS+NIRS Imaging Catheter
DualproNIRS™ Imaging Catheter (not shown in Figure 4-1)
DualproPlus® IVUS+NIRS Imaging Catheter (not shown in Figure 4-1)
Infraredx Clarispro® HD-IVUS Catheter

The system has two minor components:

- *Makoto® Controller Sterile Barrier* (packaged with catheter)
- *Catheter Priming Accessories* (includes priming syringes, packaged with catheter)

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4.1 Makoto® Intravascular Imaging System Mobile Console

The Makoto® Intravascular Imaging System mobile console, or Makoto® Console, contains many of the major components of the system.

The Makoto® Console contains a power module that distributes power to the various parts of the system. The power module supplies power to the displays, central processing unit (CPU), laser, and Makoto® Controller.

The CPU is contained within the Makoto® Console. The CPU manages, stores, and renders data recorded with the Makoto® Controller and catheter. It also controls the function of the graphical user interfaces provided to the user. The system contains a data drive that is capable of storing approximately 1000 scans. Data may be exported from the system onto optical discs (DVD or Blu-ray™ Disc), USB drive, or to a network location via Ethernet cable.

The system may be configured to send data to PACS networks.



It is NOT recommended that the Makoto® Intravascular Imaging System be utilized as a permanent data archive location. Scan data should be archived to other media and removed from the system hard drive.

The laser light source for the performance of NIRS is contained within the console. The light is delivered by fiber optic cable to the Makoto® Controller where the catheter is connected during use. It is this light pathway that permits the system to generate a Chemogram, or probability map of lipid core containing plaques of interest.

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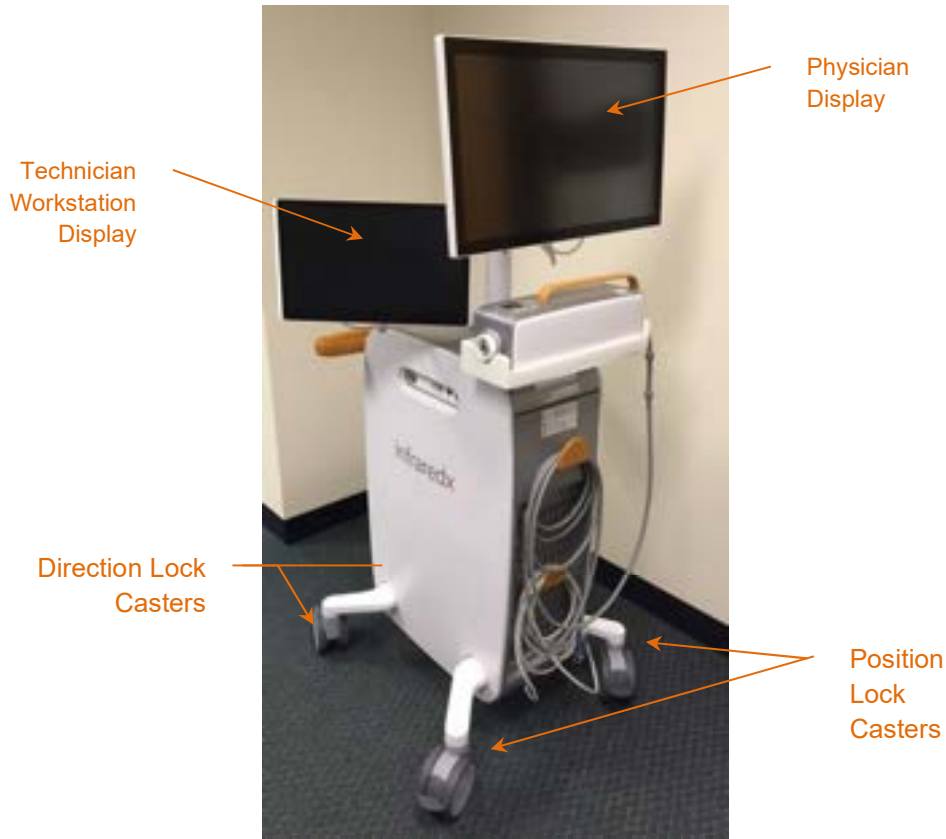


Figure 4-2: Makoto® Intravascular Imaging System (TVC-MC10).

The console contains two displays. One display, the physician display, is oriented toward the sterile operator during use. The second touch screen display, the technician workstation display, is oriented toward the non-sterile technician or circulating operator during use. This allows the non-sterile operator to annotate data while providing the sterile operator an unobstructed view of the display.

The physician display is a 21.5 inch (55cm) 1080p FHD monitor (1920x1080p). The display tilt and swivel may be adjusted to provide an optimal viewing angle for the sterile physician.

The technician workstation display is a 15.6 inch (40cm) 1080p FHD capacitive touch enabled monitor (1920x1080p). The display rotation, tilt and swivel may be adjusted to facilitate a comfortable working angle.

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Figure 4-3: Left side interface panel of the Makoto® Intravascular Imaging System (TVC-MC10) containing USB 3.0 connectors and Blu-ray™ optical media drive.



Figure 4-4: Right side interface panel of the Makoto® Intravascular Imaging System (TVC-MC10) containing the Power Button, Video Out, PACS, and X-ray Integration connectors.

The Makoto® Console is also configured to export a color video signal of 1920x1080p (16:9 aspect ratio) using a shielded DVI-D video cable. Optionally, the exported video resolution can be configured to 1600x1200 (4:3 aspect ratio).

In addition to the technician workstation display, users may interface with the system through the use of the mouse provided. This mouse is located under the technician workstation display.

The system is equipped with two directional locking casters to aid in transport and two additional locking casters to secure or park the system.

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4.2 Makoto® Intravascular Imaging System Graphical User Interface

The Makoto® Intravascular Imaging System functions are controlled by way of the software graphical user interfaces: Acquisition Mode and Review Mode.



Figure 4-5: Acquisition Mode (SmartImaging™ optional features enabled).

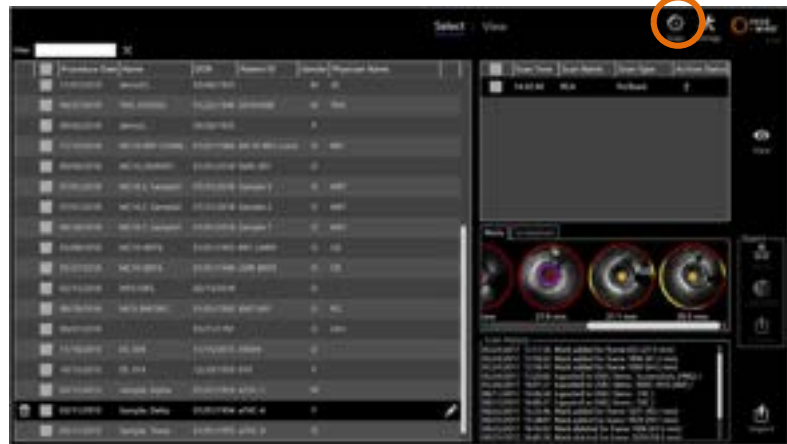


Figure 4-6: Review Mode

4.2.1 Acquisition Mode

The Acquisition Mode is the operational mode in which new data may be recorded by the Makoto® Intravascular Imaging System. It is comprised of four different phases: “Setup”, “Prime”, “Scan” and “Close”. By utilizing the Progress Strip the operator may move easily and quickly between the phases to match the pace of the procedure.

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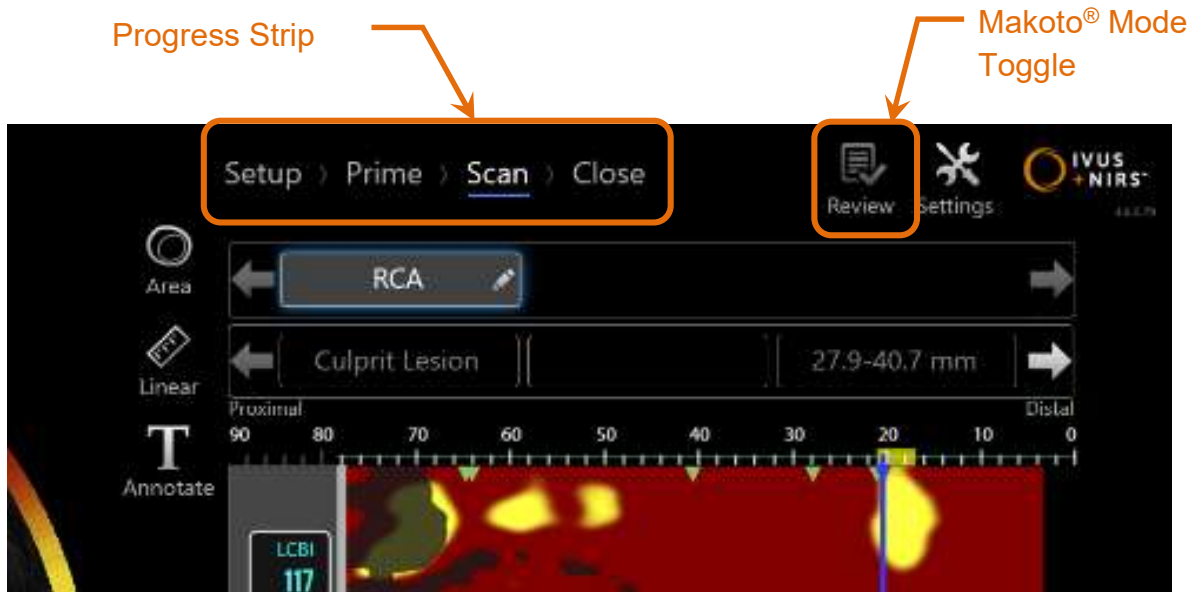



Figure 4-7: Acquisition Mode displayed with focus on the Procedure Progress Strip control to change Phases and the Makoto® Mode Toggle control to change modes of operation. The Scan Phase of Acquisition Mode is active and the Makoto® Mode toggle to access Review Mode is disabled in the image.

The Progress Strip describes the different stages or phases of data acquisition and also provides a control to change phases. Touch the different phase names to move to the desired phase.

NOTE: Phases in the Acquisition Mode are not order dependent. Any step may be skipped and then returned to if necessary or convenient.



Touch the Makoto® Mode Toggle control, Review icon , to enter the Review Mode of operation. This can only be done when there is no active procedure in progress. Any active procedures must be closed before transitioning modes.

4.2.1.1 Setup Phase

Setup Phase allows the operator to enter information about the patient and the procedure to facilitate archiving and later retrieval for review.

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Care should be taken when entering patient information to ensure accuracy.

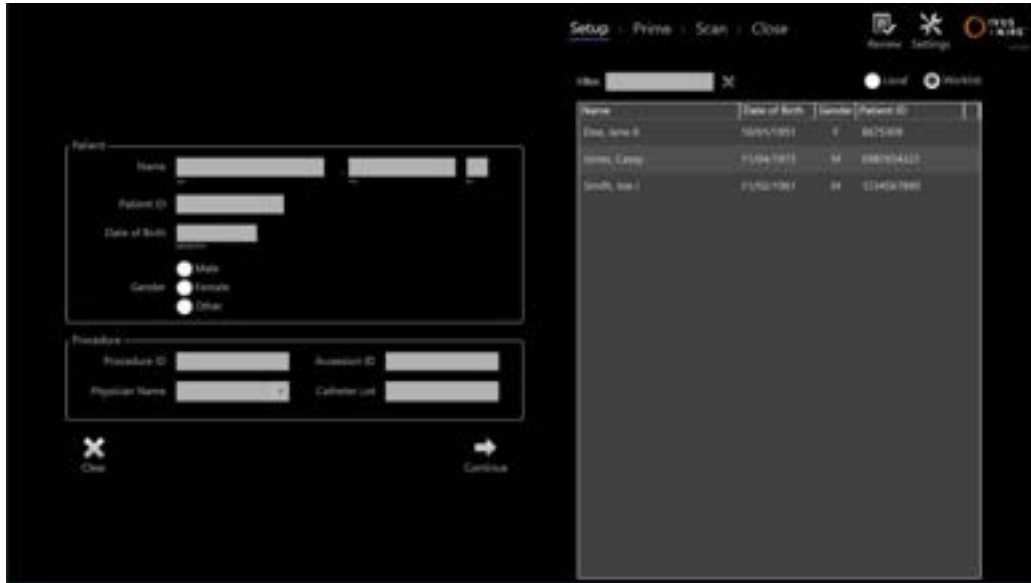


Figure 4-8: Setup Phase of the Acquisition Mode.

NOTE: Scan data may be recorded before the Setup Phase is completed.

Procedure and patient information may be configured manually or by selecting from data already on the system or from the modality worklist. Using the semi-automatic completion features can reduce transcription errors and improve accuracy of information entry.

NOTE: Using the semi-automatic completion features can reduce transcription errors and improve accuracy of information entry.

NOTE: The Setup Phase is not accessible during active scanning.

See Section 7 for more detailed information for procedure setup.
See Section 14.5 for more detailed information on configuration of Modality Worklist connections.

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4.2.1.2 Prime Phase



WARNING

The sterile catheter must be primed in accordance with the instructions for use document that is included in the catheter package.



WARNING

Use of the supplemental on-screen priming guidance is not a substitute for training in the operation of the Makoto® Intravascular Imaging System.

The Prime Phase provides guidance to the operator on the process of priming a catheter and the connection of the catheter to the Makoto® Controller.

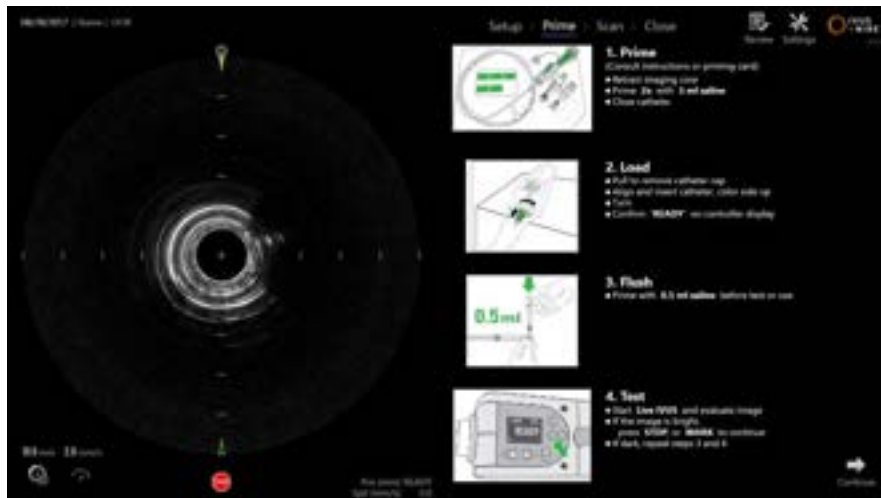



Figure 4-9: Prime Phase of the Acquisition Mode.

NOTE: Press the **Mark** button on the Makoto® Controller, , to progress to the next phase.

NOTE: The Prime Phase is not accessible during active scanning.

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See Section 8 for more information on catheter connection and the instructions for use packaged with the catheter for more detail on priming.

4.2.1.3 Scan Phase

The Scan Phase of the procedure allows the operator to record IVUS and NIRS scan data during the current procedure. The operator is also able to replay, review, delete, measure, annotate, and change the next pullback rate during the current procedure when active imaging is not underway.

This phase includes many of the displays of complex imaging data including the Chemogram, Block Level Chemogram, Chemogram Halo, Transverse and Longitudinal IVUS images.

The two sets of information, NIRS and IVUS, recorded by the Makoto® Intravascular Imaging System are co-registered and can be reviewed using synchronized playback.

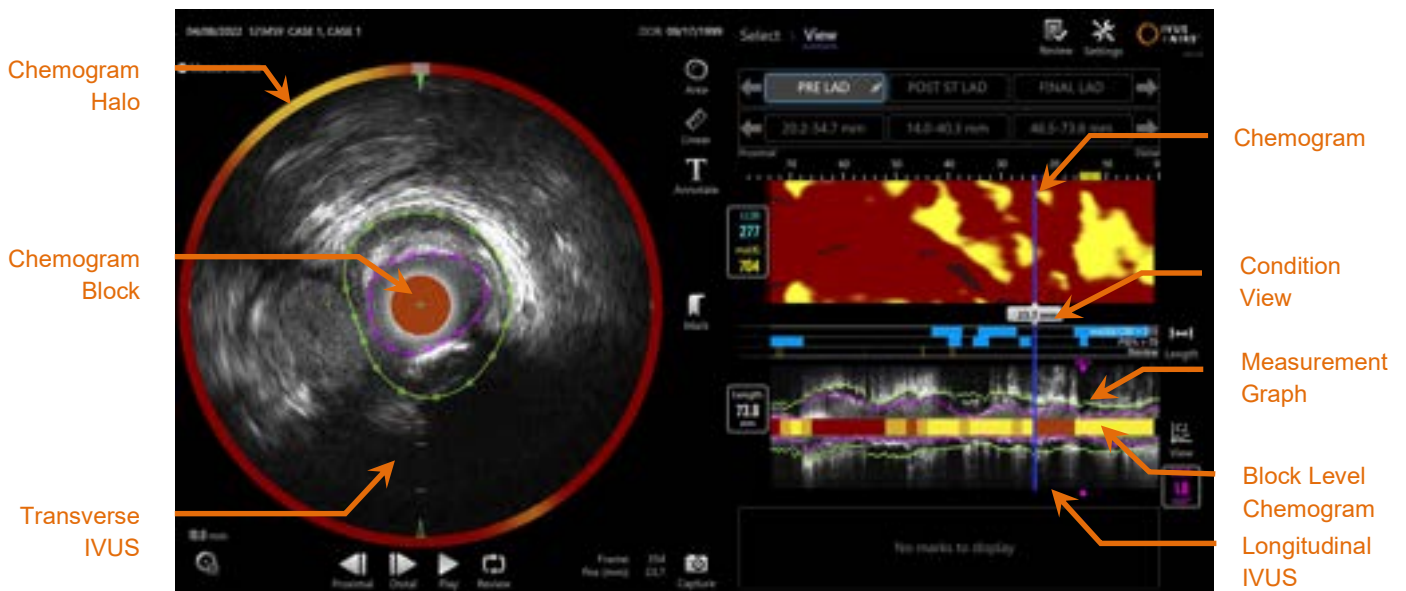


Figure 4-10: Scan Phase of Acquisition Mode with the main displays of image information indicated (SmartImaging™ optional features enabled).

NOTE: No chemogram or NIRS data will be displayed when used with Infraredx Clarispro® HD-IVUS Catheter

The Scan Phase also provides access to Annotation and Measurement features that are accessible during an active procedure. Scans may be renamed, annotated, and

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have individual frames marked for easy retrieval for review. Frame measurements may also be performed.

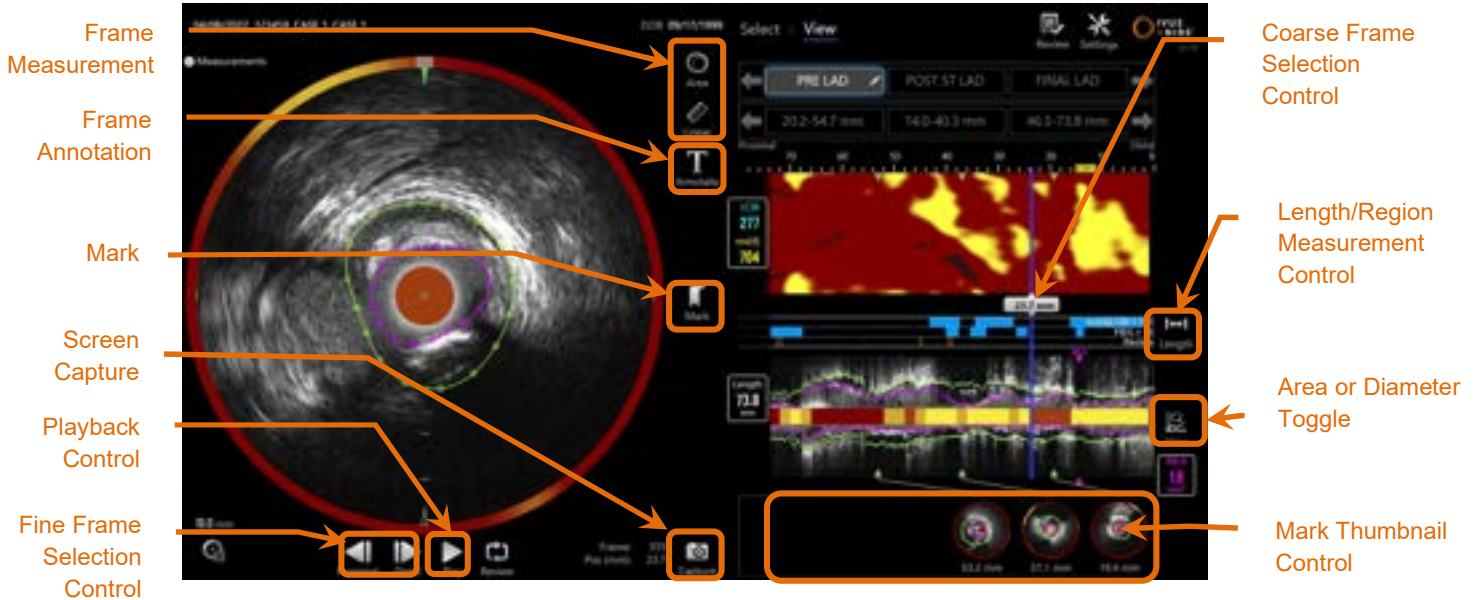


Figure 4-11: Scan Phase of the Acquisition Mode with basic controls indicated (SmartImaging™ optional features enabled).

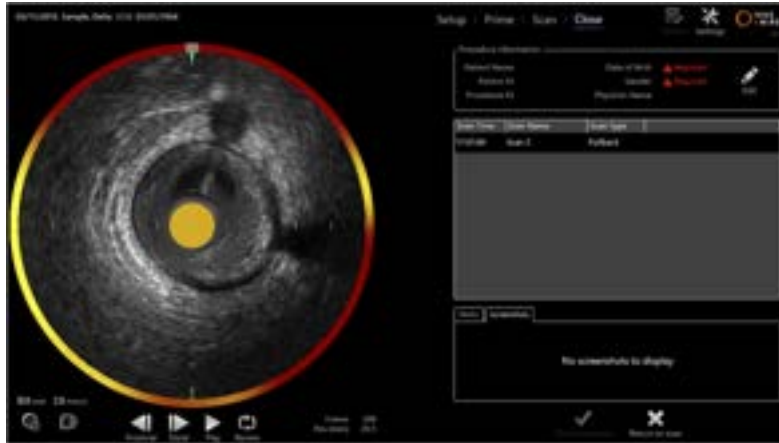
See Section 9 and 10 for more detailed information on scan acquisition, navigation, and measurement.

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4.2.1.4 Close Phase

The Close Phase of the procedure allows the operator to review a summary of the data obtained during a procedure prior to archiving on the system.

It is important to complete the Close Phase for every procedure prior to powering off the system.



4-12: Close Phase of the Acquisition Mode.

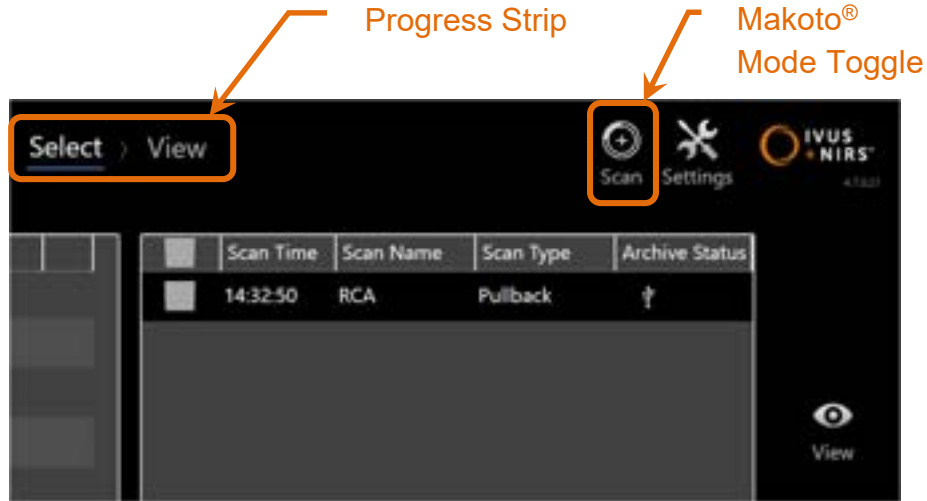
- NOTE:** Beginning a new acquisition from the Makoto® Controller will return the Acquisition Mode back to the Scan Phase automatically.
- NOTE:** You must enter the minimum required patient and procedure information on the Setup Phase screen to complete the Close Phase.
- NOTE:** Procedures that were not closed prior to system shut down or power off are accessible by the Review Mode. The procedure may be resumed and can then be Closed and Archived.

See Section 11 for more detailed information on procedure closure.

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4.2.2 Review Mode

The Review Mode is comprised of two phases. They are the Select and View phases. These phases will allow the user to select a procedure and then to either view or export for later viewing.



4-13: Review Mode with the Progress Strip and Makoto® Mode Toggle controls highlighted.

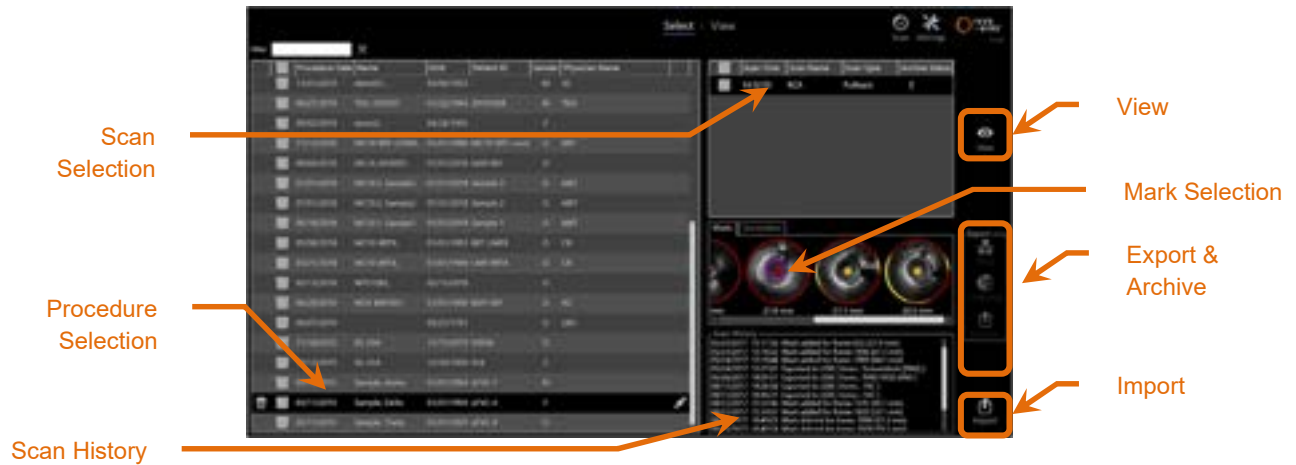


Touch the Makoto® Mode Toggle control, Scan icon , to enter the Acquisition Mode of operation. This can be done at any time when in the Select Phase of Review Mode.

4.2.2.1 Select Phase

The Select Phase allows the operator to search for and choose previously saved procedures for viewing, editing, deleting, or archiving to other media.

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4-14: Select Phase of Review Mode.

During this phase, properly formatted data may be selected from other media to be imported to the Makoto® Intravascular Imaging System.

See Section 12 for more detailed information on selection, export and import functions.

4.2.2.2 View Phase

The View Phase provides many of the same controls found during the Scan Phase of the Acquisition mode. Data here may be reviewed, analyzed, annotated and deleted using familiar controls as described in Section 10.



4-15: View Phase of Review Mode.

NOTE: Data from one procedure may be viewed at a time.

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Touch the Makoto® Mode Toggle control, Review icon, to return to the Select Phase of Review Mode.

4.3 Makoto® Controller

The Makoto® Controller (see below) is the interface between the catheter and the Makoto® Console. The catheter handle is inserted into a socket on the front face of the controller and then turned to complete the physical, optical and electrical connections. These connections allow for the unit to simultaneously actuate the inner imaging core and stabilize the catheter's outer sheath. The pullback mode of the Makoto® Controller permits automated rotation at approximately 1800 RPM and distal-to-proximal longitudinal motion at a rate of 0.5, 1.0, and 2.0 mm/s. The catheter imaging core can perform a continuous automated pullback in the distal to proximal direction over a total length of 150 mm.

The Makoto® system is equipped with an RFID receiver that is designed to work with RFID emitters within the compatible catheter handle for identification of catheter model, adjustment of display, and facilitation of other user workflows.

4.3.1 Indicators

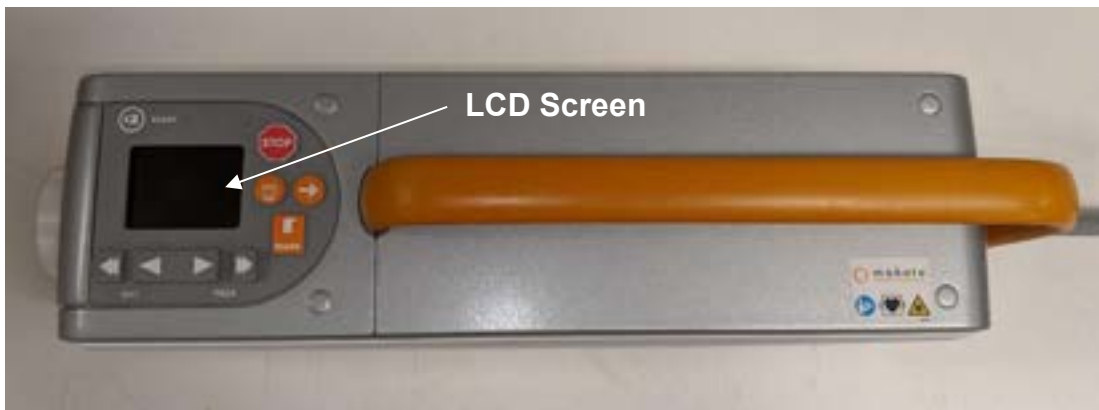


Figure 4-16: Makoto® Controller.

The Makoto® Controller is equipped with a LCD screen which will provide status messages and graphics to the user.

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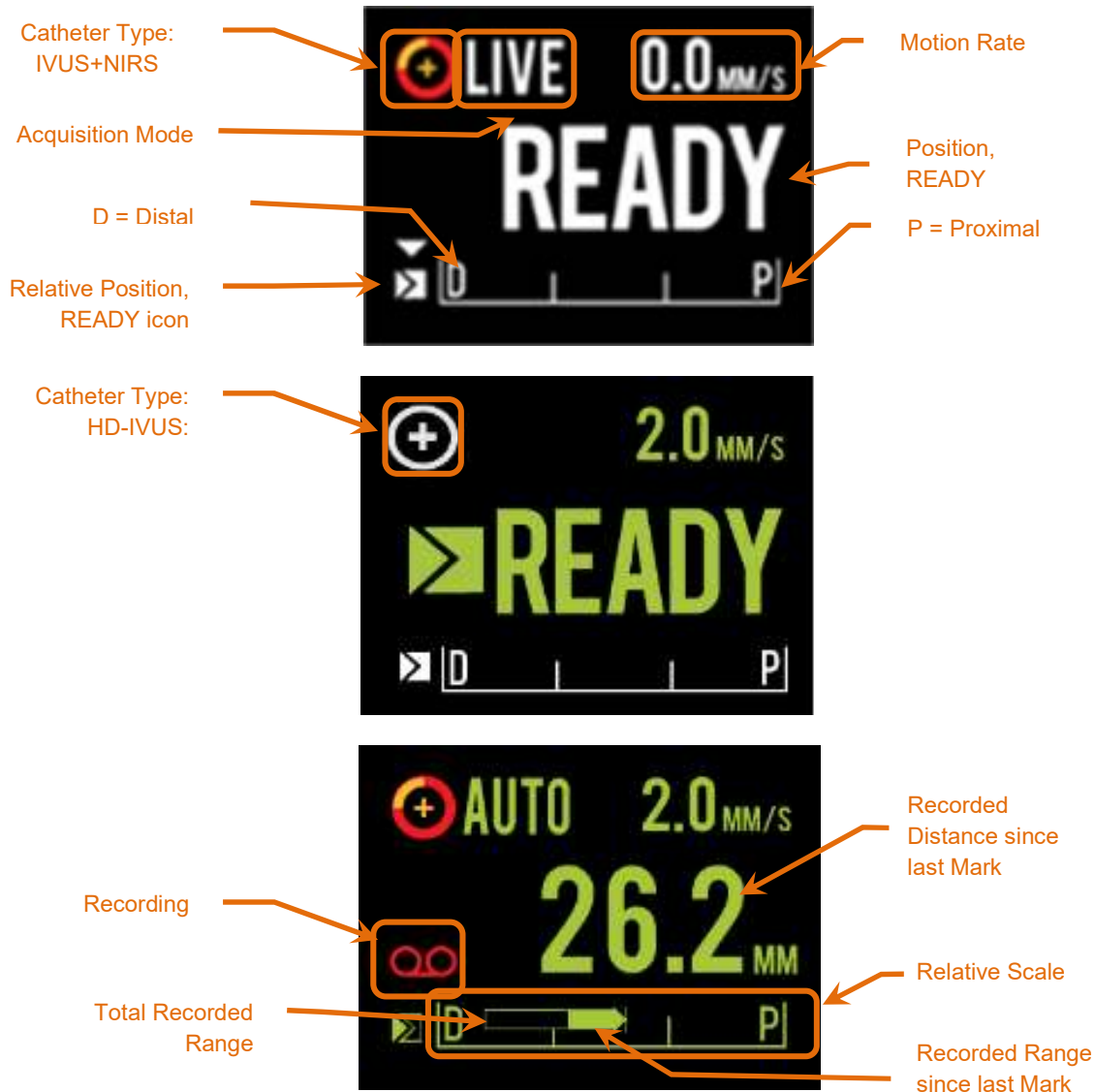


Figure 4-17: Makoto® Controller LCD screen indicators in Live IVUS acquisition in the READY position with an IVUS+NIRS capable catheter connected (top), idle with a HD-IVUS only capable catheter connected at READY position (middle), and during automated pullback acquisition with an IVUS+NIRS capable catheter (bottom).

The controller identifies for the user two important positions for operation: READY and 0.0mm position.

READY This position is the most distal position that the Makoto® Controller catheter socket can reach. This position indicates the location where the controller is ready for the user to properly LOAD (connect) or unload (disconnect) a catheter, or begin imaging. This is also the position where the transmission window of the connected catheter is most resistant to push-related kinking and is ready to be tracked on a guidewire

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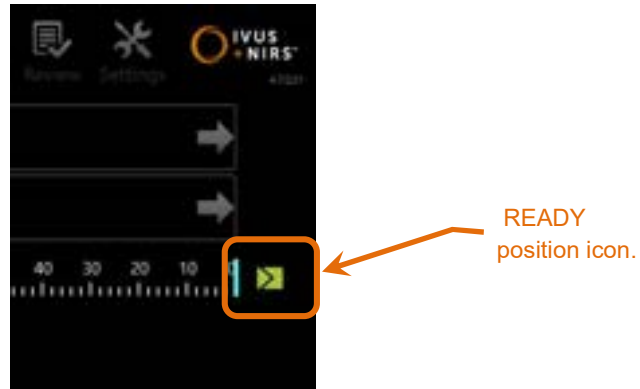




Figure 4-18: When the Makoto® Controller is in the READY position, the READY icon will appear on the right side of the Makoto® Console display.

“0.0mm” This position is the start location of continuous uninterrupted imaging during a pullback or translated Live IVUS scan. The “0.0mm” position is approximately 5mm proximal to the READY position. Transverse IVUS images are not available for viewing or recording in the locations between READY and 0.0mm.

As illustrated in Figure 4-17, the LCD screen of the Makoto® Controller is used to communicate important status information from sensors, modes of operation, and status:

- | | |
|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Catheter Type | This symbol,  , will appear to indicate that an IVUS+NIRS catheter has been connected to the controller. This symbol,  , will appear to indicate that an HD-IVUS catheter has been connected to the controller. |
| Acquisition Mode | This indicator will appear as the text “LIVE”, “AUTO” or blank/none to indicate the current image acquisition mode of the system. |
| Motion Rate | This indicator will communicate the current speed of translation when image acquisition is occurring. When there is no image acquisition in process the motion rate will communicate the setting of the Next Pullback Rate control (see section 9.2.1) |

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- READY** When the display reads “READY” this will indicate that the system is in the READY position or most distal position that can be achieved by the user when operating the Makoto™ Controller.
- Relative Scale** The range of continuous image acquisition, 0.0 - 150.0 mm, is indicated on the controller with demarcation at 50.0 mm and 100.0mm.
- Relative Position** When the Makoto® Controller is moved proximally from the READY position, the current location of the imaging tip is represented by a vertical line within the Relative Scale.

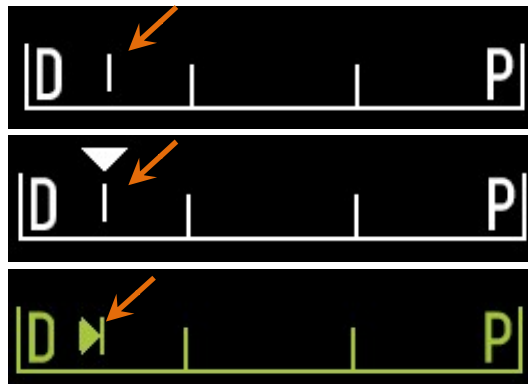


Figure 4-19: Relative Position indicator during no imaging (top), Live IVUS (middle), and Pullback (bottom).

- Position/Distance** In Live IVUS or Pullback imaging the distance displayed is from the start of imaging or most recent Mark location in millimeters. When not imaging, the current position of the imaging tip is displayed.
- Recording** The Recording indicator will appear when the system is recording the images displayed to the operator.
- Recorded Range** The range of recording of the current Live IVUS or Automated Pullback acquisition is represented by a solid rectangle. Translated Live IVUS acquisitions will appear white and Automated Pullback acquisitions will appear green. The solid portion indicates the recorded range since last Mark.

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Figure 4-20: Recorded Range during the current acquisition: Live IVUS with current position the same as the start position (top), Recorded Live IVUS with current position proximal to the last Mark press (middle-top), Automated Pullback with no Marks (middle-bottom), Automated Pullback with solid bar indicating recorded range since last Mark (bottom).

LOAD

This message indicates that the Makoto® Controller is in the READY position and a catheter may be loaded into the socket.



Figure 4-21: The Makoto® Controller LCD screen indicating LOAD status.

TURN

This message indicates that the Makoto® Controller has detected an incomplete catheter handle connection.

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Figure 4-22: The Makoto® Controller LCD screen indicating a instruction to turn the catheter handle.

WAIT

The Makoto® Controller is waiting for the Makoto® Console and software user interface to initialize.



Figure 4-23: The Makoto® Controller LCD screen indicating a status to wait for the system to complete start up.



WARNING

Hazardous situations, including injury to the patient or operator, may occur if display warnings are ignored.

SEE DISPLAY

An error or fault condition has been detected by the Makoto® Controller. This message instructs the operator to consult the Makoto® Intravascular Imaging System displays for more detailed instructions.

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Figure 4-24: The Makoto® Controller error message (left) and internal fault (right) messages. In both cases the user should consult the system monitor for instruction on the error or fault and next actions.

NOTE: If the “See Display” message appears repeatedly after following the onscreen cues, then contact your local service provider or Infraredx Customer Service for assistance.

The Makoto® Imaging System monitors system interactions for periods of inactivity. If the inactivity time limit and conditions are met then the controller will enter a power save mode. The system will not enter power save mode if a procedure is in progress or if there is a catheter connected to the system. User log in will cause the system to exit power save mode.

NOTE: Users with Administrator permissions may adjust the inactivity time, see section 14.10 System settings.

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4.3.2 Acquisition Controls



WARNING

Hazardous situations, including injury to the patient or operator, may occur if display warnings are ignored.




WARNING

Controller linear motion will stop when excessive force is encountered.

Check catheter for kinks, sharp bends, or damage and resolve before continuing.




Press the STOP button, , on the Makoto® Controller and follow -on screen prompts to resolve.

DO NOT use single step translation functions to overcome the kink or bend. Catheter sheath damage or patient injury may result.



WARNING

If at any time the **STOP** button, , on the Makoto® Controller does not halt catheter motion, immediately unplug the Makoto® Intravascular Imaging System.

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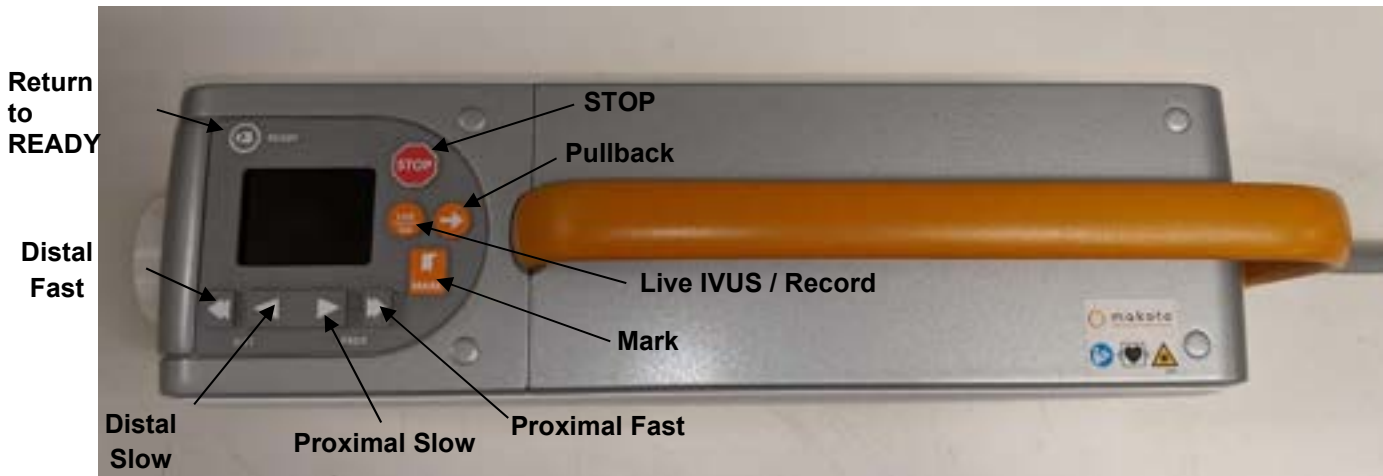
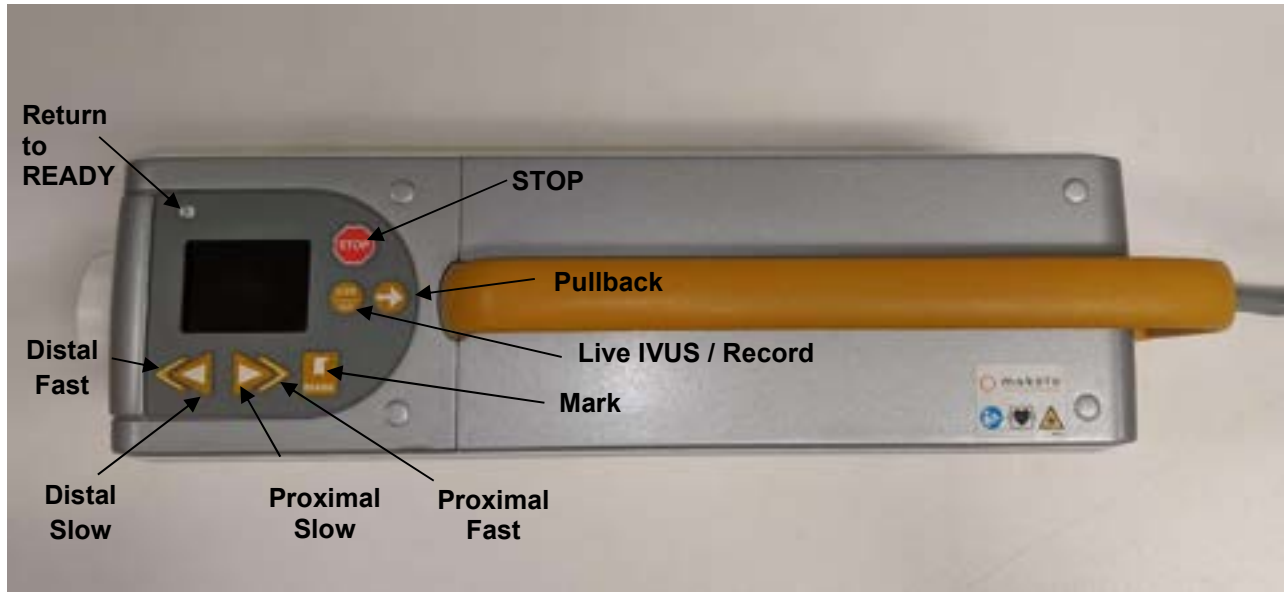


Figure 4-25: Makoto® Controller with function buttons, two models available (top, bottom).

The Makoto® Controller is equipped with simple buttons to allow the user to control the motion of the system and data acquisition.

Return to READY

This button will automatically move the catheter imaging core from its current location to the most distal or READY position. This core position is required prior to catheter movement within the patient or catheter connection/disconnection.

STOP

This button will halt the motion of the Makoto® Controller and stop any data collection in progress.

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Pullback

This button will initiate automated rotation and automated pullback of a connected catheter. The rotation speed is fixed at approximately 1800 rpm, however the pullback speed will correspond to the rate selected on the Makoto® Console (either 0.5, 1.0, or 2.0 mm/sec).

From READY: A press and release of the Pullback button will move imaging core to the “0.0 mm” position and start Live IVUS to permit a preview of the scan starting imaging location. Press pullback again to start the scan. Pressing and holding the Pullback button in the READY position will skip the preview and begin automated motion and recording. The button can be released when the display indicates that “AUTO” imaging has started.

From position ≥ 0.0 mm: A press and release of the Pullback button will start immediate motion and recording the scan.




The **Pullback** button, , may be pressed while the Makoto® Controller is stationary or while rotating during a Live IVUS acquisition.

Live IVUS / Record

The first press of this button will initiate automated rotation of the catheter imaging core (without pullback). A live transverse IVUS image will appear on the display of the Makoto® Console.



Additional presses of the **Live IVUS** button, , will toggle on and off a recording of the Live IVUS acquisition in progress. This will not stop the rotation of the catheter imaging core.

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Mark

This button will bookmark a frame or position within a scan for later reference or review.

During image acquisition, this button will zero the controller display. The distance displayed by the controller will be measured from the location of the most recent Mark press.

During unrecorded Live IVUS, this button will record a single IVUS frame.

During the Prime Phase of acquisition, this button will advance the system to the Scan Phase.

Distal Fast

Pressing and holding this button will move the catheter imaging core distal at a rate of 10 mm/s.

Press and release of this button will move the catheter imaging core in the distal direction a fixed increment of 0.5 mm.

Distal Slow

Pressing and holding this button will move the catheter imaging core distal at a rate of 2 mm/s.

Press and release of this button will move the catheter imaging core in the distal direction a fixed increment of 0.1 mm.

Proximal Slow

Pressing and holding this button will move the catheter imaging core proximal at a rate of 2 mm/s.

Press and release of this button will move the catheter imaging core in the proximal direction a fixed increment of 0.1 mm.

Proximal Fast

Pressing and holding this button will move the catheter imaging core proximal at a rate of 10 mm/s.

Press and release of this button will move the catheter imaging core in the proximal direction a fixed increment of 0.5 mm.

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NOTE: Controller functions Return to READY, Live IVUS, and Pullback can be accessed from the Makoto® Console by enabling Remote Control features, see Section 14.10.6 Enable Remote Control.

4.4 Compatible Imaging Catheters

Compatible imaging catheters are packaged separately and are sterilized for single use. Please consult the Instructions for Use packaged with the catheter for more information on the catheter as well as its proper preparation and use.

4.5 Near Infrared Spectroscopy (NIRS)

The Makoto® Intravascular Imaging System is designed to identify lipid core containing plaques of interest, through blood, in the coronary arteries of a beating heart via the Dualpro® IVUS+NIRS, DualproNIRS™, and DualproPlus® IVUS+NIRS Imaging Catheters. The system uses near-infrared spectroscopy (NIRS) to identify the chemical composition of the artery wall as an aid to the interventional cardiologist in assessing coronary plaques. The fundamental basis of this imaging capability is the principle of diffuse reflectance spectroscopy, which is well established and used in many scientific disciplines.

In summary, incident NIR light is scattered and absorbed by tissue and the collected light contains information about tissue composition based on its scattering and absorption properties. These absorption and scattering properties are governed by the chemical composition and morphology of the tissue.

4.5.1 Chemogram

After a pullback of the Dualpro® IVUS+NIRS, DualproNIRS™, and DualproPlus® IVUS+NIRS catheter imaging core through the artery, the system software displays a graphical representation, in the form of a map, indicating the likelihood that a lipid core containing plaque of interest (LCP) is present. This map is called a Chemogram. It provides an image of the artery that indicates the probability of finding a lipid core plaque of interest at a particular location in the scan. High probability is displayed as yellow, and decreasing probability smoothly transitions to red.

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4.5.2 Reading the Chemogram Display

During real-time data acquisition, the Guidewire Detection Map identifies the location of the artifact that an imaged guidewire produces and assists the physician in identifying image artifacts within the spectroscopy data. At the completion of a pullback scan, the Makoto® Intravascular Imaging System monitor displays two pseudo-color maps of the artery wall. These maps are the Chemogram and Block Level Chemogram. The Chemogram and Block Level Chemogram indicate areas in the coronary artery that are likely to contain lipid core containing plaques of interest.

The longitudinal views of the display represent the scan from right to left (distal to proximal). The x-axis indicates the pullback distance in millimeters from the distal end of the catheter transmission window. The y-axis in the Chemogram and the Guidewire Detection Map correspond to the relative angular position of the features of the vessel wall in degrees (the starting angular position in relation to the wall is arbitrary). The portion of the scan inside the guiding catheter may be indicated in solid gray on the proximal ends of the Chemogram and Block Level Chemogram, if the system detects that the scan entered the guiding catheter.

The Chemogram is colored in a scale from red to yellow, low to high probability of lipid. The yellow color is apparent to the user when the probability of lipid exceeds 0.6 at any point in the display. A black semi-transparent masking will appear over the Chemogram in areas where the LCP detection algorithm has determined that there is low signal or other interference.

The system monitor displays the Lipid Core Burden Index (LCBI) results to the left of the Chemogram. The LCBI is a ratio of positive lipid probability scores (>0.6) to total valid lipid probability scores in the selected range of the Chemogram, on a scale of 0 to 1000 (low to high lipid core burden), within a defined segment. In studies (see Section 18.2 Appendix B) with histologically-determined autopsy specimens, the LCBI was shown to correlate with the presence and volume of fibroatheroma in the artery.

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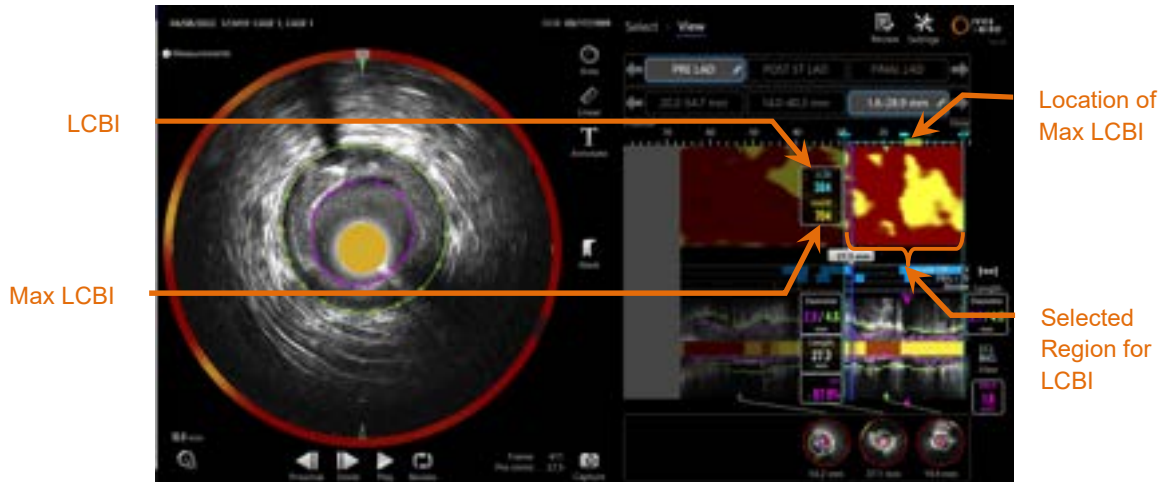


Figure 4-26: Regional and Maximum LCBI for the selected region are displayed to the left of the Chemogram (SmartImaging™ optional features enabled).

The software will display the maximum LCBI of a fixed length window (4 mm default) within a segment and display the location within the region.

LCBI	Lipid Core Burden Index computed for each pullback performed with a capable catheter and within a user defined region of interest.
Max LCBI	Lipid Core Burden Index computed on a specified width within a whole pullback or scan region specified by the user. The maximum value found will be presented to the user.

The Block Level Chemogram, which supplements the Chemogram, is displayed in the center of the longitudinal IVUS view and is dimensionless in the y-direction. The Chemogram Block associated with the currently displayed frame will appear in the center of the transverse IVUS view. The Block Level Chemogram is divided into 2mm wide blocks and summarizes all the valid prediction scores within the corresponding segment of the Chemogram. The Block Level Chemogram is represented in 4 colors from highest to lowest probability: yellow, tan, orange, and red. If the number of pixels within the block on the Chemogram that is impacted by interference or low signal exceeds 25%, then the block color is black.

NOTE: If the percentage of spectra that are too weak to contribute to chemogram generation exceed 12%, then no chemogram will be generated.

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4.6 Intravascular Ultrasound

The Makoto® Intravascular Imaging System is designed to identify the lumen and vessel wall, through blood, in the vessels of the body, excluding cerebral vessels, via a scanning imaging catheter. The system uses ultrasound to assess luminal and vessel wall boundaries of the artery and aids the physician in assessing atherosclerotic plaques. Ultrasound is capable of identifying other characteristics of the vessel such as implanted stents and of atherosclerotic plaques such as calcification.

This information is assessed by sending pulses of sound to the vessel wall from the imaging tip of the catheter and receiving the echo. The morphological features of the artery absorb and reflect the sound differently. These signals are then presented on the screen for interpretation.

Utilizing angiography images, assessments of lesion progression can be made by comparing two diameters within the area of interest. Typically, these diameters are selected from a reference location and the location with the minimum lumen diameter within the target area. The reduction of this diameter is referred to as a diameter stenosis. Use of the angiogram to assess diameters in a single projection can create challenges when assessing lesions or target locations with eccentric lumens. IVUS permits a better assessment of the lumen, including eccentric lumens.

Comparing lumen area can also provide an additional way of assessing the progression of a lesion. The Makoto® Intravascular Imaging System will compare two areas at different locations to provide a lumen Area Stenosis (AS).

$$\text{AS\%} = [(\text{LumenArea}_{\text{Distal}} - \text{LumenArea}_{\text{Minimum}}) / \text{LumenArea}_{\text{Distal}}] \times 100$$

4.7 Condition Display

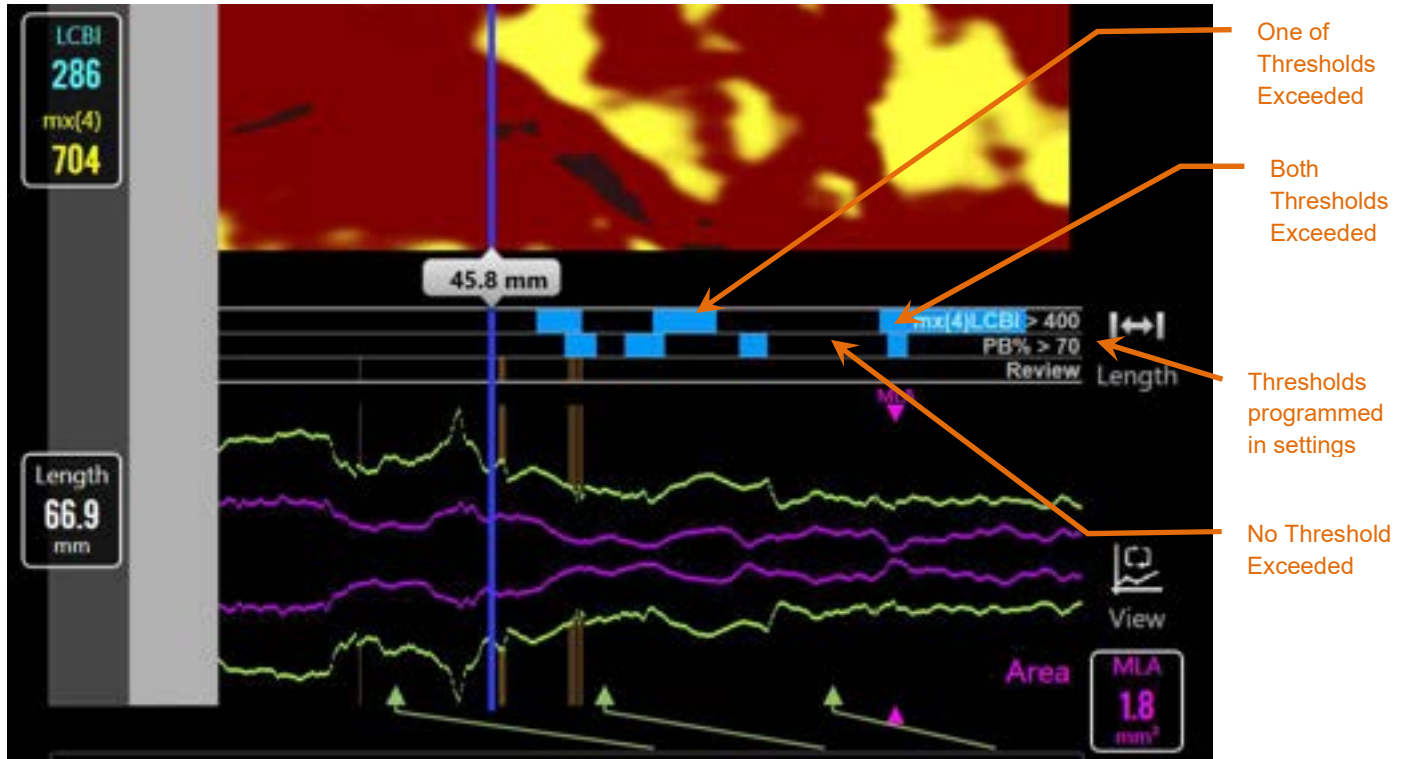


Figure 4-27: Condition Display. Threshold Set one active (SmartImaging™ optional features enabled).

The Makoto® Intravascular Imaging System is designed as a dual modality imaging system. The Condition Display is a configurable display to assist the user in pointing to segments of the imaging data that exceed or, conversely, do not exceed specified thresholds generated by the automated ultrasound measurements and the mxLCBI algorithm. The system is able to store and toggle between two sets of thresholds for per frame measures. The thresholds can be set for percentage plaque burden and mxLCBI. The percentage plaque burden is calculated as explained in Section 10 and mxLCBI is determined based on the configured window size, as explained in Section 10, and centered on the frame. Setup for thresholds is explained in Section 10.2.9.

The mxLCBI and PB% Condition Display rows are colored when thresholds, for each cross-section, are met.

As an example, the user may configure threshold set one to reveal the condition of “normal” or acceptable stent landing zones by using the condition display to point to the

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regions of vessel, derived by the automated measurements, where unacceptable or less desirable stent landing zones exist.

As an example, the user may configure threshold set two to reveal regions of the vessel that may be at increased risk of disease progression derived by the mxLCBI values or accumulated plaque burden that is based on relevant and accepted medical research.

NOTE: Select or change Threshold Set values by entering the Scan Edit window and adjusting the setting, see Section 10.2 Editing Scans.

NOTE: Toggle between Threshold Set 1 and 2 by using Right Click on the Conditional Display.

4.8 Automated Ultrasound Measurements (SmartImaging™)

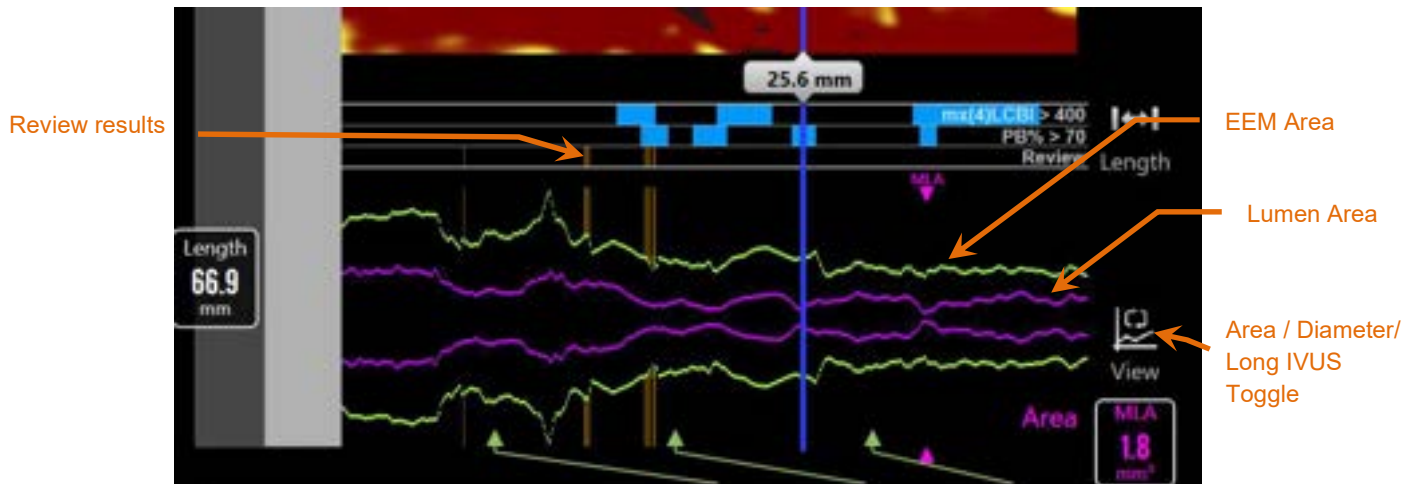


Figure 4-28: Measurement View. Area display shown, the automatically generated EEM area will be presented in green and the lumen area presented in magenta. The corresponding identification will be overlaid on the Longitudinal IVUS display (SmartImaging™ optional features enabled).

The Makoto® Intravascular Imaging System can be optionally configured with automated image assessment functions, SmartImaging™, to facilitate common tasks of the user. SmartImaging™ is a feature set that automatically identifies lumen and vessel borders which result in area, diameter, and plaque burden measurements. At the conclusion of image acquisition, the system will attempt to assess each recorded IVUS

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frame for the location of the lumen boundary and the external elastic membrane (EEM) of the vessel.

4.8.1 Review Results



WARNING

The user should review and assess the performance of the assistive measurement functions prior to diagnosis and selection of therapy.



WARNING

Where possible, the assistive measurement system will alert the user to segments that may require additional interpretation or editing by the user.

In the review results area, segments may be highlighted as the feature may not be confident in the measurement displayed. As a result, accepting, correcting, or deleting those measurements may be required. Click the chosen action to take in the measurement box located in the transverse view. The segments for review are represented by gold vertical bars in the longitudinal graphical view and gold circles in the transverse view.

Upon editing, measurements will be accepted as having been reviewed. Original measurements can be restored. See Section 10.5.2.1 for making area measurements for further information.

NOTE: This visibility of SmartImaging™ measurements on the Transverse or Longitudinal IVUS can be adjusted quickly by using the mouse to Right Click on the Longitudinal IVUS or Transverse IVUS and change the appropriate setting or by entering the Scan Edit window and adjusting the setting.

NOTE: SmartImaging™ when used with the Infraredx Clarispro® HD-IVUS catheter may require manual activation.

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The location of the identified lumen boundary and EEM will be automatically displayed in the Longitudinal IVUS.

The areas created by these measurements are presented to the user in a silhouette representing a vessel to enhance visualization and interpretation of the medical image data.

The areas measured will also be automatically assessed for their minimum lumen diameters and EEM diameter on each frame. The diameters assessed in this way will be presented to the user in a silhouette representing the vessel to enhance visualization and interpretation of the medical image data.

5 Storing, Moving, and Positioning the Makoto® Intravascular Imaging System

5.1 Moving the Makoto® Intravascular Imaging System

The Makoto® Intravascular Imaging System is equipped with two locking casters in the rear of the system and two directional-lock casters on the front of the system.

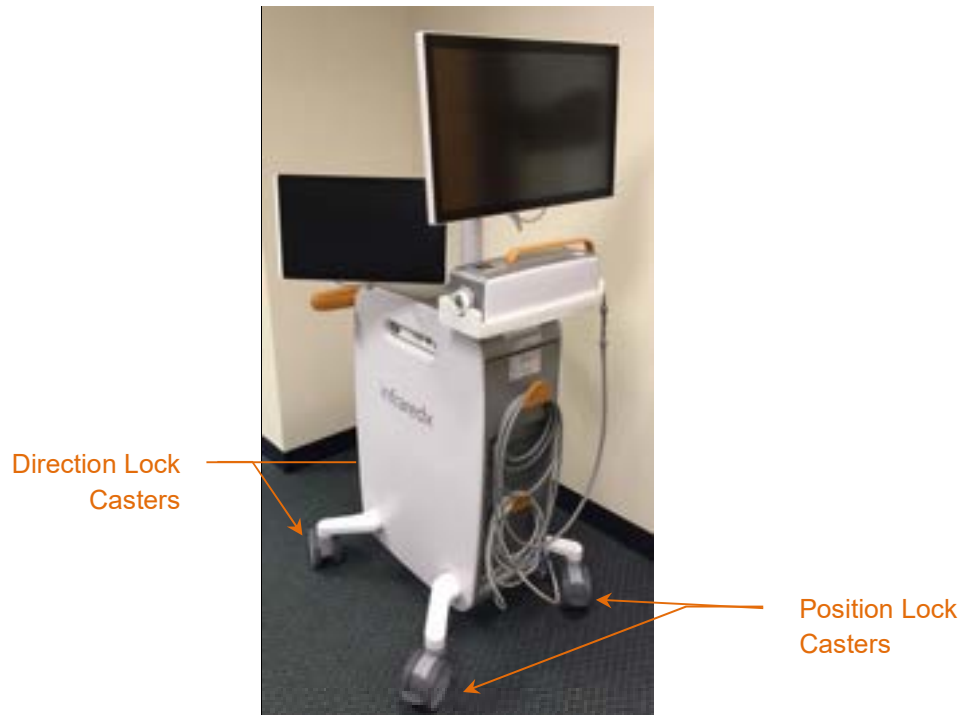


Figure 5-1: Makoto® Intravascular Imaging System.

Disengage the locks on all casters by moving the levers on the casters into the up position to move, rotate, or maneuver the system in confined spaces.

NOTE:

Engage the directional-lock casters on the front of the system to facilitate transit over longer distances.

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NOTE: During transit, position the monitors in line with the Makoto® Intravascular Imaging System body to increase visibility.

5.2 Positioning for Use



WARNING

DO NOT position Makoto® Intravascular Imaging System mobile console operator between the System and other moving equipment in the catheterization lab.



WARNING

DO NOT position the Makoto® Intravascular Imaging System with caster locks engaged within the normal range of motion of pieces of the X-ray system or other catheterization lab equipment during typical use.

The Makoto® Intravascular Imaging System is positioned for use near the foot of the procedure table or on the far side of the procedure table from the physician, to the right of the X-ray system monitor bank.

When the desired position for the system is obtained, engage the position locking casters on the system.



CAUTION

DO NOT reposition the Makoto® Intravascular Imaging System in a way that would obstruct access to the power plug.

NOTE: Adjust the position of the physician display on the Makoto® Intravascular Imaging System to optimize visibility of the image during use.

NOTE: To prevent accidental Makoto® Console motion, engage the position locking casters located at the rear of the console.

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5.3 Storage Between Uses



These instructions are NOT for long term storage of the Makoto® Intravascular Imaging System. Please contact Infraredx Customer Service or your local service provider for guidance on how to prepare the system for long term storage.

When not in use, the Makoto® Intravascular Imaging System should be configured in a manner to reduce the risk of damage to the system.

1. Position the Makoto® Controller securely within the cradle on the rear of the system.
2. Coil the Makoto® Controller umbilical neatly and hang upon the top hook on the rear panel of the system.
3. Coil the power cord neatly and hang upon the bottom hook on the rear of the system.
4. Engage the locking casters on the rear of the system.
5. Turn the monitors to be in-line with the body of the system.

In addition to the steps above, select a storage location with easy access that is located in a low traffic area where the risk of impact with other moving equipment (beds, gurneys, etc) is minimized. The location should meet the environmental and physical requirements outlined in Section 17 Maintenance of this manual.

6 Starting the Makoto® Intravascular Imaging System

6.1 Powering On



WARNING

Ensure that cables originating from or connecting to the Makoto® Intravascular Imaging System lay flat on the floor.

1. Remove the power cord from the rear of the system. While holding the plug, allow the rest of the cord to fall flat on the floor.
2. Plug the system into an easily accessible grounded power outlet.

Power Button



Figure 6-1: Makoto® Intravascular Imaging System side panel with power button highlighted.

3. Power on the system by pressing and releasing the button located on the side of the console. This action will supply power to both the Makoto® System console and Makoto® Controller.

After the System powers on and the software loads, the Makoto® log in screen will be presented to the operator.

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If the power cable plug appropriate for the region of use does not contain a ground, then attach a grounding cable to the equipotential ground stud located on the rear of the Makoto® Intravascular Imaging System at the bottom.



Figure 6-2; Equipotential grounding stud located on the rear of the Makoto® Intravascular Imaging System on the bottom right edge.



During the system start up sequence the Makoto® Controller catheter connection socket will rotate automatically. If a catheter is attached during startup of the system ensure that the catheter has been withdrawn from the patient.


NOTE:

If the Makoto® Intravascular Imaging System is powered on and it is not in the READY position, when prompted by the System please use the distal motion controls to advance the imaging core distally until the READY position is achieved.

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6.2 Powering Off



If at any time the **STOP** button, , on the Makoto® Controller does not halt catheter motion, immediately unplug the Makoto® Intravascular Imaging System.

To turn off power to the Makoto® Intravascular Imaging System, press and release the power button located on the right side of the console.



If at any time a momentary press and release of the power button does not shut the system down, then press and hold (~5 seconds) the power button until the system shuts down.

6.3 User Log In

The Makoto® Imaging System is configurable to support different user profiles to control accessibility of certain features, settings or patient data.

Review section 14.12 User Management for more information about user profiles, permissions, and restrictions.



Figure 6-3: Makoto® Imaging System user log in screen

6.3.1 Standard Log In

When the system is powered on, a valid username and password combination will be requested to record access to the system and set the proper permissions and visibility of data saved on the system.

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6.3.2 Skip or Anonymous Log-in

In some cases of an emergent procedure or if users have forgotten their Makoto® user credentials, it is still possible to operate and obtain data. When a user has logged into the Makoto® Imaging System without using a valid username or password features and functions of the system are limited to those that are essential to conduct a procedure.

6.3.3 Enable Virtual Keyboard

In some situations, or configurations of Makoto® Imaging System it may be preferable to disable the onscreen virtual keyboard. Touch the keyboard icon to toggle the keyboard on and off. Disabling the keyboard may limit some annotation and searching functions that require keyboard input if there is no physical keyboard attached.

6.4 User Log Out

The Makoto® Imaging System supports the ability for users to log out of the active session without powering off the system.

The user may Log Out of the system by touching or clicking the “Settings” icon and then selecting “Log Out Username”.

If the system remains inactive beyond the configured time limit, the system will automatically log out if a catheter is not connected.

6.5 Help

An electronic version of this manual is available for viewing in a window by touching the “Help” button from the system user log in screen.

NOTE: After log in, the electronic version of this document is also accessible by touching or clicking the Settings icon in the top right of the screens, see Section 13.1 Accessing the Electronic User Guide

The user guide may be accessed by the user by touching or clicking the “Help” icon at the “Log In” prompt or by navigating to Settings and Tools when available.

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Figure 13-1: System Log In prompt (left) and Settings and Tools (right) where the “Help” function prompt is located

User Guide Language

7 Setup of Patient and Procedure Information

In the Acquisition Mode during the Setup Phase, the user may enter information about both the patient and the procedure to permit archiving and to facilitate retrieval for later review. This information may be entered at the beginning of the procedure or at any time prior to ending the procedure.

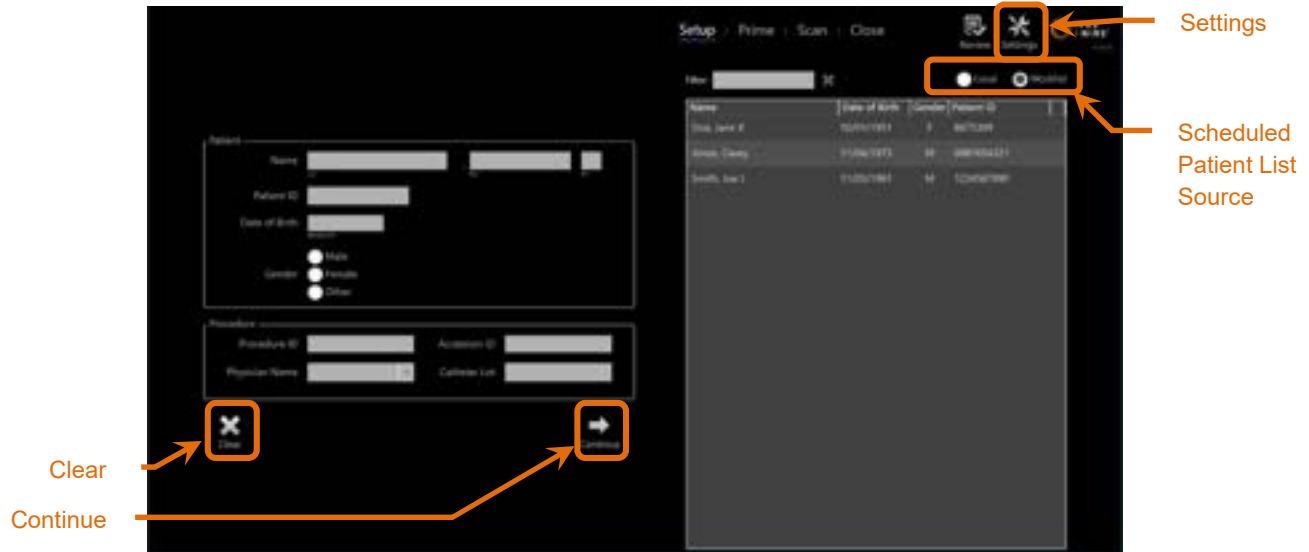


Figure 7-1: Setup Phase of Acquisition Mode with main controls highlighted.

There are four pieces of patient identification elements that can be entered for each procedure. These elements include the Patient Name, ID number, Gender, and Date of Birth (DoB). Data fields that are configured as “required” must be completed to close the procedure for later review and archive.

Patient Name	The name of the patient may be entered in the format of last or family name, first or given name, and middle name initial.
Patient ID	The medical record number or file number for the imaged patient.
Gender	The Makoto® Intravascular Imaging System provides three different gender options to help describe the patient.

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Date of Birth The month, day and year of the patient may be specified.

NOTE: Use the "Other" gender option for anonymous patient entry.

There are four additional fields that may be used to further identify the procedure:

Procedure ID	The number or code used to identify this imaging procedure.
Accession ID	This is a procedure identification value often assigned at time of patient registration for the procedure and may be used by PACS to verify transferred data. This value is typically entered automatically when Modality Worklist features are used.
Physician	The name of the attending physician for this imaging procedure.
Catheter Lot	The catheter build lot number used during this imaging procedure.



Ensure correct entry of patient information to avoid mislabeled data or misplacement of procedure data.

NOTE: Required Fields for patient and procedure identification may be configured in Settings, see section 14.7.

NOTE: Enter the catheter lot number prior to acquiring data to automatically enter the catheter lot number into each scan file when it is recorded.

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7.1 Manual Entry of Patient and Procedure Information

Manual entry of patient and procedural information can be performed using the on-screen software keyboard.



Touch **Clear** to remove the patient and procedure data from the Setup fields and begin again.

NOTE: Information fields may be completed at any time prior to closing the procedure when the system is not actively acquiring image data.

7.2 Semi-Automated Entry of Patient and Procedure Information

Patient data may be directly entered into the fields provided as described above, or to improve consistency of entry for returning or scheduled patients, it is possible to select information from the Local Directory or Scheduled Patient listing (Worklist).

NOTE: Touch the column titles in the Scheduled Patient listing to sort the list in different ways.

NOTE: Type text in the Filter to reduce the list to Names and Patient IDs that match your entry. Either delete the text or press clear to return to the complete list.

NOTE: The local patient list appears by default. Worklist option appears when the system is configured for Modality Worklist connection.

NOTE: Selecting from the list will overwrite corresponding fields in the Patient and Procedure information fields.

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7.2.1 Local Patient Listing

The system will automatically load patient information from previously recorded procedures remaining on the system into the Scheduled Patient listing.

Touch the desired name in the list to complete setup of the Patient Name, Patient ID, Gender, and DoB.

The remaining procedure fields will require manual entry.

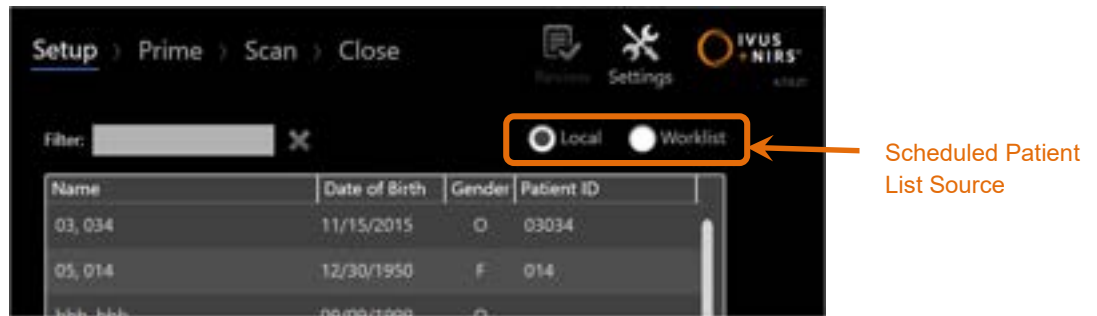


Figure 7-2: Setup Phase with selection control for the source of the scheduled patient listing highlighted.

7.2.2 Modality Worklist

If the system has been configured to load modality worklist information from the hospital information system (HIS), then the Scheduled Patient listing content can be switched from a local patient listing to the modality worklist retrieved from HIS.

See Section 14.5 to configure the Modality Worklist connection features.

The system will automatically retrieve all patient and procedure details for X-ray angiography, "XA", modality type for the current date and make it available for selection on the system.

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Touch the desired name in the list to complete setup of the Patient Name, Patient ID, Gender, DoB, and procedural information made available by the HIS, such as the Accession ID.

The remaining procedure fields will require manual entry.

NOTE: To refresh the displayed modality worklist entries, switch between the “Local”, , and “Worklist”, , options.

7.3 Clearing Patient and Procedure Information




To clear all patient and procedure information and start again, touch **Clear** .

This action will not delete any recorded scan data in the active procedure.


7.4 Proceeding to the Next Phase

Once the patient and procedure data have been entered, to move to the Prime Phase of





the Acquisition Mode, touch **Continue** .

NOTE: Use the Progress Strip control to change phases; press the desired Phase to skip phases of the procedure.

NOTE: With a catheter connected, pressing **Mark** button, , on the Makoto® Controller will immediately progress to the Prime Phase.

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NOTE: With a catheter connected, pressing **Live IVUS** button,  on the Makoto® Controller will immediately progress to the Prime Phase.

NOTE: With a catheter connected, pressing **Pullback** button,  on the Makoto® Controller will immediately progress to the Scan Phase.

8 Priming the Catheter & Preparing the Makoto® Controller for Use

The next phase of the procedure begins with priming the imaging catheter. In parallel, the Makoto® Controller may be placed into the sterile field for use. The preparation for imaging concludes with connecting the imaging catheter to the controller and evaluating the catheter preparation.

8.1 Priming the Catheter



WARNING

The sterile catheter must be primed and prepared in accordance with the instructions for use document that is included inside the catheter package.

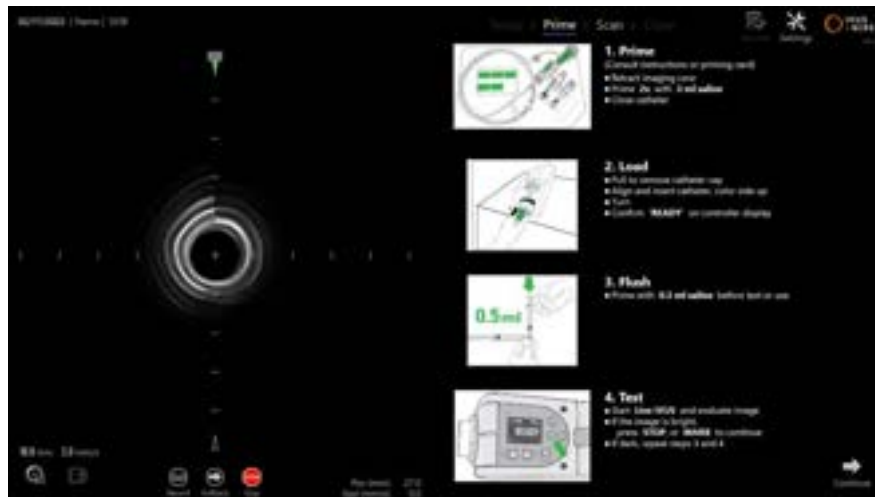


Figure 8-1 Onscreen priming guidance provided in the Prime Phase of Acquisition Mode.

The Makoto® Intravascular Imaging System will provide onscreen guidance on the main steps for priming a catheter that is attached to the Makoto® Controller.

These steps are intended to illustrate and augment the instructions included with the catheter and does not replace the need for the user to be trained, and to read and understand the Instructions for Use packaged with the catheter.

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Using the on-screen illustrations, graphical guidance provided with the catheter, and the written catheter Instructions for Use, the sterile operator must prime the catheter.

8.2 Preparing the Makoto® Controller

The Makoto® Controller must be placed into a Makoto® Controller Sterile Barrier before it is placed on the procedure table.

Please note that the following instructions require the participation of a sterile operator and a non-sterile operator to apply the sterile barrier and place the Makoto® Controller into the operating field:



WARNING

If the Makoto® Controller Sterile Barrier is damaged at any time, immediately replace with a new sterile barrier.



WARNING

Keep the sterile operator's hand outside of the blue cover on the sterile barrier.



WARNING

Position the Makoto® Controller in a stable location on the procedure table. DO NOT place the controller near the edges of the table.



WARNING

Procedure table should be kept level during Makoto® System operation or at any time when the Makoto® Controller is in the sterile field. DO NOT utilize table pitch, tilt, or roll controls, if available.



WARNING

Ensure that umbilical slack is provided within the sterile field to accommodate motion of the table, console, or patient to minimize risk of unintended Makoto® Controller motion.

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WARNING

DO NOT allow sterile items to contact Makoto® Controller through the catheter socket opening of the Makoto® Controller Sterile Barrier.



WARNING

DO NOT allow the side of the sterile barrier gasket cover that has come in direct contact with the Makoto® Controller socket to come in contact with the sterile operator.

To position the Makoto® Controller within the sterile field, perform the following steps:

1. The non-sterile operator removes the sterile barrier from the catheter box.
2. The non-sterile operator opens the package containing the Makoto® Controller Sterile Barrier.
3. The sterile operator removes the Makoto® Controller Sterile Barrier from the packaging, and unfolds the two short folds on the barrier revealing the white gasket with the blue plastic cover.
4. The non-sterile operator removes the Makoto® Controller from the storage cradle, which is outside the sterile field.
5. The non-sterile operator holds the Makoto® Controller parallel to the floor in the air near the sterile field while holding the handle at the rear of the controller.
6. The sterile operator inserts their right hand into the Makoto® Controller Sterile Barrier fold indicated with a hand and an arrow. The barrier should be oriented so that the blue cover for the socket is aligned with the top of the Makoto® Controller.

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7. The left hand is inserted into the fold on the other side of the Makoto® Controller Sterile Barrier also indicated by a hand and an arrow.
8. The sterile operator holds the Makoto® Controller Sterile Barrier open.
9. The non-sterile operator transfers the Makoto® Controller to the sterile operator by placing the controller into the open Makoto® Controller Sterile Barrier.
10. The sterile operator grasps the Makoto® Controller through the Makoto® Controller Sterile Barrier by the handle on the top of the controller, supporting the full weight.
11. The non-sterile operator then releases the controller and then grips the edges of the Makoto® Controller Sterile Barrier opening indicated by arrows and pulls the barrier to cover the umbilical cable of the Makoto® Controller.
12. The sterile operator places the enclosed Makoto® Controller on the procedure table.
13. The sterile operator aligns the white gasket of the Makoto® Controller Sterile Barrier with the socket of the Makoto® Controller and secures the barrier gasket to the socket.
14. The non-sterile operator should secure the position of the umbilical to prevent the bagged portion from leaving the sterile procedure area during use.

The Makoto® Controller is now ready for catheter connection.

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Ensure the white gasket is securely attached to the socket of the Makoto® Controller. The barrier material should not obstruct the opening. There will be a small gap between the white gasket and the front surface of the controller when properly applied.

8.3 Connecting the Catheter



The sterile catheter must be handled and prepared in accordance with the instructions for use document that is included in the catheter package.



Do not touch the underside of the blue cover as it may have been in contact with the Makoto® Controller socket which is not sterile.

The catheter instructions included in this manual are for general guidance only. Always follow the Instructions for Use documentation packaged with each Infraredx catheter.

The catheter must be connected to the Makoto® Controller by a sterile operator.



The Makoto® Controller should be positioned on the patient table such that adequate space for the catheter connection is available and the Makoto® Controller catheter socket is free of obstructions.



Do not contaminate the fiber faces of the catheter or Makoto® Controller socket during the connection process.

1. Confirm that the white gasket of the sterile Makoto® Controller barrier is secured to the Makoto® Controller socket.
2. Remove the blue covering from the sterile Makoto® Controller barrier along the perforated lines and discard out of the sterile field.

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3. Confirm that the Makoto® Controller is in the READY position as indicated by the “LOAD” message on the LCD screen located on the top of the controller.
4. Align the catheter handle with the colored side facing up.
5. Insert the catheter handle into the Makoto® Controller catheter socket.
6. Turn the catheter handle clockwise until the controller LCD screen indicates that the catheter is fully connected by observing the “READY” message.

NOTE: If the Makoto® Controller identifies a partial catheter connection, then instruction will be indicated on the LCD screen or “See Display” will be indicated on the controller LCD screen and additional detailed instruction will be provided on the Makoto® System display.

8.4 Testing the Catheter

After priming the catheter as directed by the instructions packaged with the catheter and connecting it to the Makoto® Controller, the catheter performance can be verified by using the “Live IVUS” function on the system.

Prime the attached catheter with an additional 0.5mL of saline and press “Live IVUS”,




on the Makoto® Controller to begin imaging. If an IVUS image appears as concentric circles and the image brightness is acceptable then either touch “STOP”,




on the screen or press “STOP”,  on the Makoto® Controller.

NOTE: If the image is not acceptable or is dark, continue to flush the catheter using the priming syringe.

Proceed to the Scan Phase by touching “Scan”, , in the Progress Strip control at the top of the screen.

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NOTE: Assessment of the quality of the catheter prime can be performed on either the “Prime” or “Scan” Phase screens.

NOTE: While the catheter is rotating and image is updating, press **Mark** button, , on the Makoto® Controller to advance to the Scan Phase.

NOTE: Press Pullback button, , on the Makoto® Controller to advance the system to the Scan Phase and begin an automated pullback acquisition.

9 Acquiring Makoto® Intravascular Scan Images



WARNING

See catheter Instructions for Use document for guidance on loading the catheter onto the guidewire, the catheter into the guiding catheter, and advancing the catheter into the artery.

After assessing the quality of the catheter prime, the catheter should be positioned onto the guidewire and advanced as directed by the catheter Instructions for Use.

There are two types of data acquisition that may be performed using the Makoto® Intravascular Imaging System: Live IVUS and Automated Pullback acquisitions.

A Live IVUS acquisition will generate IVUS images without a Chemogram. An Automated Pullback will generate IVUS images with a Chemogram.

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9.1 Live IVUS Acquisition

During a Live IVUS data acquisition the system will start rotation of the catheter imaging core without starting automated pullback (proximal translation) of the imaging core. A transverse IVUS image will appear on screen and will be updated while Live IVUS is enabled.

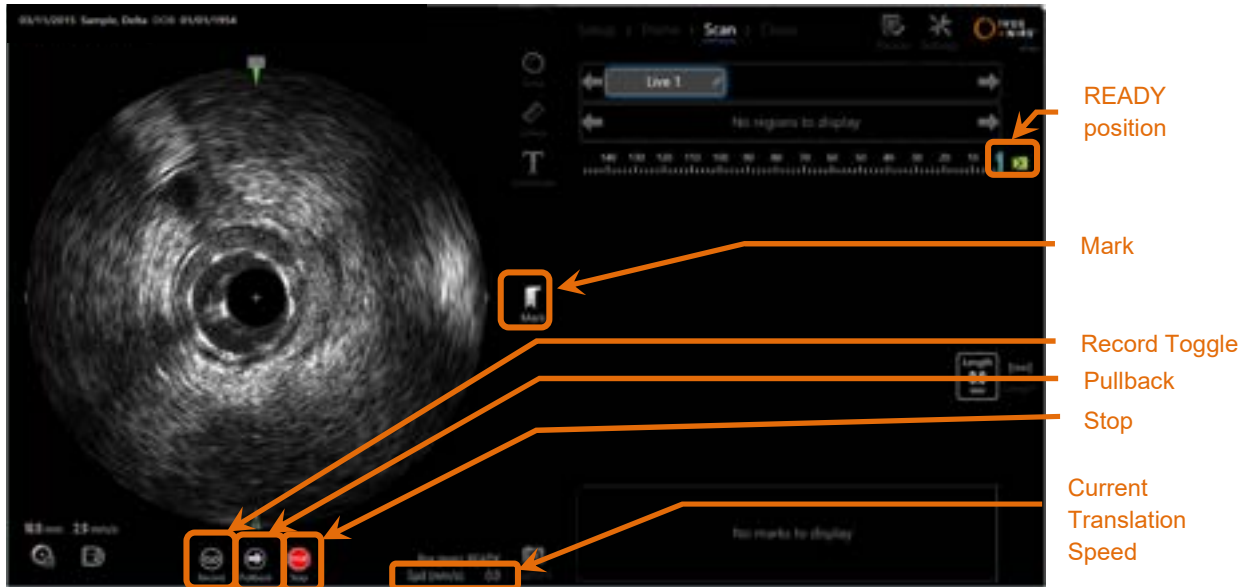



Figure 9-1: Makoto® Acquisition Mode during an unrecorded Live IVUS scan, with remote control features enabled.

NOTE: A Live IVUS scan will not be saved to system memory unless the user chooses to record the scan.

NOTE: Live IVUS will produce an IVUS image only; no NIRS data will be displayed or Chemogram generated.

NOTE: Live IVUS will produce a live transverse IVUS image. The IVUS image will also be displayed in the Longitudinal IVUS display area during a recorded Live IVUS scan.


9.1.1 Starting Live IVUS

Press the **Live IVUS** button, , on the Makoto® Controller to enable real time IVUS imaging. The imaging mode status on the LCD screen will update to show “LIVE” and the position information is printed using white text.

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Figure 9-2: Makoto® Controller showing Live IVUS acquisition that is not recorded at the READY position (left) and 0.0 mm position (right).

NOTE: If Remote Control features are enabled, then Live IVUS imaging can be initiated by touching the Live IVUS icon, , on the monitor. See Section 14.10.6 Enable Remote Control to enable the features.

9.1.2 Translating Live IVUS



WARNING

Hazardous situations, including injury to the patient or operator, may occur if display warnings are ignored.




WARNING

Controller linear motion will stop when excessive force is encountered.

Check catheter for kinks, sharp bends, or damage and resolve before continuing.



Press the STOP button, , on the Makoto® Controller and follow-on screen prompts to resolve.

DO NOT use single step translation functions to overcome the kink or bend. Catheter sheath damage or patient injury may result.

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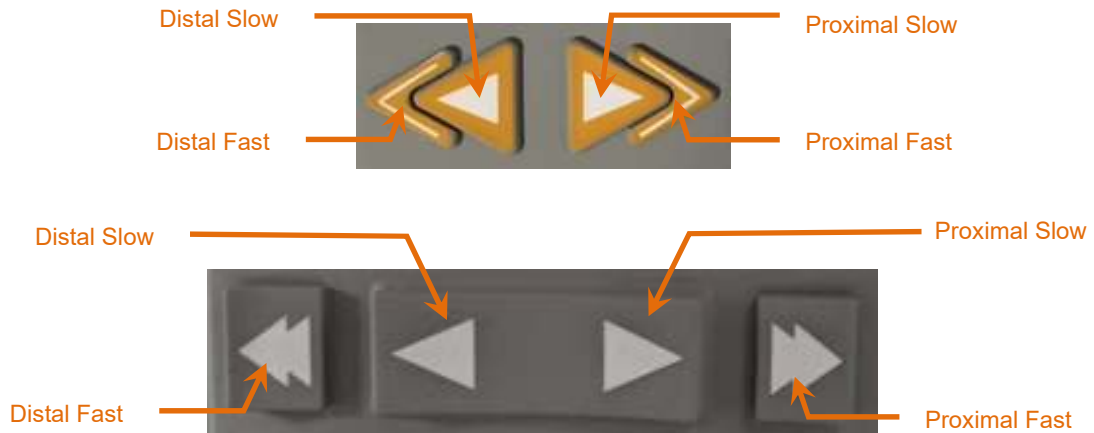


Figure 9-3: Imaging Core Translation Controls, different configurations (top, bottom) may be available.

While performing a Live IVUS scan, use the distal and proximal motion controls on the Makoto® Controller to adjust the position of the current image within the vessel.

Pressing and holding the slow motion controls will translate in the desired direction at a rate of 2.0 mm/s. Pressing and releasing will translate in the desired direction a fixed distance of 0.1 mm.

Pressing and holding the fast motion controls will translate in the desired direction at a rate of 10.0 mm/s. Pressing and releasing will translate in the desired direction a fixed distance of 0.5 mm.

NOTE: While actively imaging in the READY position, translation in the proximal direction will result in the image core position moving into the continuous imaging range of 0 mm to 150 mm.

Returning to the READY position can only occur when the system is not acquiring images.

NOTE: While actively imaging, proximal AND distal translation will occur only within the range of 0mm to 150 mm. Translation will stop automatically when these extreme positions are achieved and imaging will continue.

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NOTE: While at the 0 mm position and not imaging, pressing either of the distal position controls,  or , will return the controller and catheter imaging core to the READY position.

9.1.3 Recording a Live IVUS Frame

While performing an unrecorded Live IVUS scan, a single frame may be saved to document the procedure. This frame may be saved, reviewed, measured, or discarded.

During a Live IVUS scan, press the **Mark** button on the Makoto® Controller, , or touch the **Mark** control, , on the Makoto® System display to bookmark the frame. This frame will be recorded as a single frame scan.

9.1.4 Recording a Live IVUS Scan

A series of Live IVUS frames may be recorded in a single scan file.

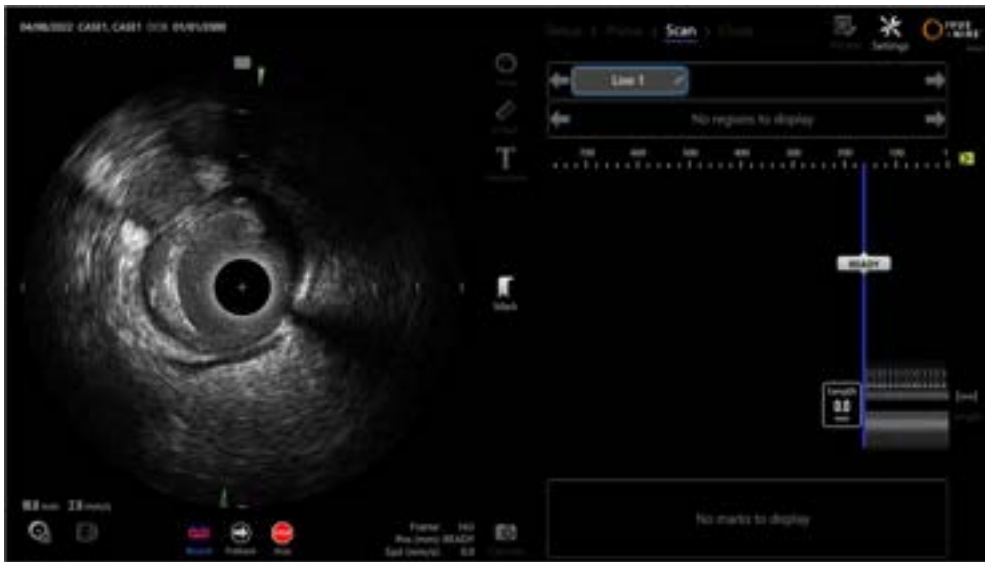




Figure 9-4: Makoto® Acquisition Mode during a recorded Live IVUS scan with remote control enabled.

Press the **Live IVUS** button on the Makoto® Controller, , or touch **Record**, , on the Makoto® System display near the transverse IVUS image to enable recording.

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Press the **Live IVUS** button on the Makoto® Controller, , or touch **Record**, , again on the Makoto® System display to stop the recording of data only. The catheter will continue to rotate and the transverse IVUS image will continue to update.




Figure 9-5: Makoto® Controller LCD screen with a IVUS+NIRS Imaging Catheter connected during the process of transitioning from the start of unrecorded Live IVUS at READY (left) to recording then translation proximal and stationary Live IVUS (middle) to zeroing and translating proximal while recording (right). Note the appearance of the recording icon during recorded Live IVUS. When translation is performed during recorded Live IVUS a solid bar appears where the recording in this acquisition was already performed since the last Mark (middle and right) and recording prior to the most recent mark is an empty bar (right).


During translation of Live IVUS, the relative position, actual position, and translation speed indicators will update.

NOTE:

Press either the **STOP** button on the Makoto® Controller, ,

or touch **STOP**  on the Makoto® System display to halt catheter rotation and motion AND terminate the recording.

NOTE:

Press the **Pullback** button on the Makoto® Controller, , to terminate the current Live IVUS recording and begin a new Automated Pullback scan at the current pullback rate setting. Automated Pullback scans are always recorded.

NOTE:

Marks may be made in the scan file and transverse IVUS measurements may be made on the frames of a recorded Live IVUS scan to further document the procedure.

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9.1.5 Marking and “Zeroing” during Live IVUS

During recorded Live IVUS acquisition, Marks can be placed and reviewed later by pressing the Mark button on the controller or touching the Mark icon on the screen.

During unrecorded Live IVUS acquisition, Marks can be placed and reviewed later as single frame recordings by pressing the Mark button on the controller or touching the Mark icon on the screen.


Adding a Mark during any Live IVUS acquisition will reset the display of distance traveled back to 0.0mm.

9.1.6 Stopping Live IVUS

A Live IVUS scan may be discontinued in two ways:

- a. Press the **STOP** button, , on the Makoto® Controller or touch **STOP**, , on the user interface to halt Makoto® Controller motion, cease updates of the transverse IVUS image, and end the recording any Live IVUS scan in progress.

Or,

- b. Press **Pullback**, , to complete the Live IVUS scan and immediately begin an automated pullback acquisition.

NOTE: After stopping the Live IVUS, the Makoto® Controller panel will display the distance traveled since the last press of the Mark button. This will remain on the panel until Live IVUS, Pullback, Return to READY, or a translate button is pressed.

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9.2 Automated Pullback Acquisition

An automated pullback acquisition will start rotation and pullback of the Makoto® Controller and catheter imaging core. This action will also start the collection and recording of both IVUS and NIRS data when used with an IVUS+NIRS capable catheter or just IVUS data when used with an HD-IVUS only capable catheter at the pullback rate set by the user.

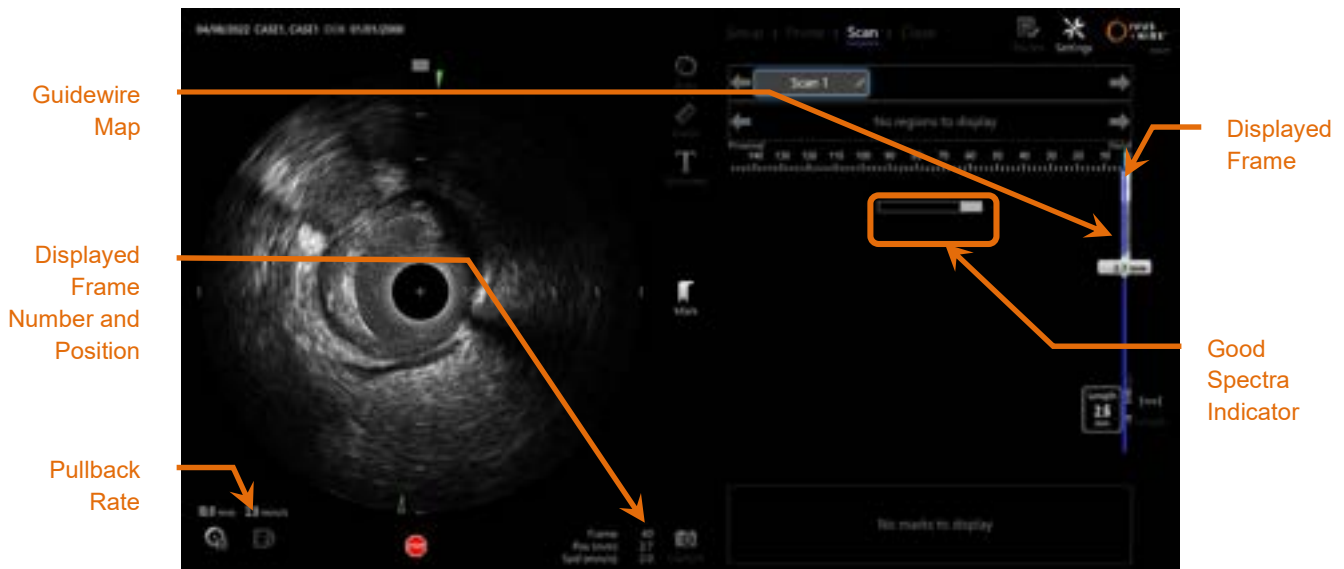



Figure 9-6: Acquisition Mode with IVUS+NIRS automated pullback acquisition in progress.

9.2.1 Setting the Next Automated Pullback Rate

The rate of translation for an automated pullback must be configured by the user prior to starting any imaging. Set the desired pullback translation rate by touching

the Makoto® Controller Panel icon, . Select the desired speed for the next pullback: 0.5mm/s, 1.0mm/s, or 2.0mm/s.

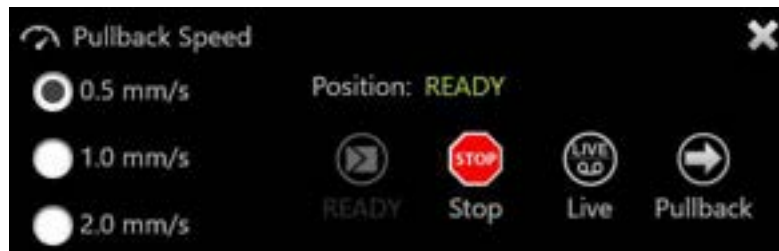




Figure 9-7: Makoto® Controller Panel with Remote Control features enabled.

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9.2.2 Starting Automated Pullback


Press the **Pullback** button, , on the Makoto® Controller to begin an automated pullback acquisition. During a pullback, Transverse IVUS, Longitudinal IVUS, Guide Wire Detection Map, and Good Spectra Indicator are updated real-time.

NOTE: If Remote Control features are enabled, then Automated Pullbacks can be initiated by touching the Pullback icon, , on the monitor. See Section 14.10.6 Enable Remote Control to enable the features.

9.2.2.1 Automated Pullback Acquisition with Preview

When starting an Automated Pullback Acquisition from the READY position using the

Pullback button, , the system will first move to the “0.0mm” position and begin Live IVUS acquisition. This permits an intravascular preview of the pullback starting

location. After previewing, press the **Pullback** button, , again to proceed with the acquisition.

9.2.2.2 Good Spectra Indicator

At the start of an Automated Pullback scan, the Makoto® Intravascular Imaging System will monitor the quality of the light spectrum recorded. The system requires a minimum number of spectra to generate a Chemogram. As good spectra are recorded the Good Spectra Indicator will fill. When the minimum number has been reached, it will disappear.

NOTE: When the Makoto® System collects enough data necessary for the system to create a Chemogram, the Good Spectra Indicator will disappear from the screen.

NOTE: Approximately 12 mm of pullback scan data, minimum, must be recorded to have enough data to generate a Chemogram.

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NOTE: Even if the Good Spectra indicator fills due to the initial collection of good quality spectra, if the percentage of spectra that are too weak to contribute to chemogram generation exceed 12%, then no chemogram will be generated.

NOTE: Good Spectra indicator will be presented only when automated pullbacks with NIRS capable catheters are performed.

9.2.3 Stopping Automatic Pullback



WARNING

Imaging within the guiding catheter should be minimized for optimum chemogram results.

Once the desired pullback distance has been reached or the desired amount of data has been recorded, the Makoto® Intravascular Imaging System may be halted in two ways:

a. Press the **STOP** button, , on the Makoto® Controller;

Or

b. Touch **STOP**, , on the Makoto® Console user interface.

Either of these actions will halt both the Makoto® Controller motion and stop data acquisition.



CAUTION

In case of emergency use the **STOP** button, , on the Makoto® Controller.

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NOTE: The Makoto® Controller automatically stops the pullback if the most proximal point is reached (position 150.0 mm).

NOTE: After stopping the pullback, the Makoto® Controller panel will display the distance traveled since the last press of the Mark button. This will remain on the panel until Live IVUS, Pullback, Return to READY, or a translate button is pressed.

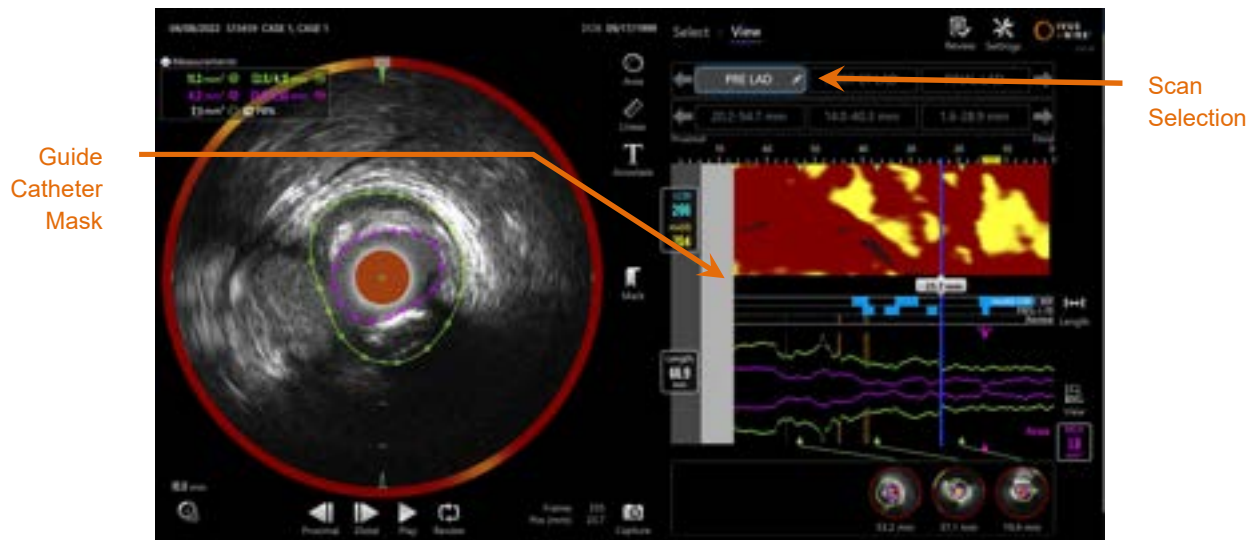


Figure 9-8: Acquisition Mode after the completion of an IVUS+NIRS automated pullback scan with detected guide catheter (SmartImaging™ optional features enabled).

Upon completion of the automatic pullback acquisition with a capable catheter, the Chemogram, Block Level Chemogram, and Lipid Core Burden Index will update. The Guidewire Detection Map will be hidden from view. See Section 10.2.11 for more information.

If the guiding catheter is detected by the Makoto® Intravascular Imaging System, then a gray guide catheter mask will be applied to the Chemogram, Longitudinal IVUS and block level Chemogram. See Section 10.2.10 for more information on how to remove the guide catheter mask from view.

NOTE: If the Guide Catheter Mask is enabled, the portion of the Chemogram within the Guide Catheter Mask will be excluded from LCBI calculation.

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9.2.4 Marking or “Zero-ing” during Automatic Pullback

During Automatic Pullback acquisition Marks can be placed and reviewed later by pressing the Mark button on the controller, image, or touching the Mark icon on the screen.

Adding a Mark during pullback acquisition will reset the display of distance traveled back to 0.0mm distance.

9.3 Performing Additional Scans with the Makoto® Intravascular Imaging System



WARNING

See catheter Instructions for Use document for guidance on preparing the catheter for additional scans.



WARNING

Hazardous situations, including injury to the patient or operator, may occur if display warnings are ignored.




WARNING

Controller linear motion will stop when excessive force is encountered.

Check catheter for kinks, sharp bends, or damage and resolve before continuing.





Press the STOP button, , on the Makoto® Controller and follow on-screen prompts to resolve.

DO NOT use single step translation functions to overcome the kink or bend. Catheter sheath damage or patient injury may result.

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Multiple scans can be performed within each procedure. The catheter may require an additional flush of heparinized saline prior to subsequent imaging.

Press the **Live IVUS** button, , or the **Pullback** button, , on the Makoto® Controller to acquire additional data. The previous scan will be saved and a new active scan will appear.

NOTE: If Remote Control features are enabled, then Live IVUS or Automated Pullback imaging can be initiated by touching the associated icons,  or , on the monitor. See Section 14.10.6 Enable Remote Control to enable the features.

Each new scan will create a new button to activate the scan for review located above the Chemogram.

NOTE: If more than three scans are recorded, use the left and right arrows to bring the desired scan button into view.

NOTE: A total of 20 recordings may be saved per procedure. If the limit is reached, delete unwanted scans or close the procedure and start a new procedure.

NOTE: Annotation of a scan name will change the text on the associated button.

10 Reviewing, Measuring, and Annotating Scans

10.1 Scan Selection

After multiple scans have been recorded it is possible to switch between scans using the Scan Selection controls.

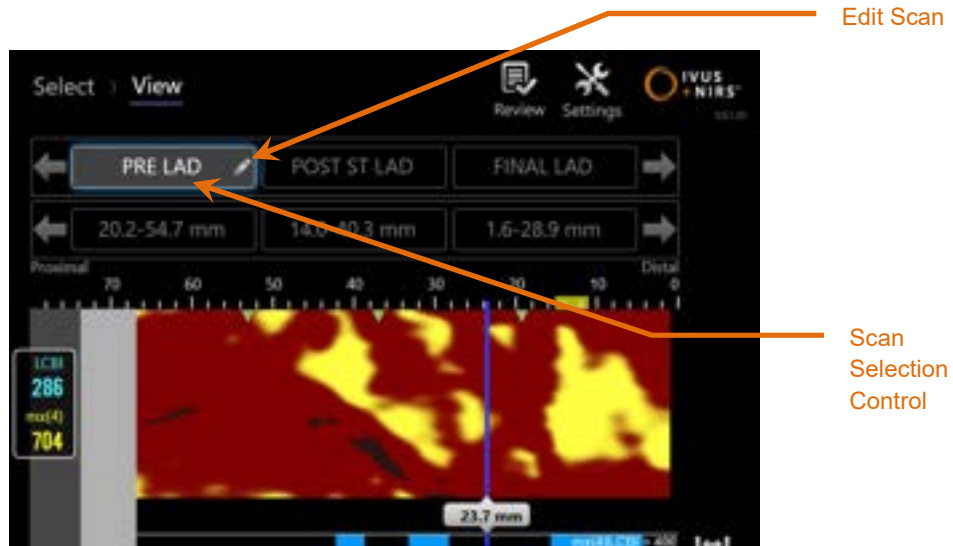


Figure 10-1: View Phase of Review Mode with "RCA" scan selected for review (SmartImaging™ optional features enabled).

Touch the desired scan name to select and load the data for display on the screen.

Up to three scans are visible at any time within the Scan Selection Control. Touch the arrow controls on either side of the Scan Selection Control to move other scans into view.

10.2 Editing Scans

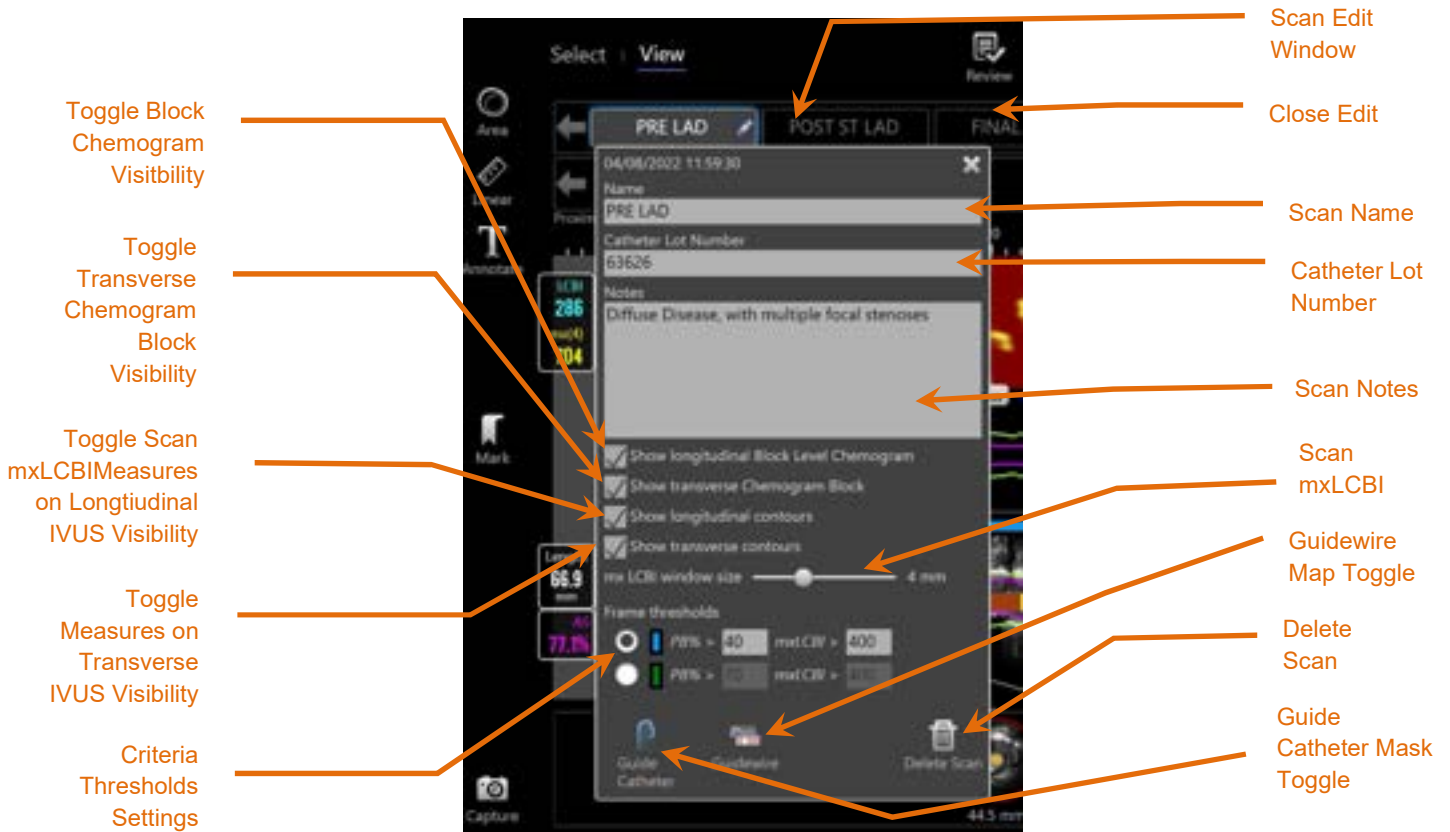


Figure 10-2: Edit Scan Window open for "PRE LAD" (SmartImaging™ optional features enabled).

Scan information can be edited to provide additional detail and facilitate later selection.

Touch the **Edit** button, , on the selected scan to bring up the Scan Edit window.

Touch the "X", , or outside the Scan Edit Window to close and save all changes.

10.2.1 Scan Name

The Scan Name may be customized to reflect information about the scan. It can include artery names, locations, or timing (i.e. "pre" or "post"). The name can be set by entering information in the Name field.

This Scan Name will appear in the directory of completed procedures and scans, as well as DICOM files and reports.

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NOTE: Use the Filter on the Select Phase of Review Mode to search for Scan Names. See Section 12.1 for more information.

10.2.2 Catheter Lot Number

Each scan is collected with a catheter that has an associated production lot number. This information can be recorded independently for each scan by entering the value from the catheter package in the Catheter Lot Number field within the Scan Edit window.

NOTE: Enter the Catheter Lot Number during the Setup Phase to automatically populate this field for scans as they are recorded.

NOTE: If available the system will read the catheter lot number from the catheter and enter it automatically into the field.

NOTE: Use the Filter on the Select Phase of Review Mode to search for Catheter Lot Numbers. See Section 12.1 for more information.

10.2.3 Scan Note

Notes about the collected scan may be recorded in the Notes field of the Scan Edit window.

NOTE: Use the Filter on the Review Mode, Select Phase screen to search for important scan details recorded in the Scan Notes. See Section 12.1 for more information.

10.2.4 Scan Longitudinal Block Level Chemogram Visibility

The visibility of the Block Level Chemogram within the Longitudinal IVUS display may be toggled on or off using this check box. This selection will only affect the current scan.

NOTE: The default visibility setting of the Block Level Chemogram for all new scans can be set in the Settings of the system. See Section 14.8 Scan Display.

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NOTE: This setting can be adjusted quickly by using the mouse to Right Click on the Block Level Chemogram and change the appropriate setting.

10.2.5 Scan Transverse Chemogram Block Visibility

The visibility of the individual Chemogram Block within the Transverse IVUS display may be toggled on or off using this check box. This selection will only affect the current scan.

NOTE: The default visibility setting of the Chemogram Block for all new scans can be set in the Settings of the system. See Section 14.8 Scan Display.

NOTE: This setting can be adjusted quickly by using the mouse to Right Click on the Chemogram Block and change the appropriate setting.

10.2.6 Longitudinal IVUS Contour Visibility

The visibility of the automatically measured contours on top of the longitudinal IVUS display may be toggled on or off using this check box. This selection will only affect the current scan.

NOTE: This setting can be adjusted quickly by using the mouse to Right Click on the Longitudinal IVUS or Transverse IVUS and change the appropriate setting.

10.2.7 Transverse IVUS Contour Visibility

The visibility of the automatically measured contours on top of the Transverse IVUS display may be toggled on or off using this check box. This selection will only affect the current scan.

NOTE: This setting can be adjusted quickly by using the mouse to Right Click on the Longitudinal IVUS or Transverse IVUS and change the appropriate setting.

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10.2.8 Scan mxLCBI

The maximum LCBI window size can be adjusted per scan from the default value. Use the slider to adjust the window used to calculate the mxLCBI from 1mm to 10mm.

NOTE: The default value for all new scans can be set in the Settings of the system. See Section 14.8.5 mx LCBI Window Size.

10.2.9 Frame Condition Thresholds

Within the Scan Edit window, use the radio buttons to select the set of condition thresholds to display in the Condition View. When the measurements on a frame exceed one or both of the conditions that were set, the Condition View will color either the bottom row or the bottom and top row. Two colors are available to set, blue and green. Only one color can display within a scan determined by radial button selected in the edit window.

10.2.10 Guide Catheter Toggle



WARNING

Imaging within the guiding catheter should be minimized for optimal chemogram results.

Within the Scan Edit window, use the Guide Catheter mask toggle control to alternate visibility of the Guide Catheter mask on the Chemogram, Guidewire Map, Longitudinal IVUS, and Block Level Chemogram.

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Figure 10-3: Guide Catheter mask enabled (left). Guide Catheter mask disabled (right). (SmartImaging™ optional features enabled)

10.2.11 Guidewire Map Toggle

Within the Scan Edit window, use the Guidewire Map toggle control to alternate visibility of the Guidewire Map and the Chemogram. When the Guidewire Map is visible the control will appear blue.



Figure 10-4: Scan Edit window with Guide Wire Map toggle enabled (left); Chemogram is hidden and Guidewire Map is visible (right) (SmartImaging™ optional features enabled).

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NOTE: Guidewire Map toggle does not change the display if there is not NIRS data available.

10.2.12 Delete Scan

Individual scans may be deleted via the Scan Edit window. A confirmation prompt will be provided to the user.

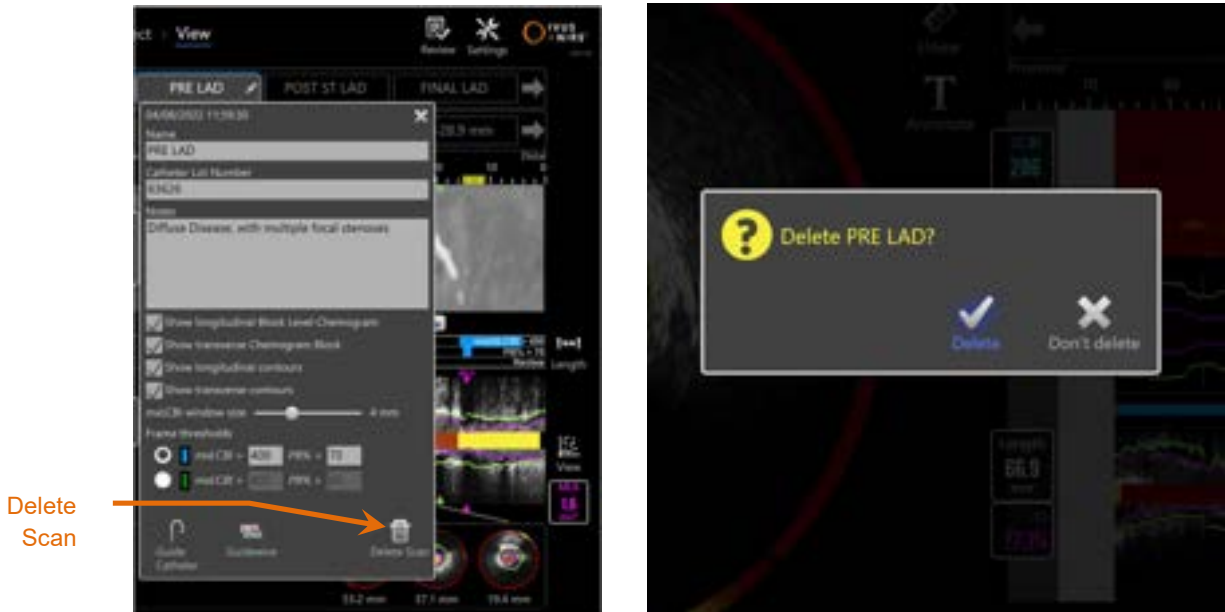


Figure 10-5: The Delete Scan control within the Edit Scan window (left) and the confirmation prompt (right) (SmartImaging™ optional features enabled).



Once confirmed by user, the deletion of a scan cannot be undone.

10.3 Scan Navigation

The selected scan may be reviewed using several controls.

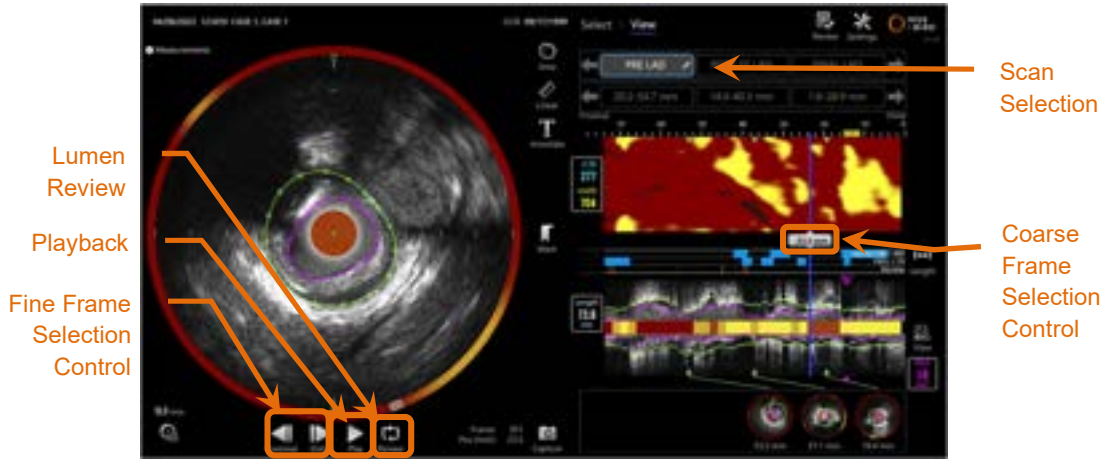


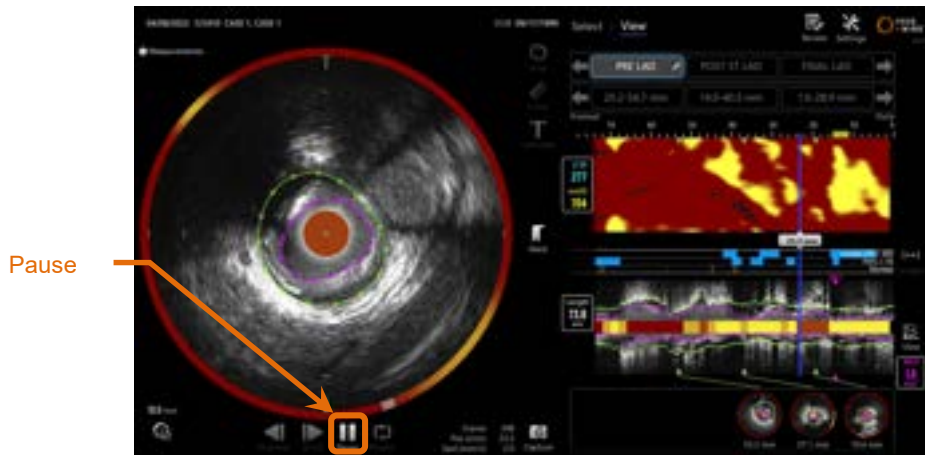
Figure 10-6: View Phase of Review Mode with Scan Selection and Playback controls highlighted (SmartImaging™ optional features enabled).

10.3.1 Automatic Playback



Touch the **Play/Pause** control, **Play** / **Pause**, located beneath the Transverse IVUS image to automatically cycle the recorded frames in the order they were recorded.

The playback will occur at approximately 16 frames per second for Live IVUS recordings or 30 frames per second for Automated Pullback recordings.



10-7: View Phase of Review Mode during automatic playback with the Pause control highlighted (SmartImaging™ optional features enabled).

Pausing will halt playback on the displayed frame. Resuming playback will begin cycling the frames from the last displayed frame.

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NOTE: When the last recorded frame is reached, the playback loop will resume with the first frame in the series.

NOTE: When a region is selected, automatic playback will loop the frames in the selected region.

10.3.2 Lumen Review

As an aid to making measurements and reviewing individual frames, Lumen Review will play a very short loop of frames to accentuate the differences in IVUS appearance of stationary vessel and plaque from the motion related to flowing blood.




Toggle Lumen Review by touching the Lumen Review control, , to the right of the automatic playback button.

NOTE: Adjust the duration or range of the Lumen Review within the system settings. See Section 14.8.2 Lumen Review Range of Frames.

10.3.3 Manual Playback


The selected scan may also be played back manually. Touch and hold either Fine



Frame Selection Control, , to play the scan slowly in the desired direction. In this manner playback will stop when the last frame is reached for the selected scan or region; it will not loop the selected frames.

NOTE:



Press and hold the Distal Fine Frame Selection Control, , to play back the selected frames in reverse order of collection.

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10.3.4 Frame Selection

10.3.4.1 Coarse Frame Selection

Drag the Coarse Frame Selection control between the Chemogram or Guidewire Map and the Longitudinal IVUS or anywhere on the blue line to quickly update the displayed frame.

NOTE: Dragging the Coarse Frame Selection control is a variable rate playback.

10.3.4.2 Fine Frame Selection

Touch the Proximal Fine Frame or Distal Fine Frame Selection controls, , to change the displayed frame in increments of one frame.

NOTE: With the cursor over the Chemogram, Guidewire Map, Transverse IVUS, or Longitudinal IVUS, roll the mouse wheel to change the displayed frame in increments of one frame.


10.3.5 “Go To MLA” or “Go To MLD”

Touch or click the MLA or MLD button to navigate directly to frame where the minimum lumen area or diameter was computed.

NOTE: Toggle the Measurement Graphical Display between Area and Diameter to show the location and value of the MLA or MLD.

10.4 Marks

During and after the scan is completed, Marks may be made. During acquisition of the

scan, press or touch the **Mark** controls,  or . During review, navigate to the desired frame and touch 'Mark' on the screen.

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- NOTE:** Only one Mark can be made on each frame.
- NOTE:** Up to 30 Marks may be created within a single scan.
- NOTE:** Up to six Marks may be in full view on the screen at any time.
- NOTE:** Completing a Transverse IVUS measurement or on frame annotation will automatically create a Mark for the frame.
- NOTE:** Use the Mark button while in the Setup or Prime phases to advance to the next phase of Acquisition Mode.
- NOTE:** During image acquisition, use the Mark button to reset the displays of distance traveled back to 0mm distance.

A Mark's relative position within the scan is indicated by small green triangles on the Chemogram and Longitudinal IVUS. When the Mark is selected the Current Displayed Frame indicator will connect the triangles.

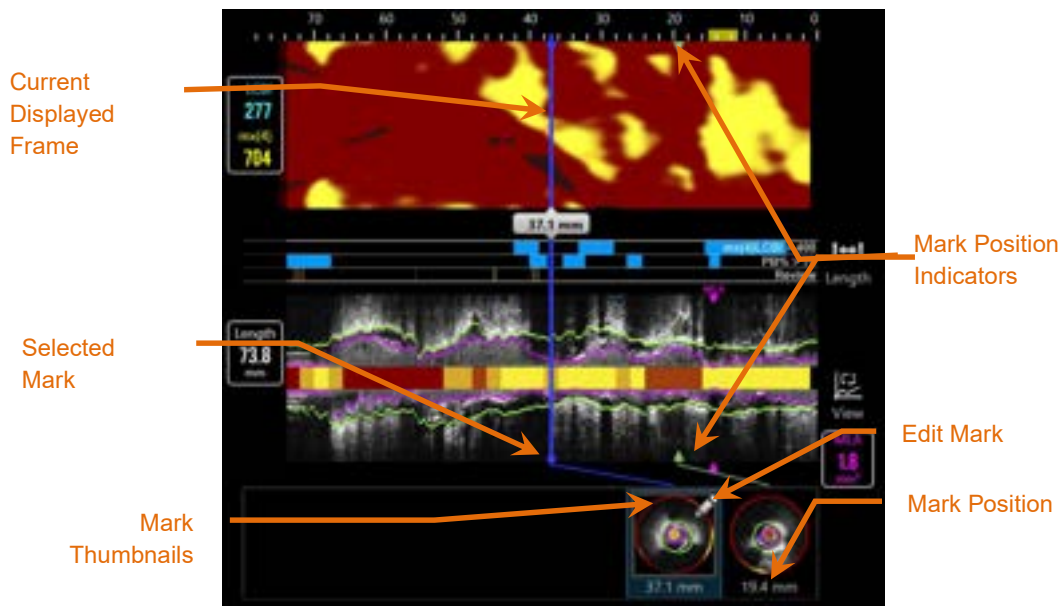


Figure 10-8: Mark positions are displayed by green triangle indicators on the Chemogram and Longitudinal IVUS and with a visual thumbnail showing content of the frame highlighted (SmartImaging™ optional features enabled).


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10.4.1 Mark Selection

A Mark Thumbnail image will be created for each placed Mark. The thumbnail image is the control to select the marked position for later review. It also provides a visual representation of the content at the frame location.

Touch the desired Mark image to update the display and show the frame in the Transverse IVUS display.

10.4.2 Mark Edits

Marks may be deleted or annotated. Touch the **Edit** button, , on the selected Mark to open the Mark Edit window.

Touch the “X”, , or outside the Mark Edit window to close the window, saving the changes.

10.4.2.1 Mark Notes



Figure 10-9: Mark Note entered in the Mark Edit Window.

Notes about the content of a frame may be recorded in the Notes field of the Mark Edit window.

10.4.2.2 Deletion

Marks may be discarded using the **Delete** control, , within the Mark Edit Window.

NOTE: Deleting a Mark cannot be undone.

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NOTE: Deleting a Mark with measurements or frame annotations will require a confirmation.

10.5 Measurements

The Makoto® Imaging System provides controls with the Scan Phase to perform measurements on the Transverse Display and the Longitudinal Displays (Chemogram and Longitudinal IVUS).

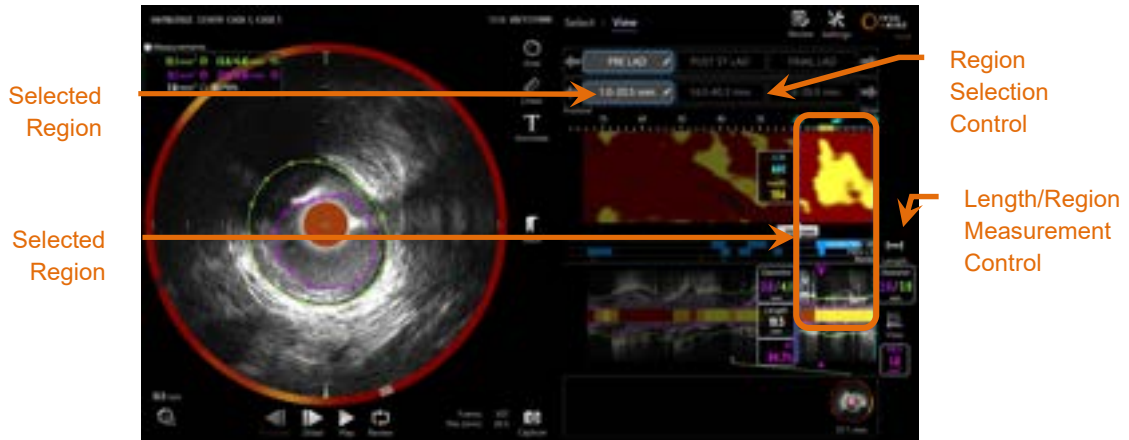


Figure 10-10: View Phase with a Region Selected within the "RCA" scan (SmartImaging™ optional features enabled).

10.5.1 Length, Lumen Area Stenosis and LCBI Measurement

Length, Lumen Area Stenosis and LCBI measurements are made on the longitudinal IVUS view and Chemogram through the creation of Regions.

10.5.1.1 Region Creation

Regions are sub-segments of a scan that have some relevance for the operator or physician. These segments may encompass lesions, normal segments, stents, etc.

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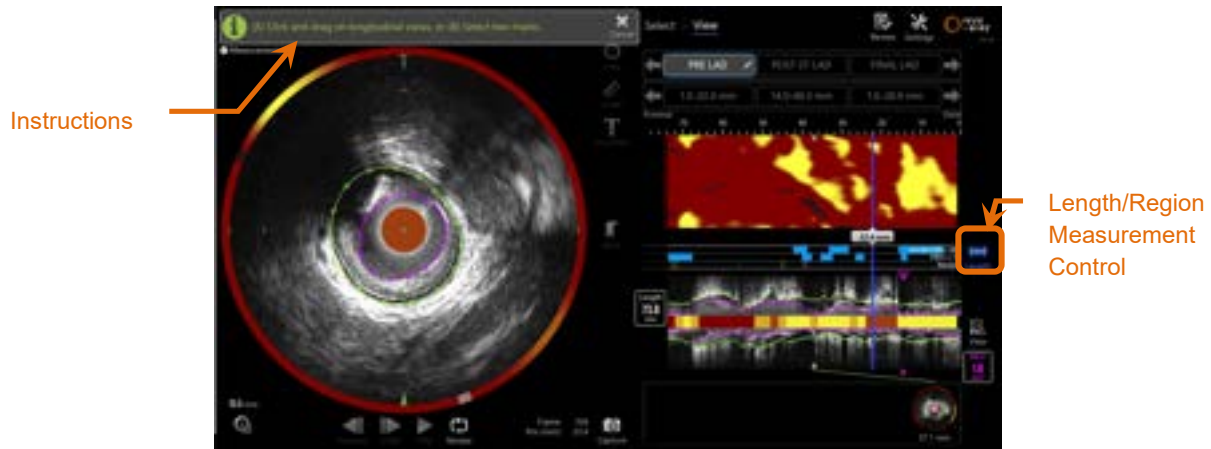



Figure 10-11: View Phase with a Region creation in process. Note the on-screen instruction on completing the region (SmartImaging™ optional features enabled).

Regions are created by touching the Length control, , and then indicating a start and end location of the Region on the Longitudinal IVUS or Chemogram. The Region may be defined by:

- (A) touch and hold the desired start position then dragging to the desired end position
- or
- (B) touch the start and end Mark positions from the Mark Thumbnails.

NOTE: Use Marks to set the start or end of a desired region with increased precision.

When the Region is created, areas of the longitudinal displays outside the region are dimmed and a Region Selection control will appear below the Scan Selection controls.

NOTE: Use the Playback control, , to loop the selected region.

The LCBI and results are presented to the left of the Chemogram region and the Length presented to the left of the Longitudinal IVUS.

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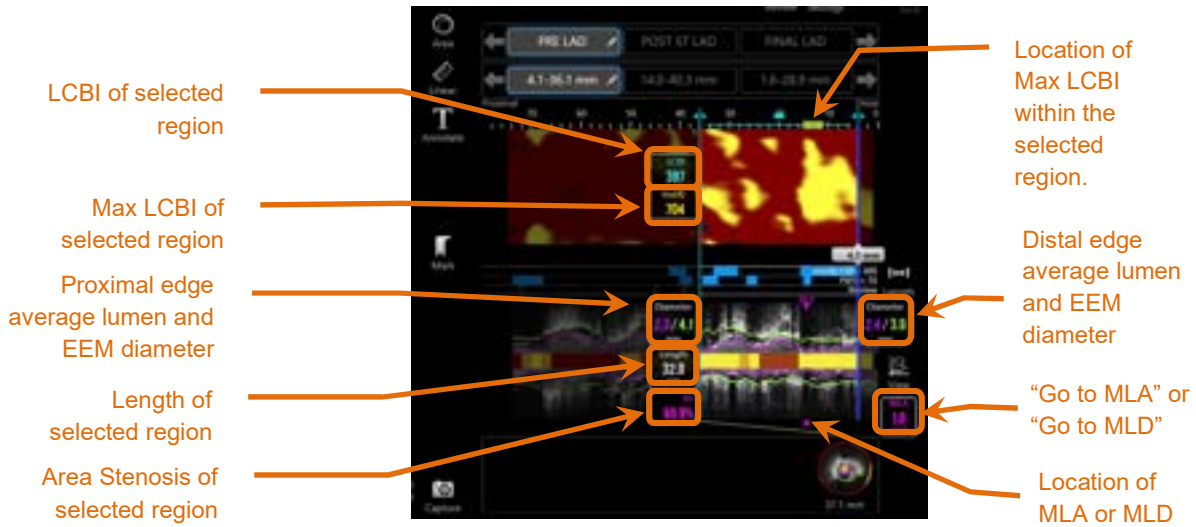


Figure 10-12: View Phase with Region selected (SmartImaging™ optional features enabled).

10.5.1.2 Region Editing

Regions that have been created within the chemogram can be adjusted for position within the scan or their start and end locations adjusted.

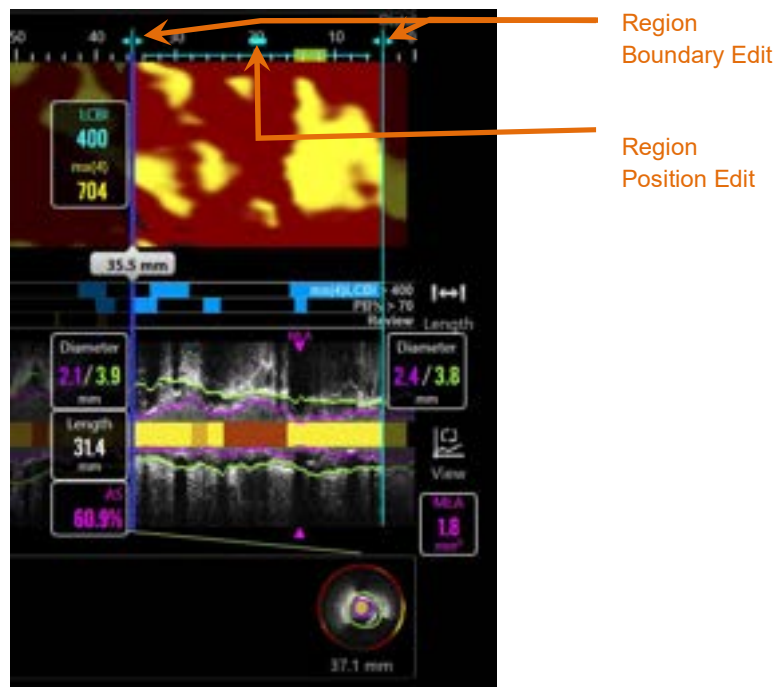


Figure 10-13: Region Editing Controls (SmartImaging™ optional features enabled).

Drag the Region Position to move the defined region without changing the length of the region.

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Drag the proximal or distal boundaries of the region to make a coarse adjustment to the selected end of the region. The length of the region will update automatically. The LCBIs will update upon completion of the edit.

NOTE: Position the mouse pointer over the edit start or end location controls and use the mouse wheel to make fine adjustments to the location of the region boundary.

NOTE: Lock the region to avoid accidental adjustment. See Section 10.5.1.7 Region Locking.

10.5.1.3 Length, Diameter, AS%, LCBI, & max LCBI

Upon completion of Region creation, five measurement results related to the Region are presented.

Length:	This is the distance in millimeters (mm) between the start and end position of the region.
Diameter	In systems with SmartImaging™ features enabled, the average of the minimum and maximum diameter will be presented for both the lumen and EEM at the distal and proximal boundaries of the region.
AS%	In systems with SmartImaging™ features enabled, the percent lumen area stenosis (AS%) for the segment will be computed, as described in Section 4.6 Intravascular Ultrasound and presented automatically.
LCBI:	This is the Lipid Core Burden Index of the region. The LCBI is a ratio of lipid positive signals to total valid pixels in the selected region on a scale from 0 to 1000.
Mx(4):	This is the maximum Lipid Core Burden Index of a fixed window size within the boundaries of the region. The default window size is 4mm.

NOTE: LCBI and Mx(4) values are only provided if NIRS data is recorded by the system.

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NOTE: In systems with SmartImaging™ features enabled, if the proximal or distal boundary frame is noted by the system that additional review may be needed then either the diameter or AS% results, or both, may not display until the boundary frame measurement is edited or confirmed. See section 10.5.2.1 Area Measurement for how to edit and confirm automated measurements.

10.5.1.4 Lumen Area Stenosis (AS%)

Lumen Area Stenosis (AS) can be computed when a Region is created. The minimum lumen area within the Region will be compared with the lumen area of the distal frame for that Region.

NOTE: Add lumen measurements to the start and end frame of an existing region to obtain Lumen Area Stenosis for the region.

NOTE: In systems with SmartImaging™ features enabled, the AS% will be computed automatically.

10.5.1.5 Selecting & Deselecting

Select Regions by touching the corresponding button within the Region Selection control. The longitudinal display, Length, LCBI, average Diameters, AS% and max LCBI results will update accordingly.

Deselect Regions by pressing the corresponding region button again or select the current scan or other scan.

NOTE: Attempting to create a new region will deselect the current region.

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10.5.1.6 Region Annotation

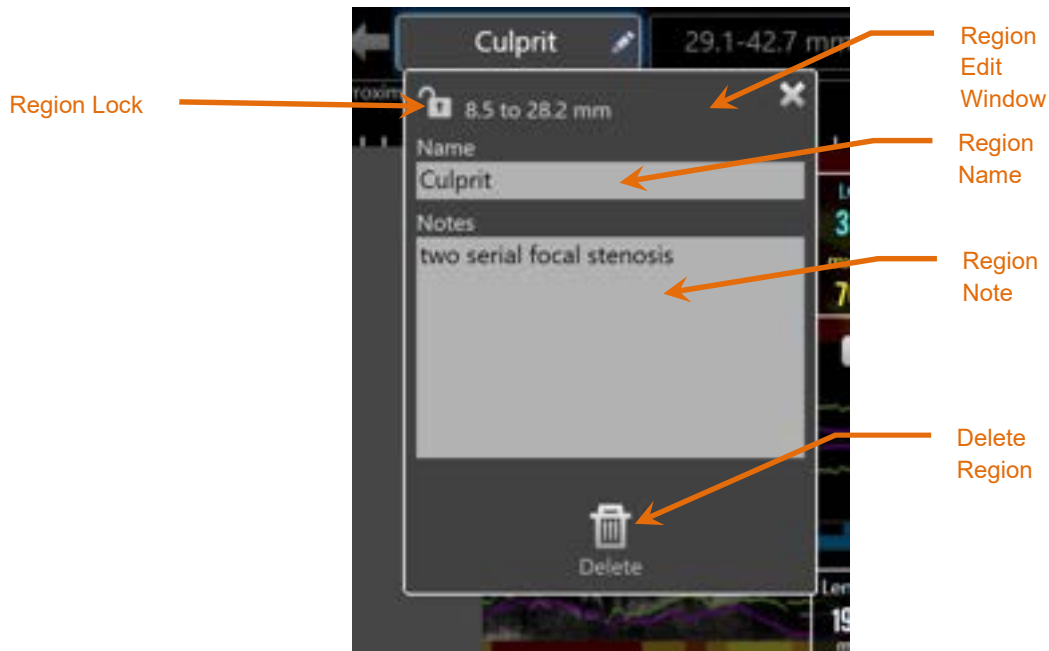






Figure 10-14: Region Name entered in the Region Edit Window.

Touch the **Edit** button, , on the Selected Region button to open the Region Edit window. Touch the desired field to update its contents.



Touch the “X”, , or outside the Region Edit window to close and save your entry.

10.5.1.7 Region Locking

Touch the Edit button, , on the Selected Region button to open the Region Edit window. Touch the Region Lock icon,  , to toggle the ability to adjust region position or the start and end position of the region.

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10.5.1.8 Region Deletion

Touch the Edit button, , on the Selected Region button to open the Region Edit window. Touch the Delete control, , to discard the region.

NOTE: Deleting a region cannot be undone.

10.5.2 On Frame Measurement


Measurements can be made on any transverse IVUS frame to clarify or quantify the content of the frame.

NOTE: Completing an On Frame Measurement will automatically create a Mark for the frame.

NOTE: Completing a measurement on a frame will update the Mark Thumbnail image.

NOTE: When active, touch the tool to abandon the measurement or on-frame annotation in progress.

10.5.2.1 Area Measurement

The Area Measurement tool, , can be used to quantify area and minimum and maximum diameters of features in the image.

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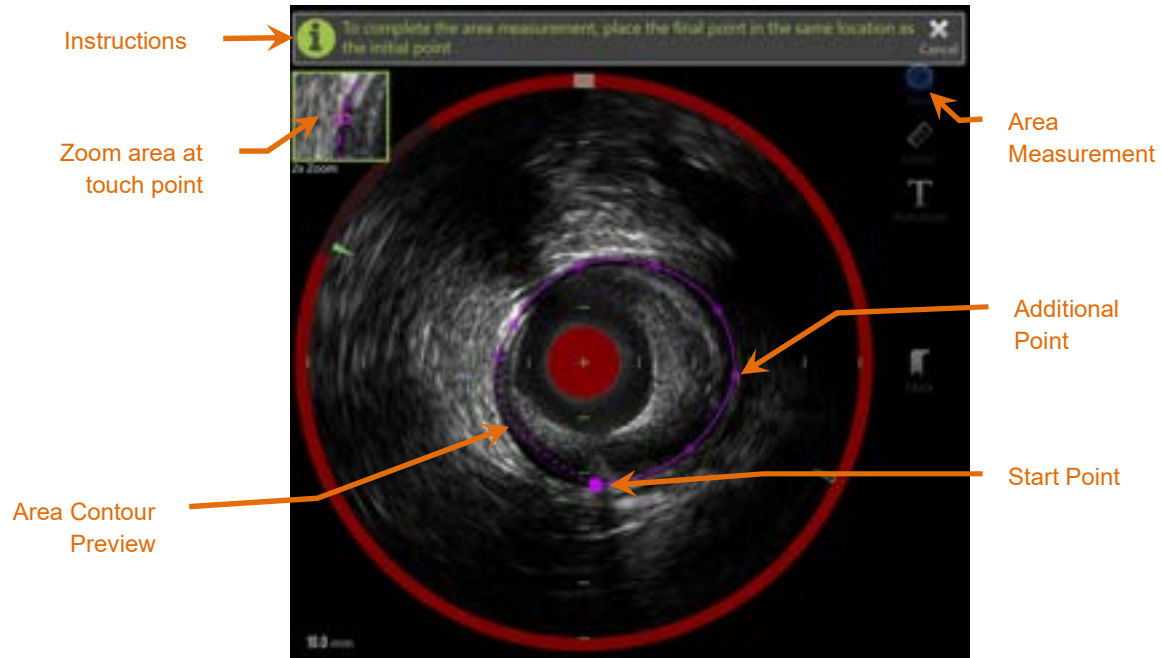




Figure 10-15: Scan Phase with Area Measurement enabled and in progress. Note that the first point placed is denoted as a larger solid circle.



Touch the Area Measurement tool, , to start the measurement. The icon will turn blue when active. Instructions will appear above the Transverse IVUS image as a guide to complete the measurement.

Touch the Transverse IVUS image to place points along the feature of interest to begin to define the area. Continue to add points until the area is defined.

NOTE: After the third point is added to define the area, a preview of the area will appear with a dotted line. This will illustrate how the completed area appears if the starting point is touched or clicked to complete the area.

NOTE: Touch **Cancel**, , in the on-screen instructions to abandon the measurement in progress.

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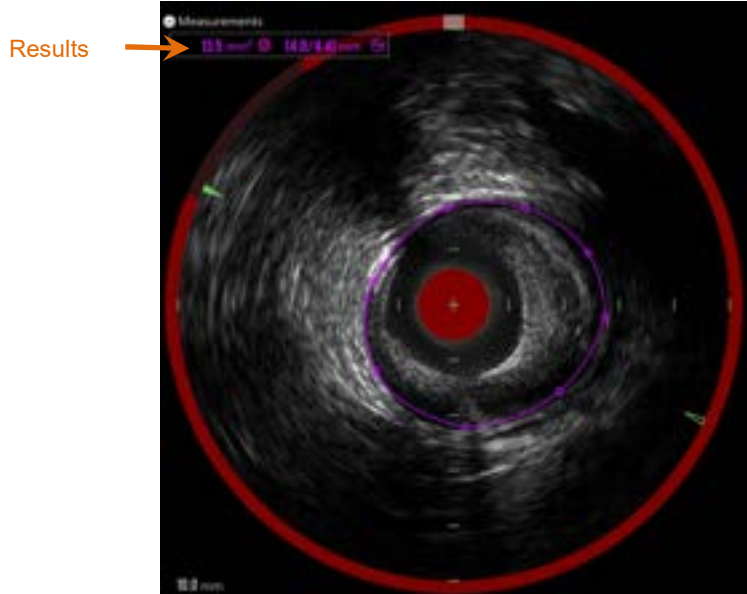


Figure 10-16: Area Measurement completed and results presented.

Touch the first point to complete the measurement and present the results. For each area completed, the cross-sectional area with minimum and maximum diameters will be presented in the top left corner of the Transverse IVUS image.

NOTE: Touch the measurement result to display the minimum and maximum diameters in the image.

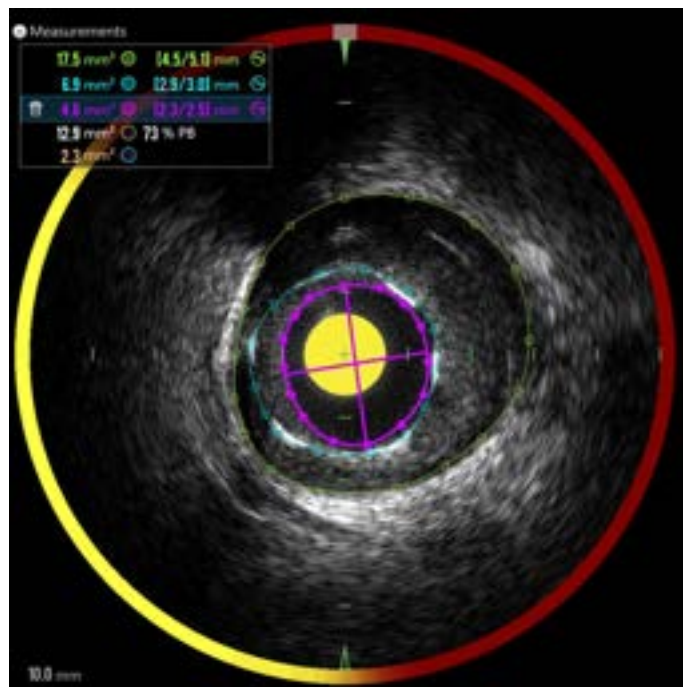


Figure 10-17: Color coded contours and results are presented when areas are drawn completely within another area. The lumen contour is selected and the minimum and maximum diameter locations are shown.

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If more than one area contour is drawn, then the results will be color coded.

NOTE: Up to three areas may be drawn on each frame.

NOTE: Each Area measurement result is color matched to its contour. Each computed area icon, for example plaque area, is color coded to the contours used to define the computed area result.

NOTE: If one area is completely contained within a second area on the same frame, then the Makoto® System will automatically assign one to represent the “Lumen” and one to the “EEM” and a plaque area, and a Plaque Burden , “PB%”, will be computed.

NOTE: If three nested areas are drawn on the same frame, Area 1 drawn completely within Area 2 and Area 2 is drawn completely within Area 3, then the Makoto® System will automatically assign the outer most area to represent the “EEM”, the inner most to represent the “Lumen”, and the middle one to represent the “Stent”. A Plaque Area and a Plaque Burden , “PB%”, will be computed between the “EEM” and “Lumen”. An additional area will be computed between the “Stent” and the “Lumen”.

Resize or reshape the area by touching the existing points and dragging them to desired location. To refine the shape of the completed area make additional points to the completed area by touching and dragging or clicking and dragging the area contour between existing points. The presented results will update upon completion of the edit.

NOTE: Drag measurement points to open the Local Zoom and enhance visualization of the image near the cursor or underneath the operator's finger.

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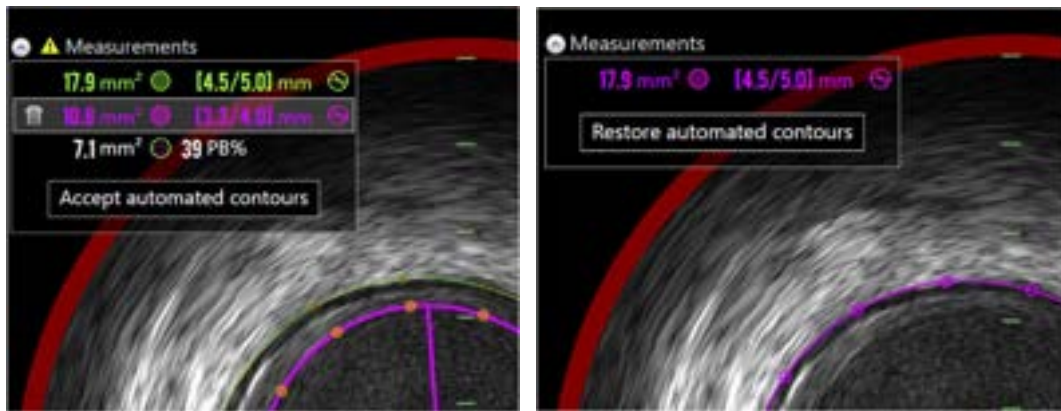


Figure 10-18. SmartImaging™ prompts to either confirm or accept suggested measurements (left) or to restore edited or deleted measurements (right).

When the SmartImaging™ optional features are enabled, the system automatically analyzes each frame to suggest the location of the lumen and external elastic membrane (EEM) to the user. The User may confirm the measurements on the frame either by touching the “Accept automated contours” button near the results, or editing the provided areas in the same manner that manually drawn areas are edited.

To reject the automated output generated by SmartImaging™, remove the corresponding result.

10.5.2.2 Linear Measurement

Linear measurements can be made on the Transverse IVUS image to measure features in the image, such as diameters or thicknesses.

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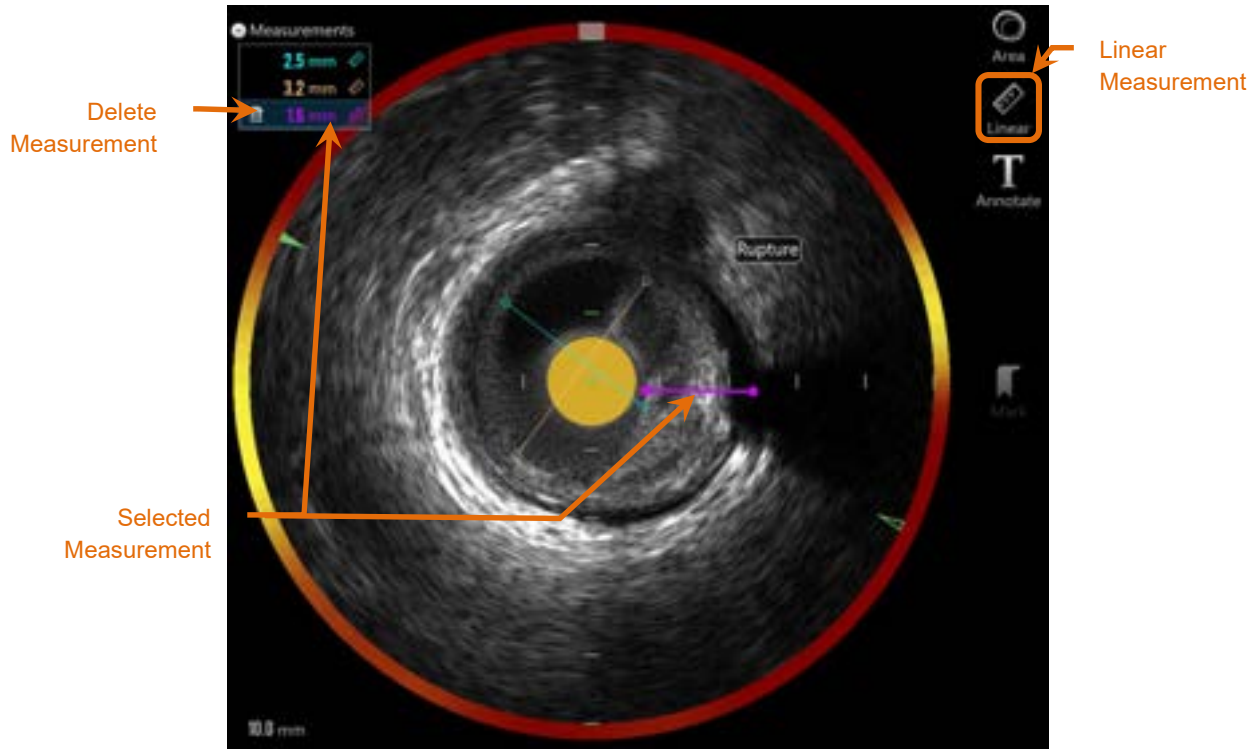


Figure 10-19: Linear Measurement completed. Three Linear Measurements have been made on this section.

Touch the **Linear** Measurement tool, , to start the measurement. The icon will turn blue when active. Instructions will appear above the Transverse IVUS image as a guide to complete the measurement.

Touch the start point of the feature to be measured in the Transverse IVUS image. Touch the end position of the feature to complete the measurement. The linear measurement will be displayed on the transverse IVUS image with the distance between the two points in millimeters.

NOTE: When using the mouse or dragging the end point a preview of the line and distance will appear prior to placing the end point.

NOTE: Up to six linear measurements may be drawn on each frame.

Drag either the start or end points to adjust the measurement.

10.5.2.3 Deleting On Frame Measurements

To delete individual on-frame measurements, select the measurement result to begin.

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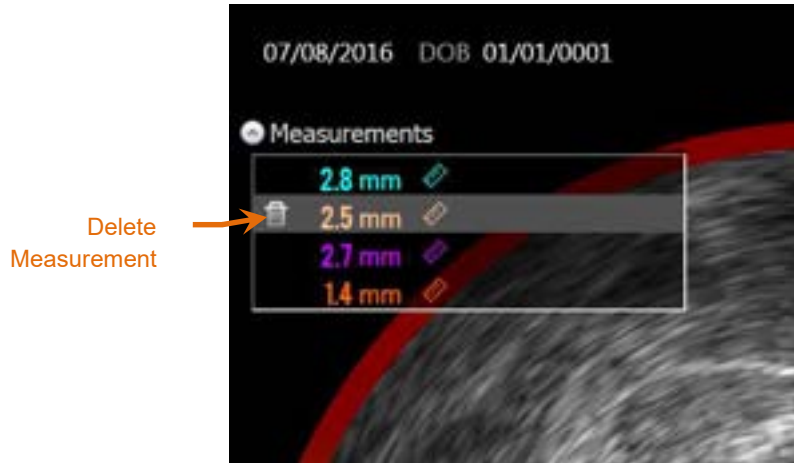




Figure 10-20: Mark with a linear measurement selected. Note the option to delete the measurement and result.

When selecting measurement results, a Delete control, , will appear to the left of the selected result. Touching the Delete control, , will clear the measurement and the result from the scan.


NOTE: Deleting measurements cannot be undone.

NOTE: Deleting individual measurements does not require confirmation.

NOTE: Delete the Mark to clear ALL measurements from a frame in a single step.

10.6 On Frame Annotation

In addition to measurements, comments can be made directly onto the transverse IVUS image.


Touch the On-Frame Annotation control, , to begin making on-frame comments. Determine the location where the note should appear, this will set the left edge of the note. Touch <Enter> on the virtual keyboard to complete the annotation.

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NOTE: Completing an On Frame Annotation will automatically create a Mark for the frame.

NOTE: Completed On Frame Annotations can be dragged to new positions on the current frame.

NOTE: Completing an On Frame Annotation will update the Mark Thumbnail image.

To delete an On Frame Annotation, touch the annotation to select it then touch the Delete control, .

10.7 Screen Capture

Images of the entire screen can be recorded during the Scan and View phases. This image will capture all the content on screen as well as buttons and controls.

While reviewing a scan, navigate to the desired frame using the coarse or fine frame adjustment controls.

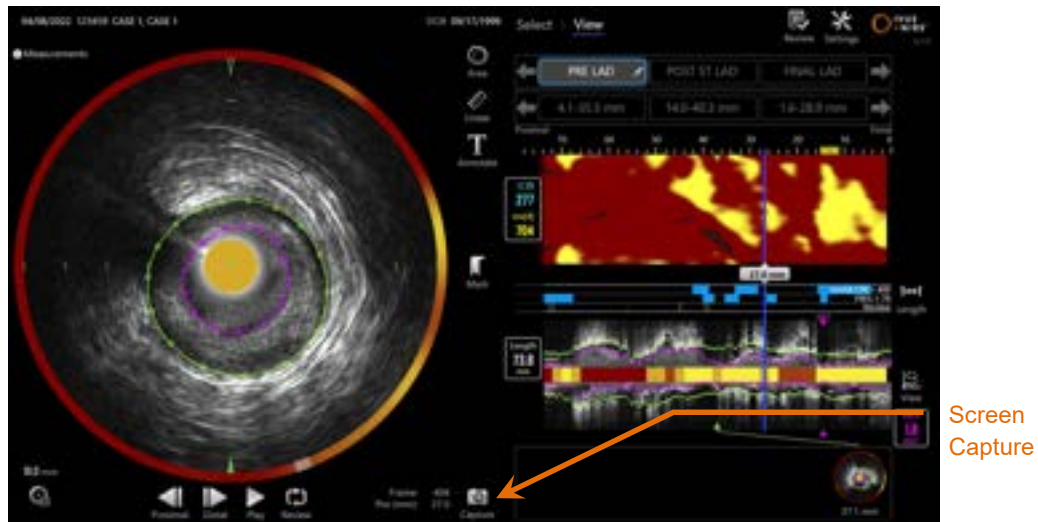



Figure 10-21: View phase of Review Mode with the Screen Capture control indicated (SmartImaging™ optional features enabled).

Touch the Capture control, , to record an image of the entire screen for later use.

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NOTE: A limit of 30 screen captures may be recorded for each scan.

NOTE: Screen Captures may be deleted from the Close Phase of Acquisition Mode or the Select Phase of Review Mode.

10.8 Display Setting

The Makoto® Intravascular Imaging System provides several controls to optimize the display layout and the image quality of the rendered IVUS images.

10.8.1 Longitudinal IVUS rotation

The Longitudinal IVUS image is created from the image data along the marked axis in the Transverse IVUS Image. The marked axis in the Transverse IVUS image is denoted by the solid and open triangles on the axis. The solid triangle on the axis identifies the portion of the image that will be drawn in the top half of the Longitudinal IVUS.

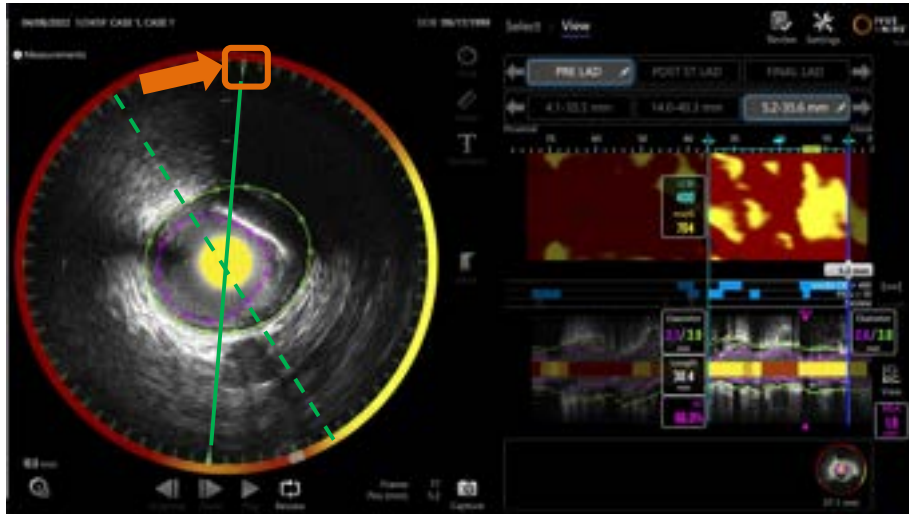


Figure 10-22: Longitudinal IVUS rotation. The dashed green line illustrates where the axis of the longitudinal IVUS started and the solid line illustrates where the axis is currently (SmartImaging™ optional features enabled). The lines are enhanced here for illustrative purpose.

To adjust the data displayed in the Longitudinal IVUS drag the solid triangle on the marked axis to a new location on the circumference of the Transverse IVUS Image.

NOTE: Adjustment of this view of the Longitudinal IVUS will not affect adjustments made to the chemogram rotation.

10.8.2 Chemogram rotation

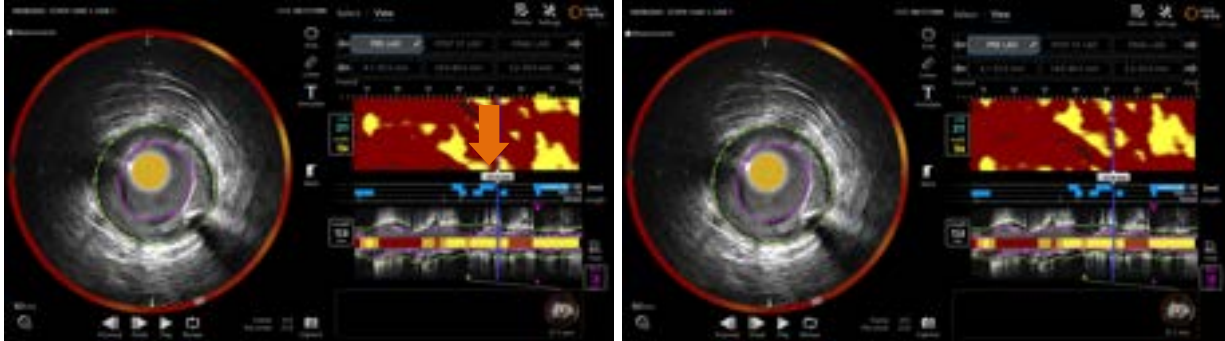


Figure 10-23: Chemograms can be rotated to move the lipid pools away from the edge of the chemogram for easier viewing and interpretation (SmartImaging™ optional features enabled).

The chemogram vertical axis is a continuous 360 degree dimension. This means the top edge of the chemogram is connected to the bottom edge. The cut location is arbitrary in order to represent it in a two dimensional map. This may result in some features being separated to the top and bottom edges.


Touch or Click and Drag in the vertical direction in the chemogram to adjust the cut location of the chemogram.

NOTE: The system will remember this chemogram cut line adjustment and apply it to future scan viewing or report generation. Screen captures will not be adjusted.

NOTE: Adjustment of this view of the chemogram will not affect adjustments made to the Longitudinal IVUS.

10.8.3 Area and Diameter Measurement Views

The graph of automated measures may be toggled between Area and Diameter views.

To toggle the displayed information, touch or click . The Minimum Lumen Area, MLA, or the Minimum Lumen Diameter, MLD, for the selected scan or region will be provided and the location will be indicated on the display.

NOTE: Touch the MLA or MLD value to navigate to the location.

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10.8.4 Condition View

Located beneath the Measurement Graphical View is the Condition View. Using the controls in the Scan Edit, the user can set criteria for thresholds for Plaque Burden or mxLCBI that may highlight vessel segments of clinical interest. If one condition is satisfied at a location the bottom row will be colored. If both conditions are satisfied then both the bottom and top rows will be colored.

The view can be toggled in the Scan Edit by selecting the appropriate button next to the condition values.

NOTE: Right click the Condition view to quickly toggle between the two sets of conditions.

10.8.5 Transverse IVUS rotation

The Transverse Image may be rotated to facilitate comparison with other scans or to help the user better visualize the anatomy.

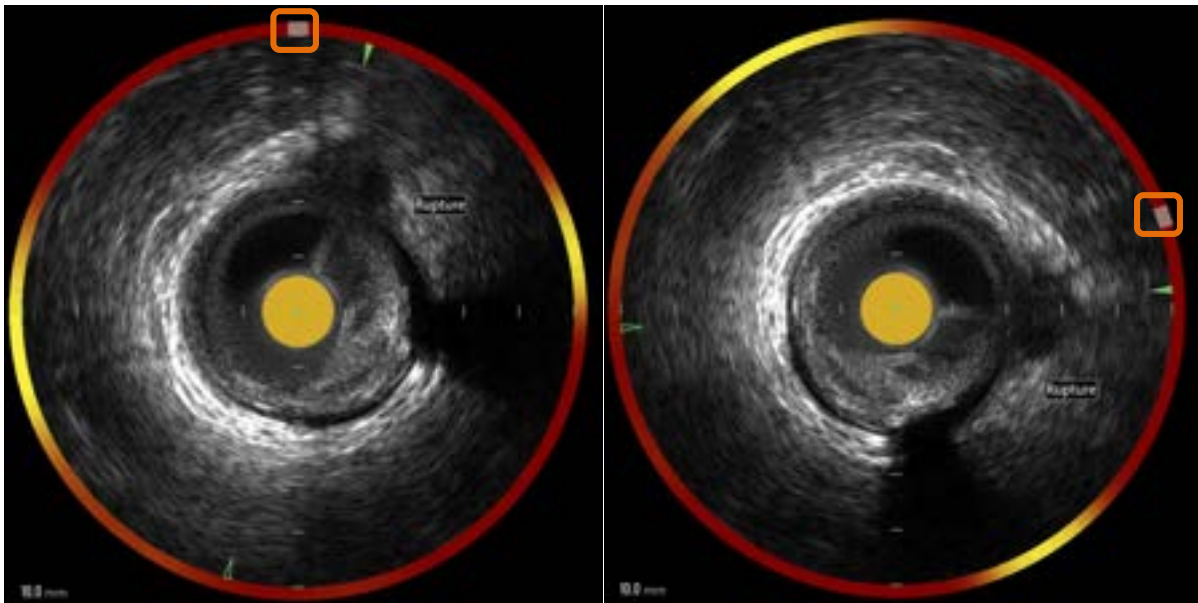


Figure 10-24: Transverse IVUS rotation. Left image shows the default orientation and the Right image shows image after rotation by dragging the control on the chemogram halo to a new location.

To adjust the rotation of the Transverse Image, drag the gray arc control that appears in the Chemogram Halo to a new location.

NOTE: The Transverse IVUS image and the Chemogram Halo are rotationally linked. Rotating the Transverse Image will also rotate the Chemogram Halo.

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NOTE: The rotation of the Transverse Image is applied to all frames in the scan.

NOTE: The Longitudinal IVUS image rotation is relative to the Transverse IVUS rotation, so adjusting the Transverse IVUS rotation will not disrupt the selected Longitudinal IVUS view.

NOTE: The Transverse IVUS rotation will appear in reports, avi, and DICOM images created in Review Mode.

10.8.6 Transverse Image Settings

The transverse IVUS image may be adjusted using the Image Settings control. These controls contain both a basic and advanced control set.

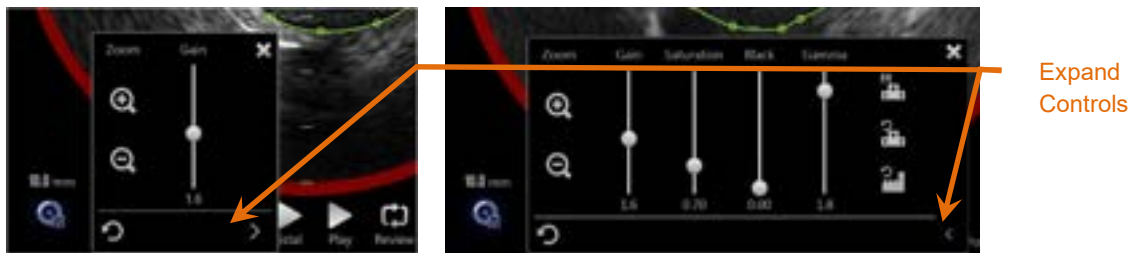




Figure 10-25: Transverse Image Settings. Basic controls, left. Advanced controls, right.

Touch the Image Settings Control to gain access and then use the **Expand** control, , to reach advanced settings and functions.

Touch the “X”, , or outside the window to use the current settings and close the window.

10.8.6.1 Zoom

The transverse IVUS field depth may be adjusted using Zoom controls near the transverse IVUS image. The transverse IVUS image depth can be adjusted from 6 mm to 16 mm in 2 mm increments.

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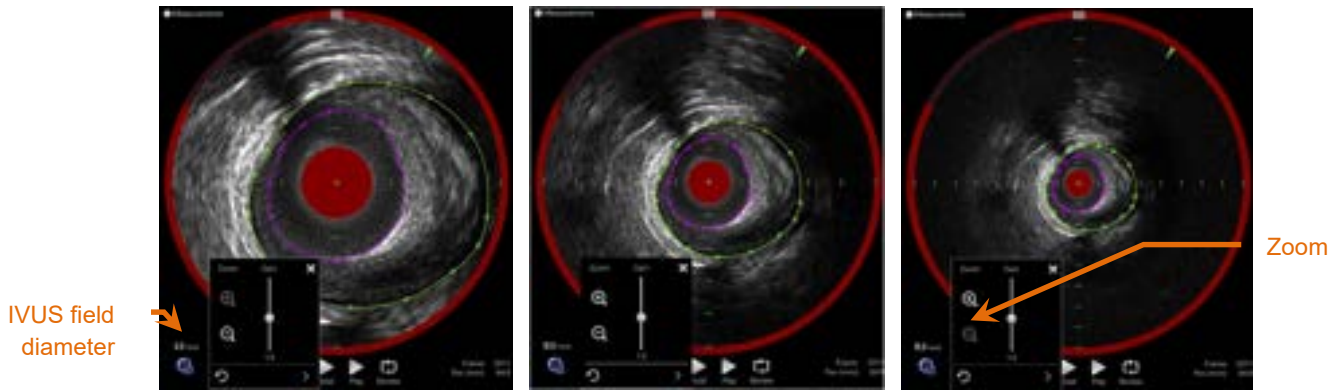




Figure 10-26: Transverse IVUS diameter is adjusted using the Zoom control. 6mm diameter, left. 10mm diameter, center. 16mm diameter, right.

Touch the Zoom controls to increase, , or decrease, , the transverse IVUS magnification. A corresponding update will be made to the longitudinal IVUS display.

10.8.6.2 Gain

Drag the slider to adjust the value of the Gain Setting. The range is from 0.5 to 3.0.

Low values will produce a dark image, while high values will produce a brighter image.

10.8.6.3 Saturation

Drag the slider to adjust the value of the Saturation Setting. The range is from 0.50 to 1.50.

Low values will produce a dark image, while high values will produce a brighter image. Use in combination with the Black setting to control dynamic range.

10.8.6.4 Black

Drag the slider to adjust the value of the Black Setting. The range is from 0.00 to 0.50.

Low values will produce a bright image, while high values will produce a darker image. Use in combination with the Saturation setting to control dynamic range.

10.8.6.5 Gamma


Drag the slider to adjust the value of the Gamma Setting. The range is from 0.5 to 2.6.

Low values will produce a whiter image, while high values will produce a darker image.

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10.8.6.6 Return to Previous Setting



Touching the Return to Previous control, , will return the settings to the values when the settings window was opened. This will not affect Zoom.

10.8.6.7 Save to Local Default Settings




Touching the Save to Local control, , will save the current settings as the default. All new procedures will start with these image settings, including Zoom.

These values will be used when the Return to Local Settings control is touched.


10.8.6.8 Return to Local Settings



Touching the Return to Local Settings control, , will load the default local settings.

10.8.6.9 Return to Factory Settings



Touching the Return to Factory Settings control, , will load the default settings established by the manufacturer.

11 Closing Procedures

At the Close Phase of the procedure, details of the procedure may be reviewed prior to committing the scans and analysis to local system memory.





Figure 11-1: Close Phase of Acquisition Mode with the Close Procedure control enabled.

Details of the procedure setup, collected scans, marks, and screen captures are presented for confirmation. This is an opportunity to review the Setup Phase data or delete unwanted scans prior to closing the procedure.

NOTE: If critical information necessary to minimally identify a procedure is missing, then the operator will be alerted to return to the Setup Phase.

NOTE: If a scan is initiated from the Makoto® Controller, the Acquisition Mode will automatically return to the Scan Phase.

If changes are required then touch the “**Return to scan**” or **Edit** controls, , or touch the appropriate phase from the Progress Strip control to edit the procedure.

Touch the “**Close Procedure**”, , confirmation to commit all scans to local memory and reset the Acquisition Mode for a new procedure.

12 Reviewing and Archiving Procedures



Connecting the Makoto® system to a network increases the risk that the equipment may be affected by network-based cybersecurity attacks. The System is designed to secure network connections and communications. However, the risks associated with a network-based cybersecurity attack cannot be entirely mitigated.

See Manufacturer Disclosure Statement for Medical Device Security (MDS2) to manage cybersecurity risks and to ensure the safe and effective use of the device in its intended use environment. Contact Service Provider to request additional copies of the statement as required.



Using removable media with the Makoto® system may expose the system to software-based risks on that media. The System is designed to secure these media ports and interact only with recognized files. However, the risks associated with software-based threats cannot be entirely mitigated.

Previously recorded procedures may be reviewed, archived, edited and deleted in Review Mode.

To enter Review Mode from the Acquisition Mode, touch the Makoto® Mode Toggle when there is no active procedure underway.

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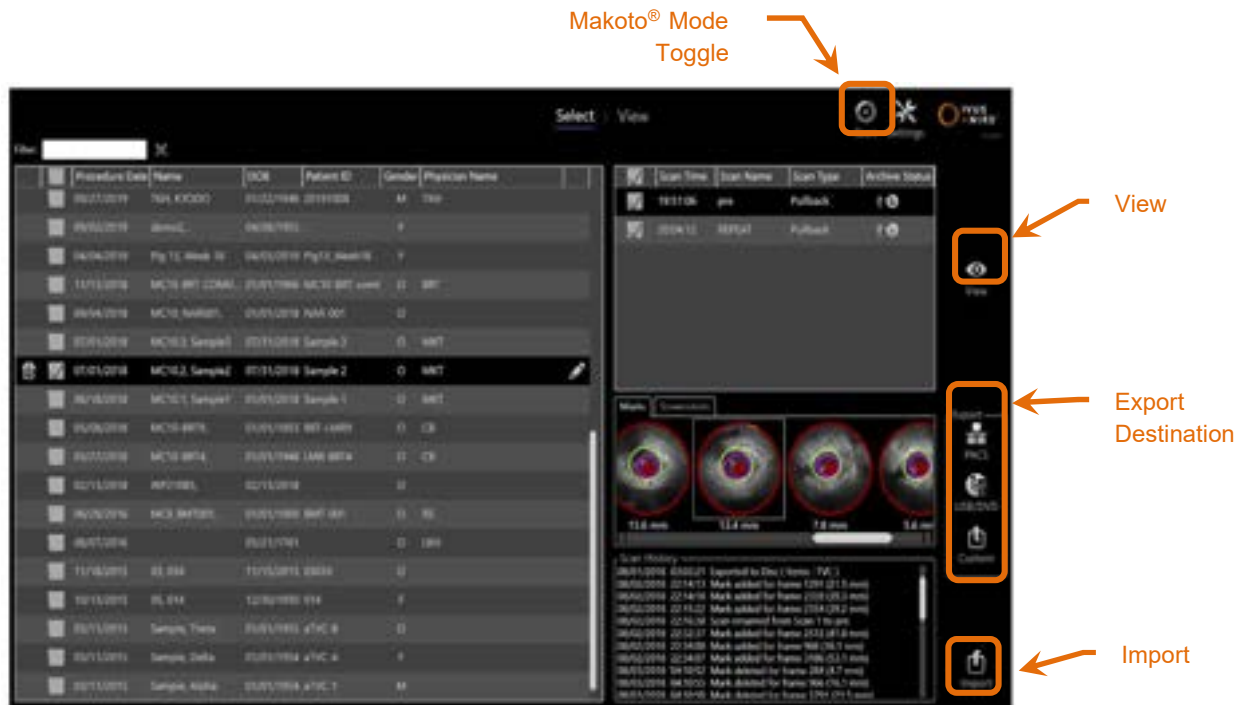


Figure 12-1: Review Mode showing the Select Phase.

Upon entering Review Mode the operator is presented with the Select Phase of the review workflow. During this phase the operator will make a selection of procedures and scans upon which to perform additional actions. The operator may choose to edit, view, or delete reports with the selected procedure or scans.

Scans may also be selected for import into local memory.

12.1 Selecting Procedures and Scans

Procedures and individual scans may be selected for further action within the Select Phase of the Review Mode.

Data contained on the system is arranged into three tables based on information type. There is a table for procedures, scans within the selected procedure, and the Marks and screen captures within the current scan selection.

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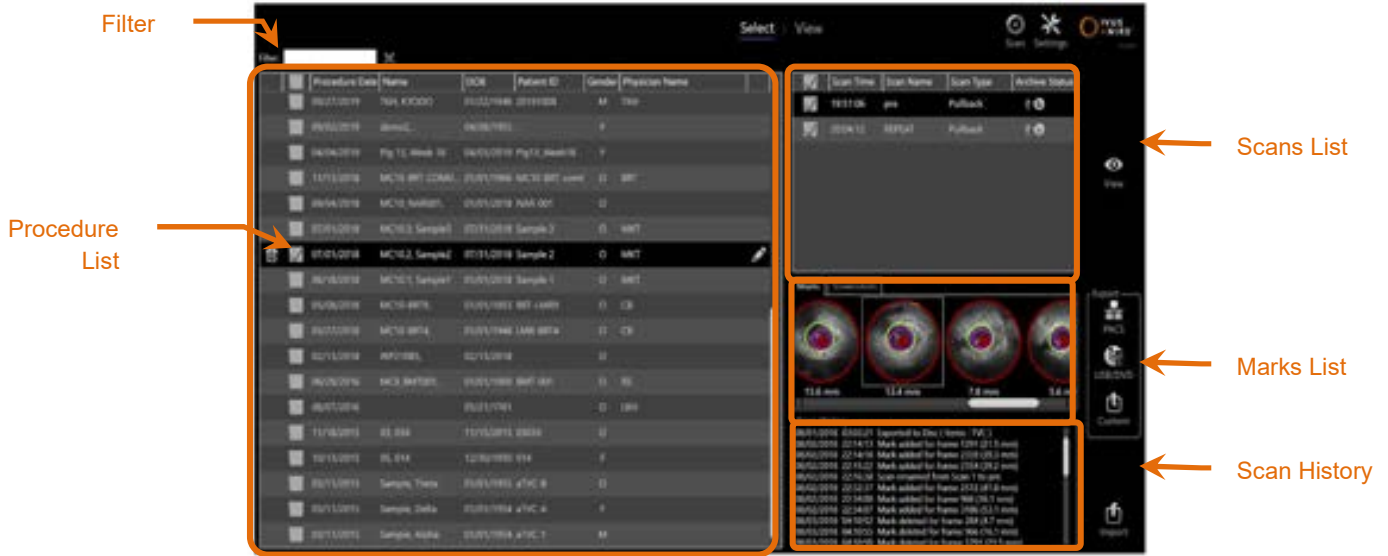


Figure 12-2: Select Phase of Review Mode with information lists highlighted.

Selected procedures may be viewed or have screen capture or Mark Reports exported to USB/DVD. Checked procedures may be exported and viewed. They may also have their screen captures exported or Mark Reports exported if the checked procedure is also the current selection.

To make a single procedure selection, touch any point within a single row of procedure information within the Procedure List. The selected procedure will become the current selection. The scans within that procedure will appear in the Scan List.

Touch the check boxes to select multiple procedures for exporting data as a batch from the system.

NOTE: Procedures will be ordered with the most recent procedure date at the top of the list by default.

NOTE: Scans will be ordered in chronological order by default with the earliest scan at the top of the list.

NOTE: Touch the column headers in the Procedure and Scan Lists to re-order the information.

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NOTE: For a checked procedure, all scans contained will be checked by default.

To make multiple procedure selections, touch the check box next to the information about the desired procedure. Remove procedures from the multiple selection by touching the check box again.

NOTE: Custom Export is only available for a single procedure.

12.1.1 Scan History

Updates made to scans after the procedure completes will be recorded in the Scan History. This will include changes to Scan Name, Mark additions or deletions, and Export or Archive actions.

12.1.2 Filtering Procedure List

The catalogue of saved procedures may become long between routine archiving and removal of data from the system. Use a filter term to reduce the displayed number of entries within the procedure list to facilitate selection.

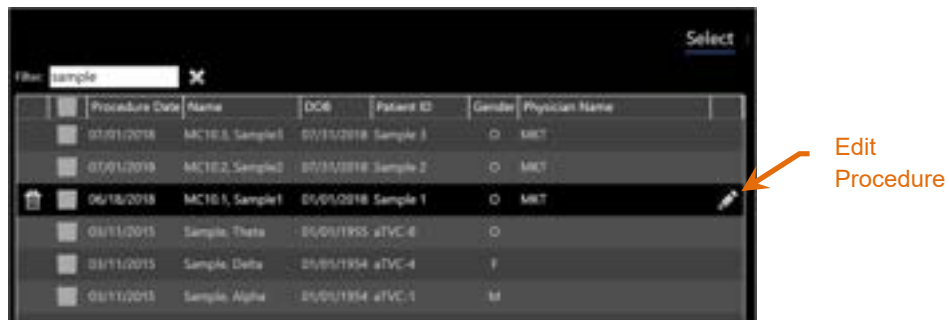



Figure 12-3: Select Phase with Filter applied to the Procedure and Scans lists for entries containing “Sample”.

Enter a short amount of text within the filter control, the list will be reduced to a more manageable number of entries.


The system will search all Procedure ID, Patient Names, Patient ID, Physician Names, Catheter Lot Numbers, Scan Names, or Scan Notes for these characters.

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Touch Clear, , to return to the complete procedure listing.

12.1.3 Edit Procedure

The procedure and patient information may be edited to correct or change information.

In the procedure list with the current selection, touch the Edit icon, , to open the edit procedure prompt.

The current procedure details will show in the Edit Procedure prompt. Use the available controls to update the fields.

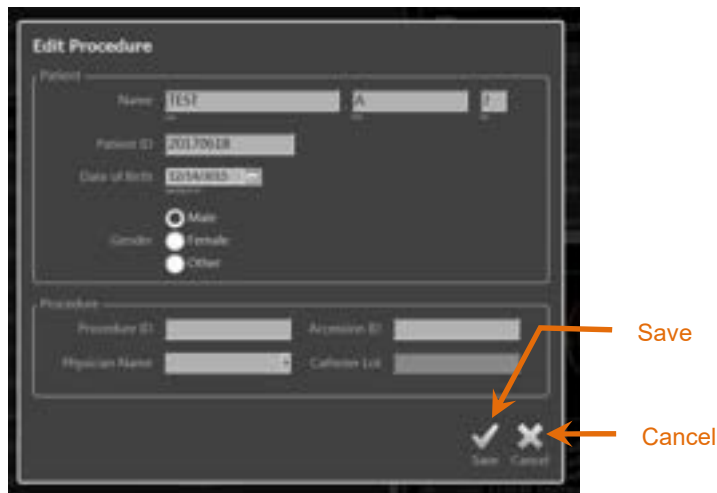




Figure 12-4: Select Phase with the Edit Procedure window open.

Touch “Save”, , to commit the changes and close the prompt. Touch “Cancel”, , to close the prompt without saving the changes.


NOTE: Edits made to the procedure will affect all scans associated with the procedure on the system. This includes unchecked scans.

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NOTE: View the procedure to edit scan details within the selected procedure.

12.1.4 Viewing

To view, edit, analyze and delete scans contained with the currently selected procedure

touch the “**View**” control, . This will load all the scans from the currently selected procedure into the View Phase of Review Mode.

The procedure and scans may be navigated, viewed, analyzed, edited and deleted in a manner similar to the Scan Phase of Acquisition Mode.

See Section 10 Reviewing, Measuring, and Annotating Scans for more information and guidance.

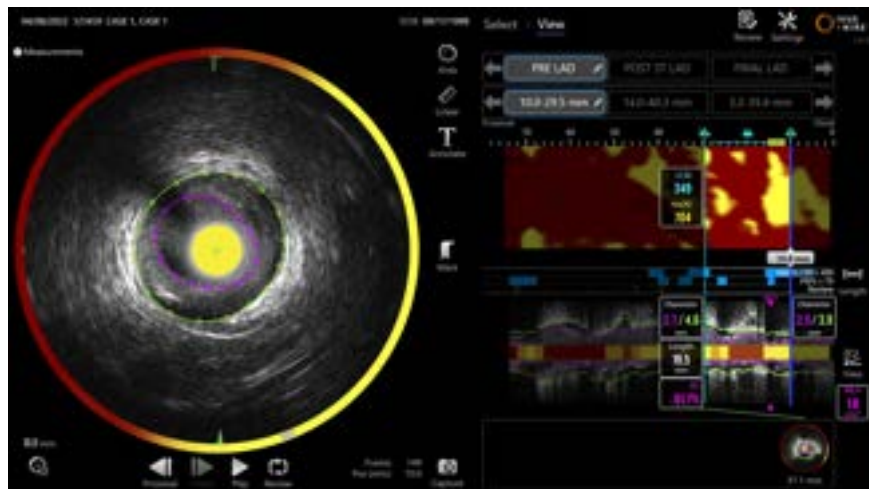
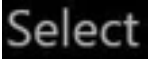


Figure 12-5: View Phase of Review Mode (SmartImaging™ optional features enabled).

NOTE: Changes to Marks, regions, measurements, and annotations during the View Phase will become part of the saved procedure data when returning to the Select Phase.

Touch **Select**, , in the Progress Strip control or the Makoto® Mode Toggle control to return to the Select Phase of Review Mode.

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12.2 Exporting and Archiving

The Makoto® Intravascular Imaging System provides several methods and formats for exporting data from the system. There are two configurable expedited methods for exporting and one method for a customized export.

Single or multiple procedure selections may be exported from the system for the purposes of archiving or other use. After making the desired procedure selections, use the Export Destination controls to initiate the data transfer.

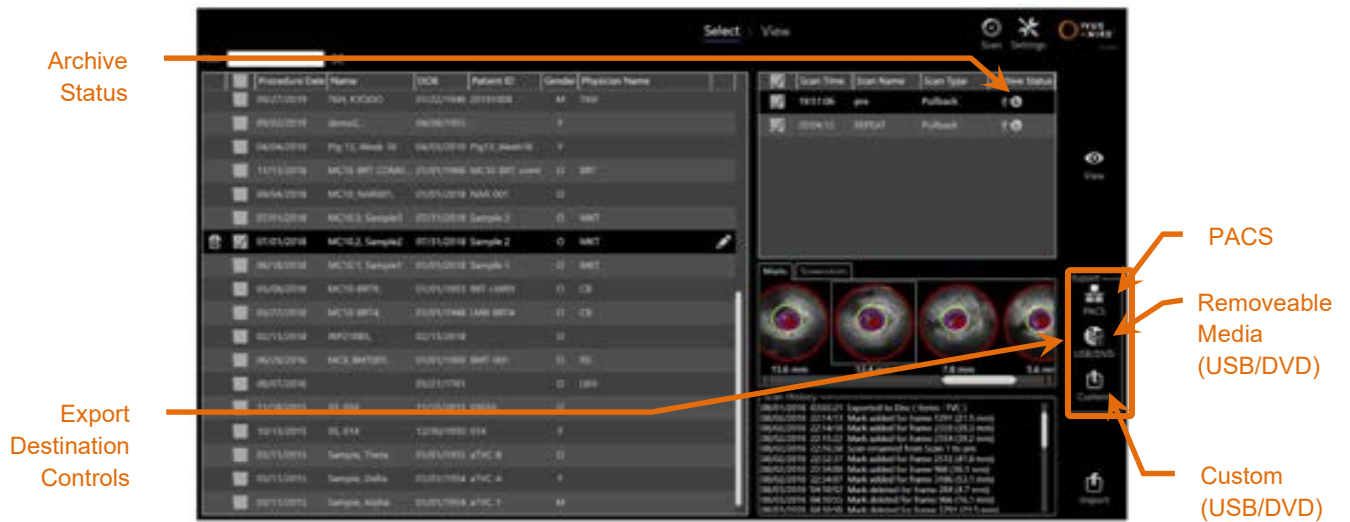


Figure 12-6: Select Phase with Export Destination controls highlighted.

Upon completion of the export the Scan List will update with the archive destination in the Archive Status column.

12.2.1 Configuring Export Destinations

Default export formats and compression can be configured for the PACS and Removable Media (USB/DVD) destinations.

Please see Sections 12.2.2 and 12.2.3 for more information on how to configure these defaults.

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12.2.2 PACS Export



WARNING


Ensure that cables originating from or connecting to the Makoto® Intravascular Imaging System lay flat on the floor.

Data from the Makoto® Intravascular Imaging System may be stored in the hospital PACS system if the systems have been properly configured. PACS systems will accept data that has been formatted using the DICOM standard.

The system is designed to function either “offline” or connected to a protected hospital network for the purpose of direct transfer of Makoto® Intravascular Imaging System data to a network storage solution such as PACS. Connect a shielded Cat5e cable to the PACS connector or Infraredx Mobile Integration cable to the X-Ray connector on the right side of the Makoto® Console.

Configure the PACS connection parameters using the guidance provided in Section 14 System Settings.



Touch the PACS control, , to begin the transfer of checked procedures to the configured destination.



CAUTION

Connecting to IT networks, including other equipment, could result in previously unidentified risks to patients, operators or third parties.

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Changes to the IT network could introduce new risks that require additional analysis. Changes to the IT network include:

- Changes in network configuration
- Connection of additional items
- Disconnection of items
- Updates of equipment
- Upgrades of equipment



The customer should identify, analyze, evaluate and control the risks associated with connecting the Makoto® Intravascular Imaging System to an IT network.

See Manufacturer Disclosure Statement for Medical Device Security (MDS2) to manage cybersecurity risks and to ensure the safe and effective use of the device in its intended use environment. Contact Service Provider to request additional copies of the statement as required.

12.2.3 Removable Media (USB/DVD) Export

Data from the Makoto® Intravascular Imaging System may be exported to removable media, either USB or Blu-Ray/DVD/CD writeable media.



Figure 12-7: Makoto® Intravascular Imaging System removable media panel

NOTE: Avoid inserting removable media into system while a scan is being completed.

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The system will automatically check for available removable media in the system USB ports and optical media drive.

Review the procedure and scan selections and the total export size. Confirm export file type formats.

If the desired export size is less than the available space on the export destination media, touch the desired media to begin the export. If the estimated export size is too great for the media, review the formats and procedure selections to reduce the size of the export.

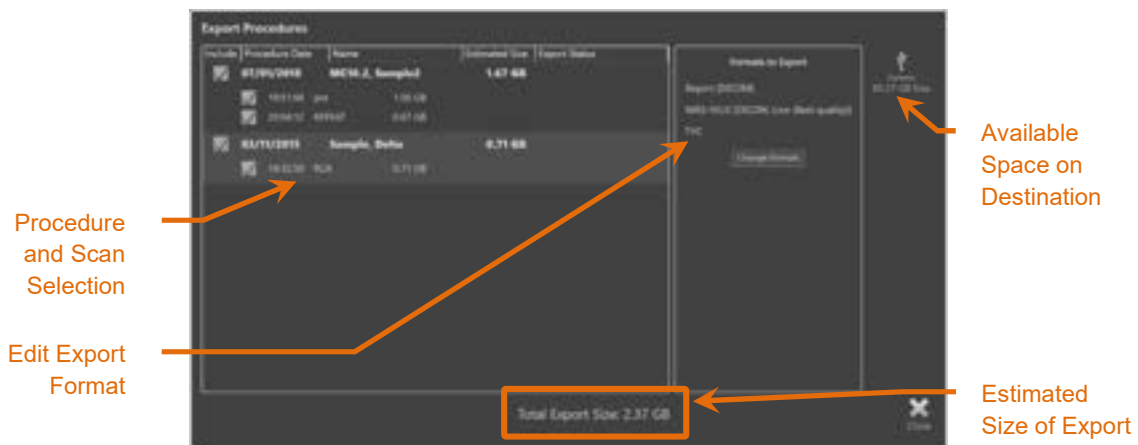


Figure 12-8: Export to Removable Media prompt.

Uncheck individual scans or whole procedures to reduce export size.

See Section 14.11 for more information on setting and changing the default export formats.

NOTE: An open session optical media disc can be created that will accept multiple exports by unchecking “Finalize disc” in the USB/DVD export options outlined in Section 14.11.

12.2.4 Custom Export

Data from the Makoto® Intravascular Imaging System may be exported to removable media in customized ways. This method of export will require selection, or confirmation, of the data formats and storage destination. This method will also permit the user to remove identifiers from the data set as desired.

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CAUTION

Identifying information contained within the text of annotations on frames or scans will not be modified.

NOTE: Custom Export is useful for non-routine export of data or for research applications that require anonymization.

NOTE: Custom Export is only available for single procedure export.


Select the desired procedure and scans by touching their entries in the Procedure and Scan lists. Touch the Custom Export control, , to bring up the Custom Export window.



Figure 12-9: Custom Export window for setting data types and formats for export to removable media.

Either confirm the last data format settings used for removable media or adjust as needed for this export. See Section 14.11 for more information about data types and formats.

See Section 14.11.3 for more information about finalizing optical media.

If the intended DICOM player requires the DICOMDIR to be written to root level of the desired removable media, then check the “Export files to root directory (top level) of target media” option. This option requires the target media to be empty.

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Figure 12-10: Custom Export window for configuring alternative network storage location.

If the Custom Export data will be sent via network then either confirm or adjust the DICOM data files and compression settings. Configure an alternate PACS server to send the custom data.

NOTE: The PACS items to include and PACS settings for a Custom Export will not affect standard PACS export settings.

NOTE: Many analysis programs that can analyze Makoto® System data accept network transfer of DICOM information. Use the Custom Export to configure the network address of analysis workstations if they are different than the hospital medical record PACS.

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Figure 12-11: Custom Export window for anonymization of the procedure record.

Make the data anonymous by utilizing the “Anonymize” functions. Check the anonymize box and enter the desired alternate information.

NOTE: Anonymization will not change the original data remaining on the system.

NOTE: Anonymization features will not affect the procedure time, any notes, comments, or annotations made within the scans.

NOTE: Anonymization features will obscure patient name and date of birth information, but will not affect the other content of screen captures.

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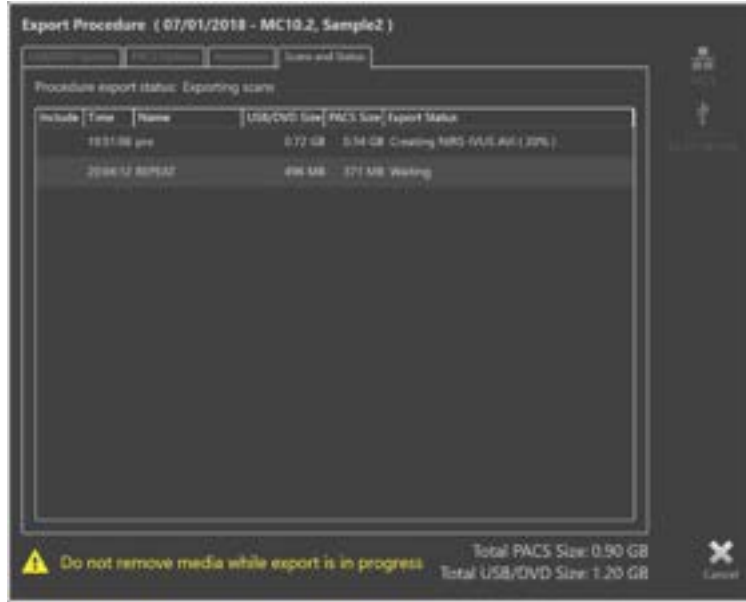


Figure 12-12: Custom Export window with scan export to USB in progress.

Review the size of the data to be exported to ensure that it will fit on the destination media. Make adjustments to your selections as required.

Touch the removable media destination to begin transfer to the destination in the file types, formats and compressions that have been configured.

12.3 Importing Data

Procedure and Scan data may be imported onto the Makoto® Intravascular Imaging System for viewing, editing, measuring, and re-export.

NOTE: Data archived in TVC Format may be imported onto any Makoto® Intravascular Imaging System of a compatible model number for later viewing.

The Makoto® Intravascular Imaging System will accept TVC Format data (*.tvc from TVC-MC10 or TVC-MC9) or TVC Export data (*.zip from TVC-MC8 or TVC-MC8x) generated by this system or another TVC Imaging System. This data may be imported from Blu-Ray, DVD or USB sources.

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NOTE: Data imported from TVC-MC10 or TVC-MC10i systems can have automated area measures computed upon viewing if equipped adequately with the SmartImaging™ feature.

12.3.1 Importing Conflicts

If the data already exists or the imported scan procedural or patient data are similar to data already on the system, then additional input from the user may be required in order to complete the action.

Conflict resolution will occur after all import attempts have been processed. In this way, all conflicts can be resolved at one time greatly facilitating batch import.

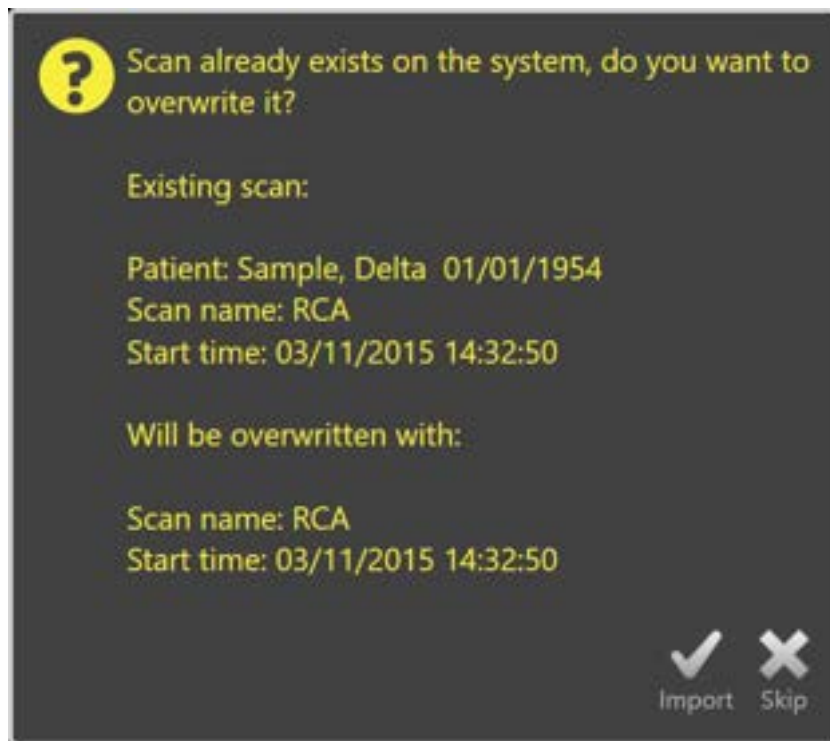


Figure 12-13: Import Conflict prompt. Proceed with resolution and overwrite or cancel import of this conflicting file.

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When the import conflict prompt appears, choose:

Import To proceed with conflict resolution. If there are no changes in procedure or patient data, then the existing file on the system will be overwritten. If there are differences in procedure or patient data then the user will be prompted to decide on the appropriate information.

Or

Skip This conflicting import will be skipped and the user will be prompted to resolve other conflicts with the import batch.



Figure 12-14: Import conflict resolution prompt.

If the user chooses to resolve the conflict with the import and procedure or patient information has changed, the user must choose:

Use Import To use the procedure and patient information from the imported file. This decision will apply to other scans imported for this procedure during this batch import AND will update any scans already on the system belonging to the same procedure.

Or

Use Existing To use the procedure and patient information already in system memory to update the imported file. This decision will apply to other scans imported for this procedure during this batch import.

Or

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Skip This conflicting import will be skipped and the user will be prompted to resolve other conflicts with the import batch.

Selecting Import will proceed with importing this procedure data based on the selection.

12.4 Deleting Scans & Procedures

Procedures and Scans stored on the system may be deleted to make more space available in the local memory.

Entire procedures may be deleted, one at a time, from the Select Phase of Review

Mode. Touch the procedure to select it, then touch the Delete control, . This will require confirmation of the action as deletion cannot be undone.



Deletion of data from the system is permanent and CANNOT be undone.

Scans may be deleted during the View Phase or the Scan Phase by deleting the scans individually by opening the Scan Edit window. See Section 10.2.12 Delete Scan for more information and guidance on this feature.

NOTE: The last scan in a procedure cannot be deleted during the View Phase. Return to the Select Phase and delete the procedure to completely remove the procedure from the system.

NOTE: Deleting a scan will delete all associated screen captures and measurements.

The Makoto® Intravascular Imaging System is not designed to be a permanent data storage location. The customer is strongly encouraged to develop a data back-up and archiving plan that includes periodic deletion of data from the system.

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The Makoto® Intravascular Imaging System is not intended as a permanent data storage or archive location.

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13 Electronic User Guide

The Makoto® Intravascular Imaging System User's Guide (this document) can be viewed electronically on the system monitors.

NOTE: Electronic User Guide is available only in select markets

NOTE: See System Settings section 14.4 for selecting language

NOTE: Language setting can only be activated by Field Service or Site Administrator

13.1 Accessing the Electronic User Guide

The user guide may be accessed by the user by touching or clicking the “Help” icon at the “Log In” prompt or by navigating to Settings and Tools when available.

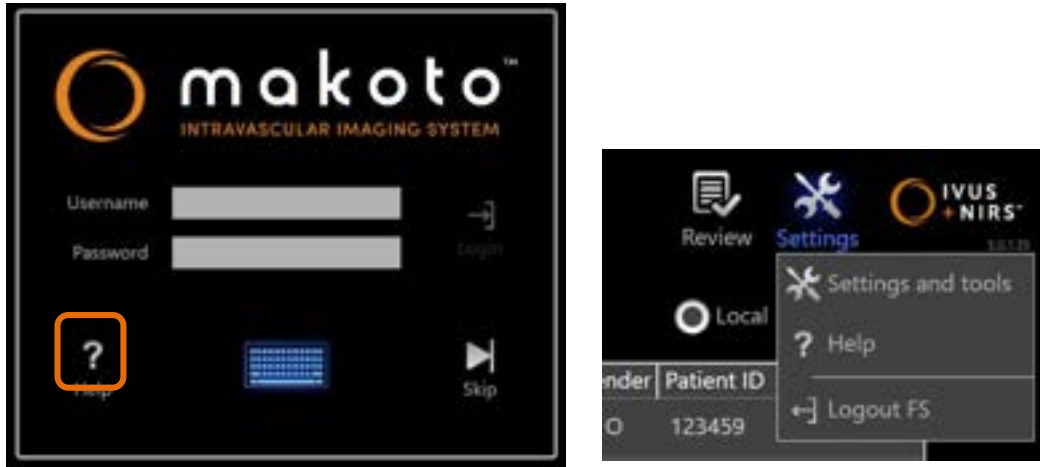


Figure 13-1: System Log In prompt (left) and Settings and Tools (right) where the “Help” function prompt is located

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13.2 User Guide Language



Figure 13-2: Electronic User Guide reviewing interface

The language of the electronic user guide may be changed from the default language to any other language installed. Select the desired language from the drop-down list at the top of the window.

NOTE: Electronic user guide is available only in select languages.

NOTE: See System Settings section 14.4 for selecting the default language of the user guide that will appear.

13.3 Navigating the User Guide

After accessing the user guide, it can be navigated in familiar ways. The document contains many links to allow faster navigation to sections with desired information.

In addition to embedded links (i.e. table of contents entries, section references), the page numbers maybe entered, incremented or decremented, or scrolled using the mouse buttons or wheel by using the provided controls. Text searches may also be performed.

Touch or Click Close to return to the prior screen.

14 System Settings



Connecting the Makoto® system to a network increases the risk that the equipment may be affected by network-based cybersecurity attacks. The System is designed to secure network connections and communications. However, the risks associated with a network-based cybersecurity attack cannot be entirely mitigated.

See Manufacturer Disclosure Statement for Medical Device Security (MDS2) to manage cybersecurity risks and to ensure the safe and effective use of the device in its intended use environment. Contact Service Provider to request additional copies of the statement as required.



Using removable media with the Makoto® system may expose the system to software-based risks on that media. The System is designed to secure these media ports and interact only with recognized files. However, the risks associated with software-based threats cannot be entirely mitigated.

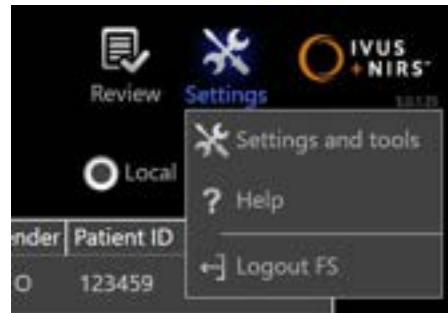


Figure 14-1. Settings and Tools menu.

Local settings of the Makoto® Intravascular Imaging System may be adjusted to meet the needs of the user. The user may configure network communication settings, default export formats, adjust display parameters and access system diagnostic utilities.

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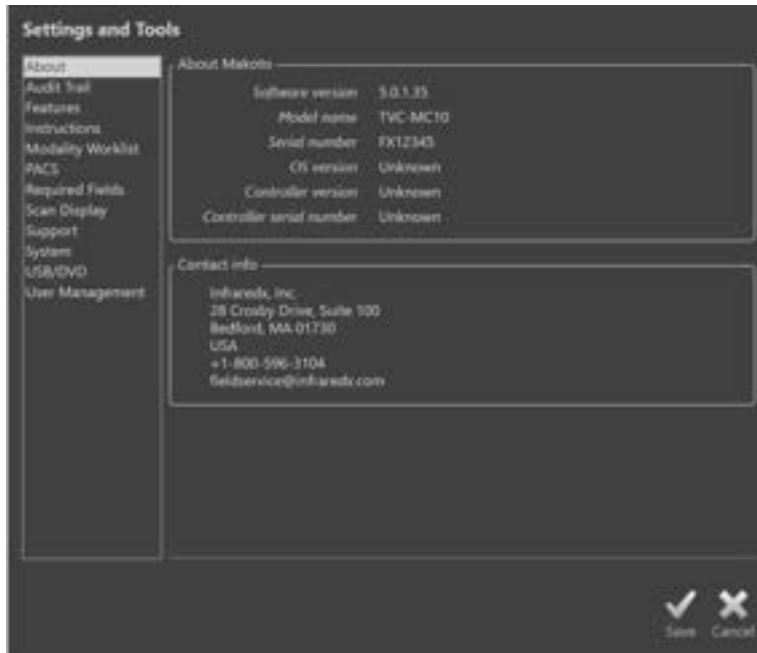



Figure 14-2: System Settings, About section.

NOTE:

The user must 'Save', , the changes to settings for them to take effect.

NOTE:

The figures in this section are visible to users with Administrator permissions. Some Settings are restricted due to the active user's permission levels.

14.1 About

This System Settings section will provide information about model number of the system as well as current installed software version numbers.

Contact information for the customer's sales and/or service provider is available in this location.

14.2 Audit Trail

This section is available to Administrator users. This section provides a display of log in, log out, and user management events for each user of the system during the specified date ranges. The system login/logout audit log may be exported to desired available removable media in *.csv format.



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14.3 Features

This section is available to Administrator users. This section provides controls for system administrators to enable license keys to optional feature sets.

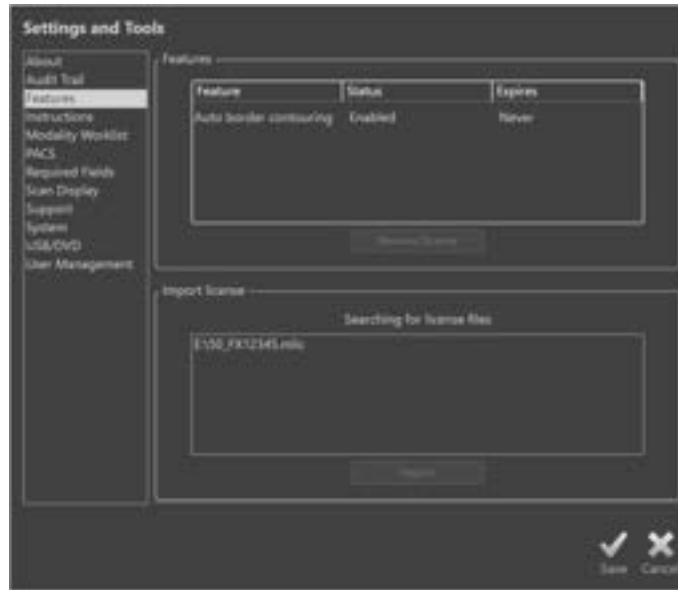


Figure 14-3: System Settings, Features Section

14.3.1 Importing License Files

System administrators can import license files for feature sets they've obtained by placing removable media containing the license key into either the USB or DVD\Blu-ray™ drive. Any compatible license keys recognized by the system will appear in the "Import License" area of the display. To import the license to activate the feature, select the license key file and then touch import.

NOTE: Features may not be approved in every market

14.3.2 Removing License Files

System administrators can remove license files for feature sets. Removing the license file will disable the associated optional features on the system.

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NOTE: Removing SmartImaging™ license files will prevent the feature from being applied to any additional scans on the system. The results of SmartImaging™ already applied will continue to be accessible to the user.

14.4 Instructions

14.4.1 User Guide Default Language

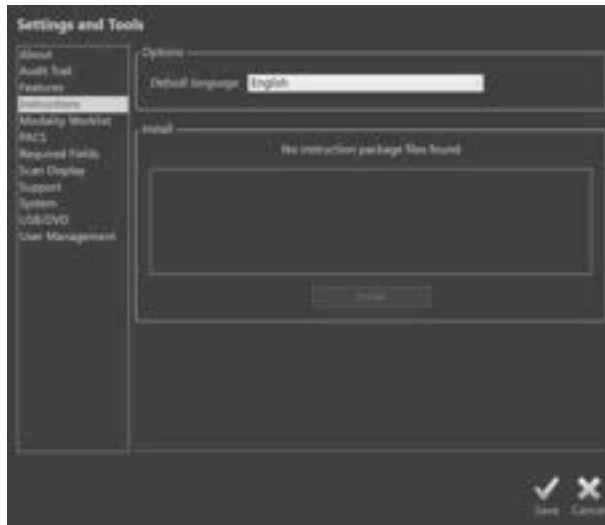


Figure 14-4 Setting the default language for the electronic instruction manual.

The default language of the electronic user guide may be set by the system administrator by selecting the desired language from the drop-down list at the top of the window. Touch save to accept the change to the default setting.

NOTE: Electronic user guide is available only in select languages.

Additional languages or updated instructions may be made available by the manufacturer or system service provider. These will be provided as an electronic file in a format recognized by the system. Insert the removal media containing the file into either the USB or DVD\Blu-ray™ drive, select the file, and touch or click “Install”.

14.5 Modality Worklist

The Modality Worklist network location and connection credentials can be configured by completing the fields in this section.



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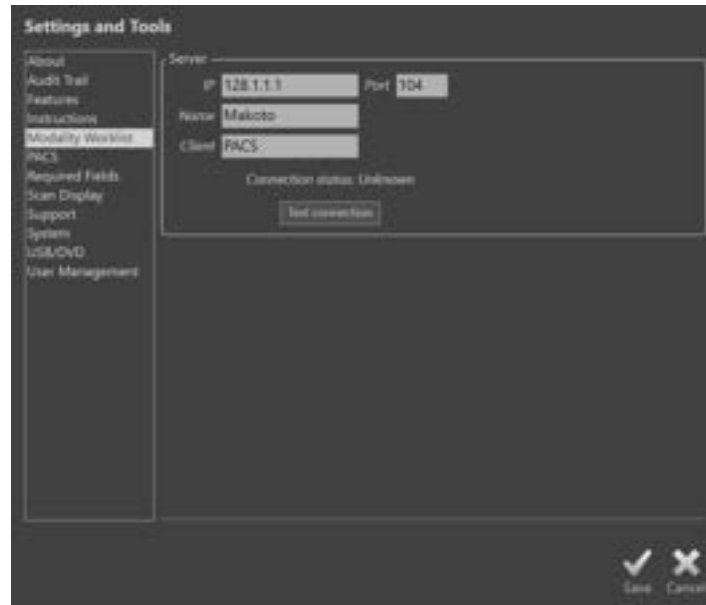



Figure 14-5: System Settings, Modality Worklist.

14.5.1 Modality Worklist Server Connection Settings

To use the Modality Worklist semi-automatic procedure setup options, the network address of the Worklist server must be configured. To configure the address, enter the following information:

IP	The internet protocol, version 4, address of the Worklist server.
Port	The communication port on which the Worklist server expects communication. This is typically port 104.
Name	The Worklist server network name.
Client	The name by which the Makoto® Intravascular Imaging System will be identified on the network.

Touch the Test Connection, , to ensure that the Worklist server and Makoto® Intravascular Imaging System can communicate. Contact your service representative or Infraredx customer service for assistance in configuration.

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14.6 PACS

In this section of System Settings, configure the data types, PACS server location and credentials.

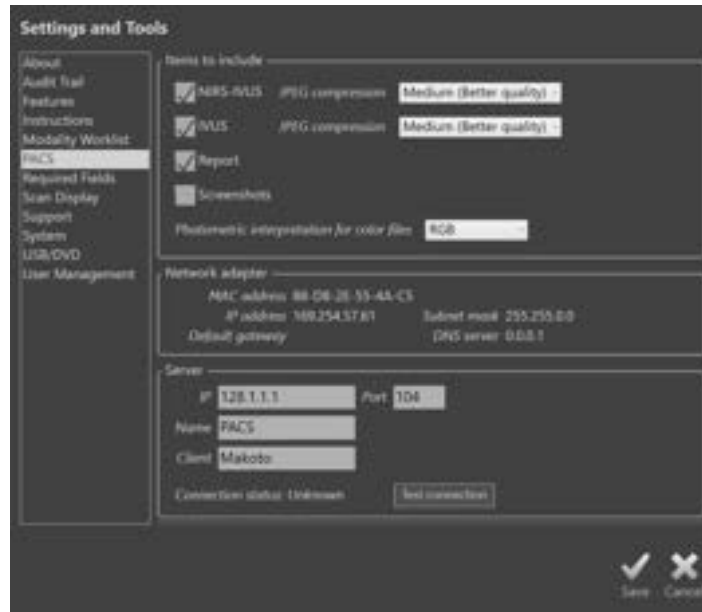


Figure 14-6: System Settings, PACS section.

14.6.1 Items to Include

There are several types of data and reports that can be generated from the Makoto® Intravascular Imaging System.

These file types and formats are described in the table below:

Table 14-1: Available data file types and formats

File Type	Available Formats		Description
	DICOM	Standard	
NIRS-IVUS	Yes	*.avi	A loop of the recorded transverse frames of NIRS and IVUS data. Live IVUS and Frame recordings will produce only IVUS or grayscale images.
IVUS	Yes	*.avi	A loop of the recorded transverse frames of IVUS data only.
Report	Yes	*.pdf	A report that summarizes patient information, procedure details, annotations, measurements, regions and Marks.

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File Type	Available Formats		Description
	DICOM	Standard	
TVC	No	*.tvc	A file that contains the NIRS and IVUS data in the native system format.
Screen Shot	Yes	*.png	Screen captures generated by the system and recorded by the user.

14.6.2 JPEG Compression

The compression settings of the DICOM data format can be adjusted to improve image quality or reduce data file size.

The Makoto® Intravascular Imaging System offers JPEG compression to produce low, medium, or high compression image files.

Table 14-2. DICOM Compression Settings

Compression Setting	Image Quality (qualitative)	Image Quality Setting (1-100)	File Size (qualitative)
Low	Best	100	Large
Medium	Better	80	Medium
High	Good	50	Small

14.6.3 Photometric Interpretation for Color DICOM Files

The DICOM standard provides for different methods of encoding color image information. On the Makoto® Intravascular Imaging System choose from either “RGB” or “YBR Full 422”.

14.6.4 Network Adaptor

Information related to the Makoto® Integrated Imaging system network adapters that may be useful for connecting the system to the hospital network can be found in this section.


14.6.5 PACS Server Connection Settings

To use the PACS export option, the network address of the PACS server must be configured. To configure the address, enter the following information:

IP The internet protocol, version 4, address of the PACS.

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Port	The communication port on which the PACS expects communication. This is typically port 104.
Name	The PACS server network name.
Client	The name by which the Makoto® Intravascular Imaging System will be identified on the network.

Touch the Test Connection, , to ensure that the PACS and Makoto® Intravascular Imaging System can communicate. Contact your Service Representative or Infraredx Customer Service for assistance in configuration.

14.7 Required Fields

The system Setup Phase can be configured to require particular fields be completed prior to closing procedures or editing the information related to completed procedures. The required fields can be set by selecting the field from the “Not Required” list and then clicking or touching the “Add >>” button. Select fields in the “Required” list and click or touch “<< Remove” to reduce the requirements.

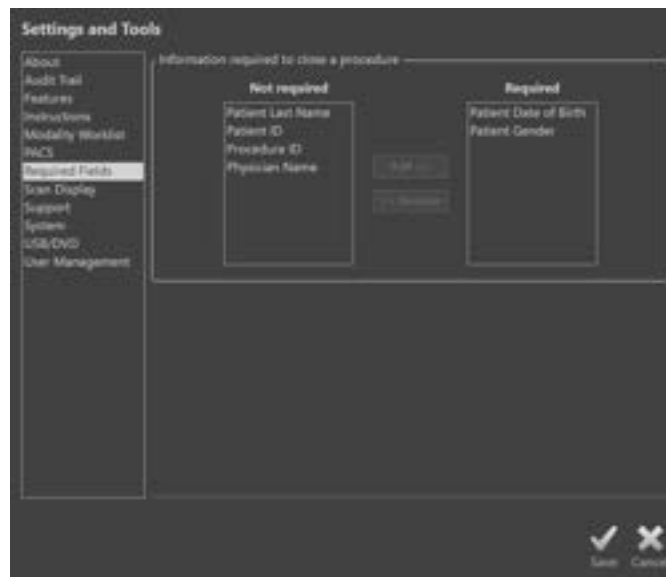


Figure 14-7: System Settings, Required Fields section.

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14.8 Scan Display

The Scan Display section of System Settings permits customization of some visual aspects of the Scan Phase and View Phases.

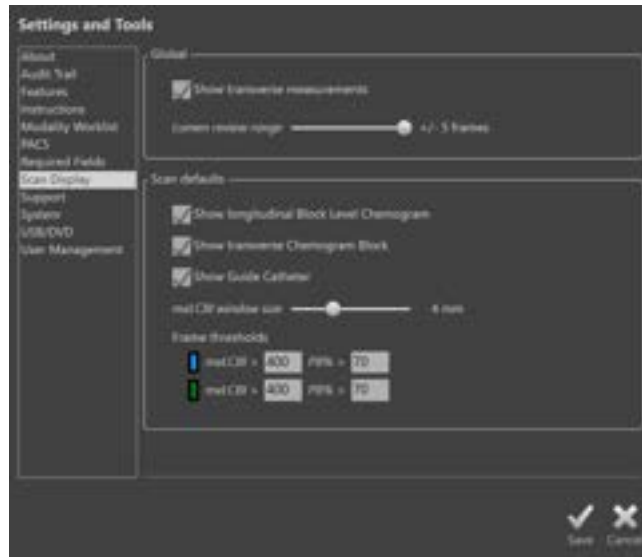


Figure 14-8: System Settings, Scan Display section.

14.8.1 Transverse Measurements

Use this toggle to view or conceal transverse measurements and results on the display. Collapsing the measurement results will also hide the measurement contours. When opening scans for review, the measurements will be hidden and the results will be collapsed.

14.8.2 Lumen Review Range of Frames

Use this control to vary the range of frames that will be played when Lumen Review function is activated, see Section 10.3.2 Lumen Review.

14.8.3 Longitudinal Block Level Chemogram Visibility

The visibility of the Block Level Chemogram may be updated based on the user preference. These changes will apply as a default to all new recorded scans. The visibility of the Block Level Chemogram on individual scans may be set by editing the scan properties, Section 10.2 Editing Scans.

NOTE: To adjust the visibility of the Longitudinal Block Level Chemogram on an individual scan see Section 10.2 Editing Scans.

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14.8.4 Transverse Chemogram Block Visibility

The visibility of the Chemogram Block in the center of the transverse IVUS may be updated based on the user preference. These changes will apply as a default to all new recorded scans. The visibility of the Chemogram Block on individual scans may be set by editing the scan properties, Section 10.2 Editing Scans.

NOTE: To adjust the visibility of the Chemogram Block on the transverse IVUS image on an individual scan see Section 10.2 Editing Scans.

14.8.5 mx LCBI Window Size

Use this control to vary the size of the default scan max LCBI window size on the display. Max LCBI results in reports will generate using the current setting for the max LCBI window size. This value may be set using the slide control provided in a range from 1 mm to 10 mm, in 1 mm increments.

NOTE: To adjust the mxLCBI window on an individual scan see Section 10.2 Editing Scans.

14.8.6 Show Guide Catheter

Use this control to set the default visibility of the automatic guide catheter mask.

14.8.7 Frame Thresholds

Use this control to set the default mxLCBI and Plaque Burden thresholds to display on Condition Indicator screen.

14.9 Support

This section of System Settings provides controls for exporting system log files. These files provide useful information to service personnel in diagnosis of system performance issues.

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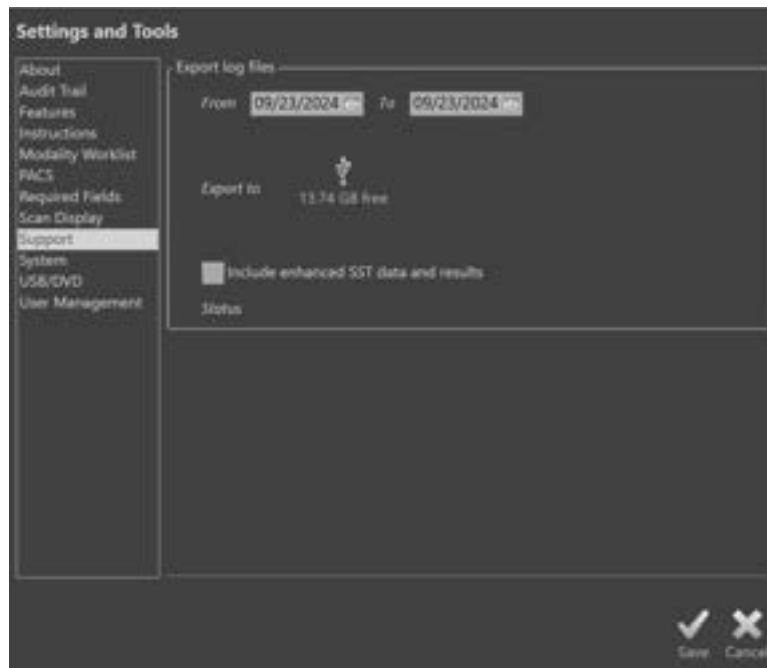


Figure 14-9: System Settings, Support section.

Set the desired date range using the provided controls, decide on inclusion of enhanced SST data and results files, and then choose the destination where the files will be copied.

The files generated by this utility do not contain any protected health information.

14.10 System

This set of Settings parameters are used to configure system operation or labeling parameters. Some changes to these settings will require a re-start of the system to enable.

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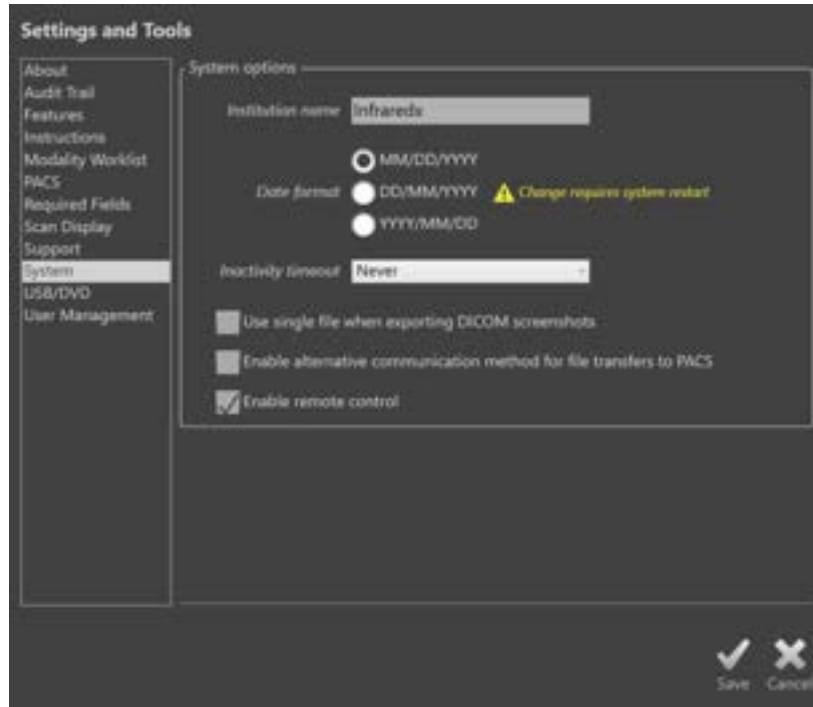


Figure 14-10: System Settings, System options section.

14.10.1 Institution Name

Use this field to configure the name of the institution as it will appear within the header of DICOM files or other reports generated by the system.

14.10.2 Date Format

Use this option to configure the date format displayed by the system on screen and in reports.

14.10.3 Inactivity Timeout

Use this option to configure the amount of time that the system must remain idle before the system automatically logs out the active user.

The system will not automatically log out during an active procedure.

14.10.4 Single File DICOM Screen Shots

Use this option to consolidate all the recorded screen shots for a scan into a single DICOM frame stack of images.

14.10.5 DICOM Transfer Method

The Makoto® Integrated Imaging system maintains ability to transfer or communicate DICOM files to a PACS in two ways. The primary method is enabled by default. Some PACS systems are limited in the PACS communication methods that will be accepted. Check this option to use the alternate communication method for PACS transfers.

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This communication method does not impact the content of the DICOM file being transferred.

14.10.6 Enable Remote Control

Use this option to enable the Makoto® System User Interface to control some motions of the Makoto® Controller and attached catheter.

14.11 USB/DVD (Removable Media)

The default data format options to be saved to removable media may be configured in this section of System Settings.

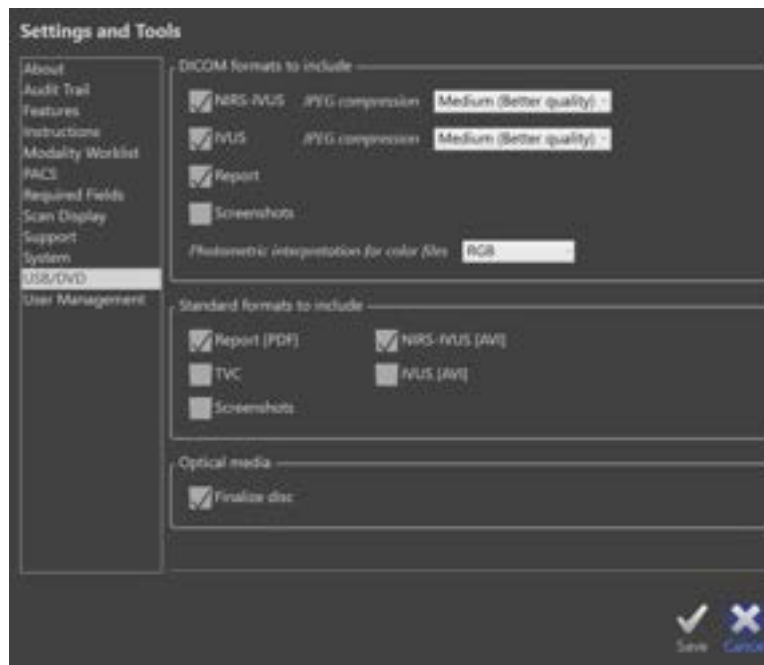


Figure 14-11: System Settings, USB/DVD section.

14.11.1 DICOM Formats to Include

DICOM formats available, described in Table 14-1 above, are also available for export to removable media. Export of DICOM and standard file formats may be combined into a single export action.

14.11.2 Standard Formats to Include

In addition to the data file types only available in DICOM format, additional data file types in standard format (non-DICOM) may be selected.

The standard formats may be more suitable for presentation creation or viewing when DICOM tools are not available.

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14.11.2.1 AVI Compression

The avi compression settings of the IVUS or IVUS+NIRS data is set to the following codecs: XviD.

14.11.3 Optical Media

Multi-session recording is supported when exporting to optical media (CD, DVD, Blu-ray™). Uncheck “Finalize disc” to permit additional exports to the same media.

14.12 User Management

This section is available to Administrator users. This section of settings is for managing user lists, editing permissions of users, setting or changing passwords or replicating user profiles on other Makoto® Integrated Imaging Systems.

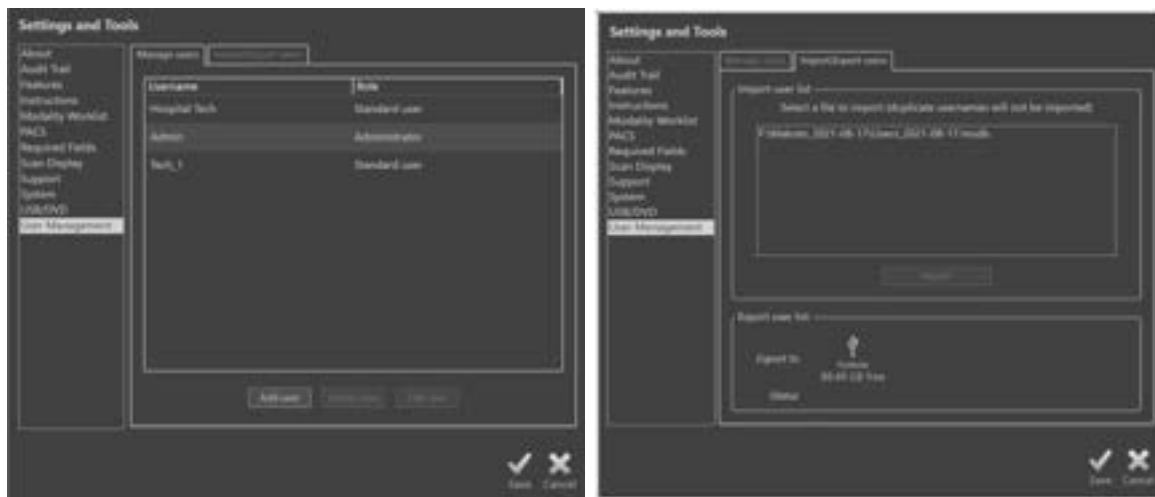


Figure 14-12: System Settings, User Management section. Manage Users (left) and Import/Export Users (right).

14.12.1 Manage Users

A list of registered can be viewed and edited. Administrators are permitted to add, delete, or edit user profiles.

14.12.1.1 Add User

14.12.1.1.1 User Name

User name maybe a minimum of 1 character in length and not a duplicate of another recognized user name.

14.12.1.1.2 Roles

Administrator Profile

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This profile is established to create and maintain other established user profiles. The Administrator profile can configure all system settings accessible to the institution including PACS and Modality Worklist connectivity. The Administrator profile has access to all patient data on the system and may import and export data.

Standard Profile

This is the profile used by typical users of the Makoto® Integrated Imaging System. These users must provide valid login credentials. This profile may have limited access to some configuration options of the system. Patient data can be viewed and may be imported or exported to configured destinations.

Anonymous Profile

This is the profile used when a valid Login is not completed due to use of the “Skip” function. This profile does not have permission to view other procedure or patient data on the system other than the data collected during the current active session. Configuration of system settings and data export options are limited.

Service Profile

A factory set profile for Service Engineers is pre-configured. This profile accessible to authorized service personnel for the purposes of configuring the Makoto® for the institution or restoring Administrator User profiles.

14.12.1.1.3 Password

Passwords must be set with the assistance of a user with the Administrator role. If standard users forget their password, they can still record procedure information by skipping the log in. However, access to prior data and transfer functions will be limited. With the assistance of the Administrator of the System, the standard user password may be reset. If an Administrator must reset their password and there is no other user with administrator role, then contact your service representative for assistance.



It is strongly recommended that the Makoto® Administrator implement and enforce password strength requirements that conform to their institution's security policies for this type of medical equipment.

14.12.1.2 Delete User

Users with an “Administrator” profile type may delete other user profiles. The administrator currently logged in cannot delete the in-use profile.

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14.12.1.3 *Edit User*

Users with an “Administrator” profile type may edit other user profiles. Administrators may change the role of other users and enable the password assignment.

14.12.2 **Import/Export Users**

14.12.2.1 *Import Users*

Connected media will be searched for valid Makoto® User Data Base files. Available files will be presented. To import a user database file from another Makoto® Imaging System, select the desired database from the available list by clicking or touching the file name and then click or touch “Import”. Any new users found in the data base file will be added to the system.

14.12.2.2 *Export Users*

Touch the removable media destination to make a backup of the user profiles contained on the system. This file may be used to replicate the user profiles onto other Makoto® Imaging systems to ensure common user credentials across all Makoto® maintained by the Institution.

15 Video Export & X-Ray System Integration



CAUTION

Connecting the Makoto® system to a network increases the risk that the equipment may be affected by network-based cybersecurity attacks. The System is designed to secure network connections and communications. However, the risks associated with a network-based cybersecurity attack cannot be entirely mitigated.

See Manufacturer Disclosure Statement for Medical Device Security (MDS2) to manage cybersecurity risks and to ensure the safe and effective use of the device in its intended use environment. Contact Service Provider to request additional copies of the statement as required.

The Makoto® Intravascular Imaging System may transmit video, data, or share control with a connected, compatible fluoroscopy X-ray system.

Utilization of the features outlined in this section may result in additional cable connections from fixed locations to the Makoto® Console.



WARNING

Ensure that cables originating from or connecting to the Makoto® Intravascular Imaging System lay flat on the floor.

15.1 Digital Video Output

Video signal may be exported from the Makoto® Console by connecting an external monitor to the system with a DVI-D cable. Connecting the DVI-D cable to the Video Out connector will export 1920x1080 pixel image of the Physician Monitor display.

Optionally, the exported video resolution can be configured to 1600x1200 pixel (4:3 aspect ratio), please contact your Service Representative or Infraredx Customer Service for assistance.

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Figure 15-1: Makoto® Intravascular Imaging System video and control export panel

The DVI-D video output is located near the center of the panel as the third connector from the right edge.

16 Glossary of Terms

Block Level Chemogram	A simplified representation of the Chemogram information segmented into discrete blocks that are not dependent on rotation position information.
Chemogram	A map in the form of a graphical representation indicating the likelihood that lipid core containing plaques of interest are present.
Chemogram Block	A single segment in the block level Chemogram.
Chemogram Halo	A representation of the portion of a Chemogram located at a particular transverse IVUS frame that is displayed with a color ring around the transverse IVUS that is rotationally registered.
Composite Image	The Makoto® Intravascular Imaging System display configuration that contains the Chemogram, longitudinal IVUS, and transverse IVUS with Chemogram halo.
Console	The main component of the Makoto® Intravascular Imaging System; it contains the laser, software, power supply and computer.
Console User Interface	Provides the user an interactive interface to collect or review data using onscreen control buttons.
Good Spectra Indicator	Graphical display to represent the number of valid spectra recorded during a pullback acquisition.
Guide Catheter Mask	Included in the software package to automatically detect a guide catheter. This feature can be turned on and off by the physician.
Guidewire Map	A map that allows the physician to identify possible artifacts, including those caused by the presence of a guidewire.
Letterbox	An appearance of displayed information where a black border appears above and below the image content to fill a screen and not distort the image contents.

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Lipid Core Burden Index	A measure of the overall proportion of lipid core in the scanned artery segment on a scale of 0 to 1000 (low to high lipid core burden).
Umbilical	The cable connecting the Makoto® Controller to the Makoto® Console.
XviD	A video file compression codec that produces small manageable video files that play on many viewers.

17 Maintenance

17.1 System Information

The system consists of three major components: a console, a controller (pullback/rotation sub-system), and the catheter. These components are connected optically, electrically, and mechanically.

The system is compatible with the following accessories:

- Shielded Cat5e Cable (REF PN2690)
- Shielded DVI-D Video Cable (REF PN2665)
- Integrated Data and Video Cable (REF TVC-10PMC)

The Makoto® Intravascular Imaging Systems (TVC-MC10, TVC-MC10i) manufactured by Infraredx® are designed for use with the following catheter model:

- Dualpro® IVUS+NIRS Imaging Catheter (REF TVC-C195-42)
- DualproNIRS™ Imaging Catheter (REF TVC-C195-42J)
- DualproPlus® IVUS+NIRS Imaging Catheter (REF TVC-C195-52, TVC-C195-52J)
- Infraredx Clarispro® HD-IVUS Imaging Catheter (REF TVC-E195-42)

NOTE: The Infraredx Clarispro® HD-IVUS Catheter is approved only in select markets.

NOTE: The DualproPlus® IVUS+NIRS Imaging Catheter is approved only in select markets.

NOTE: The DualproNIRS™ is only available only in select markets.

The system has the following add on feature:

- SmartImaging™ (REF TVC-MC10-UPA)

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NOTE: SmartImaging™ feature is approved only in select markets

NOTE: SmartImaging™ feature may require additional hardware. Please contact your supplier for additional information.


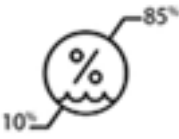

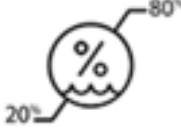
The Makoto® Intravascular Imaging System console and Makoto® Controller specifications are listed below. The imaging catheter specifications can be found in the associated catheter instructions for use documentation that is included in the catheter package.

17.1.1 Physical

- The Makoto® Console fits within a 24" wide, 56" tall, and 28" deep (61 x 150 x 71cm) volume (excluding cables and fibers).
- The Makoto® Console has four wheels, two of which may be position locked and two that can be directionally locked.
- The Makoto® Console handle is designed for rolling the console. The console cannot be lifted by its handle.
- The Makoto® Controller fits within a 5" x 6" x 17" (12.7 x 15.2 x 43.2cm) volume (excluding cables and fibers).
- The Makoto® Intravascular Imaging System weighs 202lb (92kg).





17.1.2 Environmental

Table 17-1: Console Transportation, Storage, and Operation Environmental Conditions

Type	Temperature °C	Humidity % (non-condensing)
Transportation & Storage		
Operation		

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Table 17-2: Catheter Transportation, Storage, and Operation Environmental Conditions

Type	Temperature °C	Humidity % (non-condensing)
Transportation		
Storage		N/A
Operation		N/A

17.1.3 Electrical

- The device operates from a nominal line voltage of 100 VAC, 120VAC, 220 VAC, or 240VAC, 50 - 60 Hz, single phase. The power entry module must be manually configured for the appropriate input voltage and fusing. For operation at 100VAC or 120VAC, two 5 A fast blow high breaking capacity, 3AG fuses are used. For operation at 240 VAC, two 3 A, fast blow high breaking capacity, 3AG fuses are used.
- The device operates with a single power cord.
- Power connection is hospital grade.
- The device is a Class I electrical device.
- Protection Type CF Applied Part.
- The system is capable of transmitting and receiving wireless communication via Bluetooth®2.0 communication protocol.

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17.1.4 Optical

- The Makoto® Intravascular Imaging System contains a near infrared Class 1M laser.
- Laser light is transmitted from the console to the connected catheter by way of the Makoto® Controller and connecting cables.

17.1.5 Makoto® Controller

- Rotation speed = 960, 1800 rpm, counterclockwise viewing the connection socket.
- Longitudinal speed = 0.5, 1.0, 2.0, 10.0 mm/s.
- Full range of longitudinal movement = 155 mm (minimum).
- The Makoto® Controller functions inside an intermediary sterile Makoto® Controller Sterile Barrier.

17.2 Installation Responsibilities

This section describes the installation site requirements and the potential relocation of the system.

17.2.1 Customer Responsibilities

The Makoto® Intravascular Imaging System is intended to be installed in a catheterization laboratory or similarly equipped facility. Before installation, the intended site must be prepared as described in this section. The site must have sufficient space to accommodate the system, must provide the proper electrical power configuration and receptacles, and must meet the additional environmental specifications outlined below.

It is the responsibility of the customer to ensure that the installation configuration of the Makoto® Intravascular Imaging System (TVC-MC10) complies with applicable requirements as described in IEC 60601-1.

17.2.2 Manufacturer Responsibilities

Installation of the Makoto® Intravascular Imaging System is performed by a service representative. Following installation, Infraredx personnel or authorized representative will instruct designated catheterization laboratory personnel on the basic operation and care of the system; this instruction supplements the more detailed information presented in this manual.

17.3 Installation Requirements

17.3.1 Facilities Requirements

The Makoto® Intravascular Imaging System is designed to be used in a typical catheterization laboratory or similarly equipped facility.



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NOTE: The emissions characteristics of this equipment make it suitable for use in industrial areas and hospitals (CISPR 11 class A). If it is used in a residential environment (for which CISPR 11 class B is normally required) this equipment might not offer adequate protection to radio-frequency communication services. The user might need to take mitigation measures, such as relocating or re-orienting the equipment

In most cases, no special modifications to an existing facility are necessary.

17.3.2 Space Requirements

Sufficient floor space is required for the system. Approximately 15 inches (40 cm) of clearance is required between the rear panel of the system and the wall behind it to provide room for the power cord and to allow circulation of air from the cooling vents.

17.3.3 Electrical Requirements

The Makoto® Intravascular Imaging System is designed to work with the standard electrical wiring available in a catheterization laboratory or similarly equipped facility.

The Makoto® Intravascular Imaging System is equipped with an equipotential ground stud located on the rear of the unit.

17.4 Environmental Requirements/Precautions

17.4.1 Air Quality

Ensure that the atmosphere is non-corrosive, with no salts or acids in suspension in the air. Acids, corrosives, and volatile materials are likely to attack electrical wiring and the surfaces of optical components.

Keep airborne dust particles to a minimum. Dust particles can cause permanent damage to optical surfaces. Metallic dust can be destructive to electrical equipment.

There is an air filter in the console. This filter will be inspected and cleaned or replaced as necessary during routine maintenance visits.

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17.5 General & Contact Information

In general, the Makoto® Intravascular Imaging System requires no special maintenance by the user. Routine care of the Makoto® Controller as well as cleaning and disinfection of the exterior of the system are covered in the Section 17.5.2 Cleaning and Disinfection.

Fault or warning indicators are described in Section 17.6 Warning and Fault Indicators with the recommended responses.

All other maintenance and service must be performed by a qualified service representative. Routine preventive maintenance of the system should be performed by a qualified service representative at least every 12 months. At each of these visits, the service representative checks and adjusts the functionality of the system as necessary.

17.5.1 Contact Information:

For all service, maintenance, and replacement part requests please contact your local sales and service provider or call Infraredx, Inc. at: 1-800-596-3104.

17.5.2 Cleaning and Disinfection

The exterior of the Makoto® Intravascular Imaging System console and Makoto® Controller may be cleaned using a soft cloth moistened with a solution of mild soap and water. Harsh detergents should not be used. If it becomes necessary to disinfect the exterior of the Makoto® Console or Makoto® Controller, a soft cloth moistened with hospital-grade disinfectant may be used.



Hospitals and healthcare facilities should follow their protocol for handling blood borne risks.



Care should be taken to prevent cleaning fluids, saline, or other liquids from entering into the Makoto® Controller or Console.

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Care should be taken to avoid contamination of the optical connectors of the Makoto® Controller. In the event that the controller optical fiber connectors cannot be cleaned, please contact your local service provider or Infraredx for further instructions.

17.6 Warning and Fault Indicators

During Makoto® Intravascular Imaging System use, the data acquisition software checks the electrical communication link with the Makoto® Controller and the laser light source. If the devices are not attached or communication with either device is not functioning properly, then the software alerts the user with a fault message that appears at the top of the screen.

If this fault is encountered then contact your local service provider or Infraredx customer service.

Beyond the warnings and fault indicators listed above, there are no other warning or fault indicators on the Makoto® Intravascular Imaging System.

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17.7 Troubleshooting

Symptom	Possible Causes	Remedies
System will not power on	System not plugged in	Plug in system, See Section 6.1.
	Fuses not functioning	Contact service provider, see Section 14.1.
System will not remain powered	CPU battery is drained.	Plug system into power source between uses.
	Supplied power is unstable.	Try a different power outlet or socket. Contact service provider, see Section 14.1.
No image on console monitor	Monitors turned off	Locate and press power button on bottom of physician monitor.
		Locate and press power button on rear of technician monitor.
	Monitors not powered	Secure power cable in monitor.
		Contact service provider, see Section 14.1.
	Video feed disconnected	Secure connections of video cables to monitor.
Internal video distribution subsystem not functioning	Contact service provider, see Section 14.1.	
System software does not start, error message received	A component of the system has failed to respond during start up sequences.	Turn system off and then on. If problem persists then contact service provider, see Section 14.1.
	Operating system cannot open a necessary configuration or data file.	Turn system off and then on. If problem persists then contact service provider, see Section 14.1.

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Symptom	Possible Causes	Remedies
Touch Screen Not Responding	USB cable is loose.	Check connection of USB cable.
	Mouse is moving	Stabilize mouse or turn mouse over.
	System not properly configured for 1600x1200 video output	Contact service provider, see Section 14.1.
No virtual keyboard appears	Virtual keyboard is disabled.	Click or touch Settings, then Log Out. Enable keyboard at Log In.
Unable to Login	User name not registered.	Contact Administrator to register user.
	User name typed incorrectly	Enter username and password again.
	Incorrect password provided	Enter password again or contact Administrator to reset password.
Review Mode Toggle disabled	Active procedure in progress with data recorded	Close procedure, see Section 11.
		Delete all scans, see Section 10.2.12.
Data Export disabled	No procedures selected	Select procedures, see Section 12.2.
	Insufficient user permissions	Contact Administrator.
Custom Export disabled	Multiple procedures selected	Reduce selections to 1 procedure, see Section 12.2.4.
	Insufficient user permissions	Contact Administrator.
No procedures in Select Phase	All data removed from system.	Perform more procedures, see Section 7.
		Import data, see Section 12.3.
	Filter found no procedures or scans that apply.	Clear Filter, see Section 12.1.2.
	Insufficient user permissions	Contact Administrator.

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Symptom	Possible Causes	Remedies
Not recognizing USB storage device	Incompatible device	Use alternate USB storage device
	Encrypted device attempting to load data or program onto Imaging System.	Use alternate USB storage device.
No IVUS image visible	Black Level set too high or other improper image adjustment.	Return to Factory image settings or adjust Black Level, see Section 10.8.6
	Insufficient priming of catheter	Flush catheter with additional heparinized saline or Consult catheter instructions for use.
	Catheter transducer not functioning	Exchange catheter.
IVUS Image is dim or flickers	Image settings require adjustment	Return to Factory image settings or adjust individual image settings, see Section 10.8.6
	Insufficient priming of catheter	Flush catheter with additional heparinized saline or consult catheter instructions for use.
Guidewire Map is uniformly white.	Catheter optical fiber damaged.	Exchange catheter
Guidewire Map is uniformly black.	Catheter model does not produce chemograms.	Check catheter model and product description to confirm that NIRS data is generated, see Section 4.4.

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Symptom	Possible Causes	Remedies
Catheter will not load or connect	Controller is not in the LOAD position	Use the distal motion controls on the Makoto® Controller until the display reads LOAD. Controller out of calibration. Contact service provider, see Section 14.1.
	Catheter handle is not aligned with controller socket	Orient the catheter handle with colored button up prior to insertion in the Makoto® Controller catheter socket.
	Catheter connection occurs while automated reset sequence is in process.	Remove the catheter from the controller socket, allow automatic reset sequence to complete and attempt connection again.
	Catheter rotating imaging core is not aligned with catheter handle.	Using the cap, turn the core so that the core colors match the color of the buttons on the handle.
Unable to locate Instructions for Use	Accompanied physical instructions are no longer with the Makoto® system.	Touch Help on Login Screen; see Section 6.3
		Touch Help on Settings; see Section 14

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Symptom	Possible Causes	Remedies
Catheter will not unload or disconnect (inside rotating core stays connected after handle is removed)	Controller is not in the READY position at time of disconnection	Reconnect catheter handle and advance the controller to the READY position prior to attempting disconnection
	Catheter handle buttons are depressed during removal.	Reconnect catheter handle, adjust grip to avoid pressing the colored buttons on the catheter handle during disconnection.
		Remove sterile barrier gasket from controller socket. Insert handle through gasket and connect to controller socket inside the barrier. Attempt catheter removal again.
Chemogram fails to generate	Live IVUS acquisition performed.	No Chemograms are generated during Live IVUS acquisitions. Consult Section 9.1.
	Pullback distance insufficient	Repeat automated pullback acquisition with increased length, consult Section 9.2.2.
	Excessive low optical signal recorded during scanning.	Return to READY, unload then load the catheter again. Retry scan.
	Catheter fiber optics damaged	Exchange catheter, try again.
	System optical component failure.	Contact service provider, see Section 14.1.
	Catheter model does not produce chemograms.	Check catheter model and product description to confirm that NIRS data is generated, see Section 4.4.

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Symptom	Possible Causes	Remedies
Chemogram generates unexpectedly	HD-IVUS catheter model number read incorrectly or failed to read by RFID sub-system.	Replace catheter with new HD-IVUS catheter and try again.
Chemogram is covered with dark patches.	Biologic source of artifact: reflection of excessive thrombus	Exclude chemogram analysis in this region or repeat automated acquisition. See Section 9.3.
	Non-Biologic source of artifact: reflection of dense spacing of overlapping stents or covered stents.	Exclude chemogram analysis in this region or repeat automated acquisition. See Section 9.3.
	Biologic source of artifact: excessive blood depth	Exclude chemogram analysis in this region or repeat automated acquisition. See Section 9.3.
	Controller fiber optics dirty.	Contact service provider, see Section 14.1.
	Controller malfunction.	Contact service provider, see Section 14.1.
	Catheter fiber optics dirty.	Exchange catheter, try again.
	Catheter fiber optics damaged.	Exchange catheter, try again.
Controller will not return imaging core to READY position or move distally	Attempting to advance imaging core into a kinked transmission window	Follow on screen guidance. Straighten kinks attempt again. If problem persists, exchange catheter, try again.

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Symptom	Possible Causes	Remedies
	Catheter imaging core is bound or damaged.	Carefully remove catheter handle, then imaging core by pulling on the catheter shaft. Follow on screen guidance to exchange catheter.
Controller inner carriage is not moving when motor is running and translation buttons are pressed.	Controller has worn drive mechanism.	Contact service provider, see Section 14.1.
Catheter Lot Number is not automatically recorded	Catheter not programmed with lot number information	Enter the lot number found on the catheter packaging manually.
	Catheter lot number is read incorrectly.	Enter the lot number found on the catheter packaging manually.

17.8 Spare Parts

For ordering information, please call your local service provider or Infraredx, Inc. by dialing:

+1-800-596-3104.

17.9 System Lifetime

The Makoto® console and controller lifetime is 5 years. Infraredx® recommends performing preventative maintenance, service repairs and system upgrades as needed.

17.10 Decommissioning the Makoto® Imaging System

For information on safely decommissioning the system, please call your local service provider or Infraredx, Inc. by dialing:

+1-800-596-3104.

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17.11 Product Disposal

Infraredx® is committed to protecting the natural environment, and ensuring continued safe and effective use of this product through proper preventative maintenance, service repairs and system upgrade. Therefore, Infraredx® products are designed and manufactured to comply with relevant guidelines for environmental protection. As long as the product is used and maintained properly, it presents no environmental risks. However, the product may contain materials which could be harmful to the environment if disposed of incorrectly. Use of such materials is essential for the product's functions and its compliance to the statutory and other requirements.

17.11.1 Final Disposal of the Product

Final disposal is when the user disposes of the product in such a way that it can no longer be used for its intended purposes. The return, proper disposal and recovery of the medical device take place in accordance to the respective requirements of national legislation. Assuming no parts of the system housing are opened and the system is used properly, there are no risks to people or the environment.



Do not dispose of any parts of this product as industrial or domestic waste. The product contains hazardous materials which require special disposal. Incorrect disposal of any of these materials may lead to serious environmental pollution.

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18 Appendices

18.1 Appendix A: Warranty and Related Information

Most service support requirements that occur during the first year of your ownership of the Makoto® Intravascular Imaging System are covered by our warranty, as explained in the following sections. For support not specifically covered under the terms of the Infraredx® warranty, we will provide support on a per-call basis. Please contact the Infraredx® Customer Service Department at 1-800-596-3104 for equipment support for your Makoto® Intravascular Imaging System, or for information on available service support programs.

Warranty

Infraredx® warrants that all standard components of its Makoto® Intravascular Imaging System will be free of defects in material and workmanship for a period of one (1) year. Infraredx® will repair or replace, at its discretion, all defective components during this warranty period. Any such replacement may include refurbished parts or components. After the termination of the initial warranty period or any purchased extended warranty, repair services may be purchased from Infraredx® at its published rates.

Infraredx® warrants that the software designated for use with the instrument will execute its programming instructions when properly installed. Infraredx® will provide any software corrections or “bug-fixes” if and when they become available, without charge, for a period of one (1) year after installation. The warranty period will begin on the date of initial installation for hardware and software installed by Infraredx® personnel unless the installation date has been delayed at your request.

The above warranties shall not apply to defects resulting from misuse, negligence or accident, including, without limitation: operation by untrained operators; operation outside of the environmental specifications for the instrument or accessories; improper or inadequate maintenance by the user; installation of software or interfacing not supplied by Infraredx®; making of modifications to the instrument or the software not authorized by Infraredx®; making of repairs by anyone other than Infraredx® or an authorized repair agent of Infraredx®.

Warranty Shipments, Returns, and Adjustments

A warranty claim must be made promptly and must be received by Infraredx® during the applicable warranty period. Should it become necessary to return a product for repair and/or adjustment, a Return Merchandise Authorization (RMA) must be obtained from the Infraredx® Customer Service Department (1-800-596-3104). Infraredx® will provide instructions as to how and where products should be shipped. Any product or component returned for examination or for warranty repair shall be sent insured and prepaid via the means of transportation specified by Infraredx® Customer Service.

Shipping charges for all products or components replaced or repaired under warranty shall be the sole responsibility of the buyer. In all cases, Infraredx® has sole responsibility for determining the cause and nature of a product or component's failure, and Infraredx®'s determination with regard thereto will be final.

Decontamination of Returned Equipment

To comply with United States postal and transportation laws, equipment returned to Infraredx® must be properly decontaminated with a chemical germicide that is approved for use as a hospital disinfectant. If equipment is received without having been decontaminated, Infraredx® will charge cleaning costs to the customer.



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Limitations

This warranty does not cover the compatible catheters and related test components, or other OEM equipment that is not included in the Makoto® Intravascular Imaging System. This warranty does not cover normal calibration, cleaning, or maintenance of the system. Any product returned to Infraredx® without prior authorization shall be returned at sender's expense. Infraredx® reserves the right to change or discontinue this product, its specifications, or price without prior notice.

Indemnification

Buyer agrees to indemnify and hold Infraredx® harmless from and against any and all actions, suits, liabilities, claims, fines, damages, losses or expenses including reasonable attorney's fees and expenses of litigation (the "Losses") incurred by or imposed in connection with any and all actions, suits, claims or demands, brought by third parties including, without limitation, those arising from violation of local, state, or federal laws relating to the product or its use including, without limitation, Losses related to improper inspection, the injury of any person or the injury or destruction of any property, selection of patients, application, operation, or use of Infraredx® products, including multiple use of single-use items, except for such Losses resulting from the sole and exclusive negligence of Infraredx®, its employees and duly authorized agents. No agent, employee, or representative of Infraredx® has the authority to change any of the foregoing, or assume or bind Infraredx® to any additional liability or responsibility in connection with the product.

Licenses

The Makoto® Intravascular Imaging System is comprised of both hardware and software developed and owned by Infraredx, Inc., as well as software licensed by Infraredx® from various software licensors ("Infraredx®'s Software Suppliers"). Those installed software products of Infraredx® and Infraredx®'s Software Suppliers, as well as all associated media, printed materials, and "online" or electronic documentation ("SOFTWARE") are protected by copyright laws and international copyright treaties, as well as other intellectual property laws and treaties. The software is provided to you under a non-transferable and non-exclusive license or sublicense for use by you solely in connection with the use of the Makoto® Intravascular Imaging System, which license may be more fully set forth in a separate license agreement with the product. No title to or ownership of the SOFTWARE or any part thereof is hereby transferred to you. You may use the SOFTWARE only on the Makoto® Intravascular Imaging System. You may not: (1) copy (other than for back-up purposes), distribute, rent, lease or sublicense all or any portion of the SOFTWARE; (2) modify or prepare derivative works of the SOFTWARE; (3) publicly display visual output of the SOFTWARE; or (4) transmit the SOFTWARE over a network, by telephone, or electronically using any other means. You agree to keep confidential and use your best efforts to prevent and protect the contents of the SOFTWARE from unauthorized disclosure or use. You may not reverse engineer, decompile, or disassemble the SOFTWARE, except and only to the extent that such activity is expressly permitted by applicable law.

Infraredx® WARRANTS THAT REASONABLE CARE HAS BEEN USED IN THE DESIGN AND MANUFACTURE OF PRODUCT SOLD HEREUNDER. THE SOFTWARE IS PROVIDED "AS IS" AND Infraredx® DOES NOT WARRANT THAT ITS OPERATION WILL BE UNINTERRUPTED, ERROR OR BUG FREE. THE ENTIRE RISK AS TO SATISFACTORY QUALITY, PERFORMANCE, ACCURACY, AND EFFORT (INCLUDING LACK OF NEGLIGENCE) IS WITH YOU. ALSO, THERE IS NO WARRANTY AGAINST INTERFERENCE WITH YOUR ENJOYMENT OF THE SOFTWARE OR AGAINST INFRINGEMENT. **THIS WARRANTY AND THE REMEDIES SET FORTH ABOVE ARE IN LIEU OF AND EXCLUDE ALL OTHER WARRANTIES NOT EXPRESSLY SET FORTH HEREIN, WHETHER EXPRESSED OR IMPLIED BY OPERATION OF LAW OR OTHERWISE, INCLUDING, BUT NOT LIMITED TO, ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.**

HANDLING, STORAGE, CLEANING AND STERILIZATION OF THE PRODUCT AS WELL AS OTHER FACTORS RELATING TO THE PATIENT, DIAGNOSIS, TREATMENT, SURGICAL PROCEDURES, AND OTHER MATTERS BEYOND INFRAREDx®'s CONTROL DIRECTLY AFFECT THE PRODUCT



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AND THE RESULTS OBTAINED FROM ITS USE. INFRAREDx® SHALL NOT BE LIABLE FOR ANY INCIDENTAL OR CONSEQUENTIAL LOSS, DAMAGE, OR EXPENSE DIRECTLY OR INDIRECTLY ARISING FROM THE USE OF THE PRODUCT (INCLUDING WITHOUT LIMITATION LOSS OF USE, LOST BUSINESS, REVENUE, PROFITS, DATA OR GOODWILL) EVEN IF INFRAREDx® IS ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. INFRAREDx® NEITHER ASSUMES, NOR AUTHORIZES ANY OTHER PERSON TO ASSUME FOR IT, ANY OTHER OR ADDITIONAL LIABILITY OR RESPONSIBILITY IN CONNECTION WITH THE PRODUCT.

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Export Restrictions

Unless otherwise agreed to by Infraredx®, if you export the Makoto® Intravascular Imaging System you shall assume all responsibility for obtaining any required export authorization and shall comply with all the applicable laws, rules, and regulations of all governmental authorities, including, without limitation, the Export Administration Act. You shall not export or re-export technical data supplied by Infraredx® or the direct product of such data in violation of applicable export regulations. You acknowledge that the software is of US-origin. You agree to comply with all applicable international and national laws that apply to the software, including the U.S. Export Administration Regulations, as well as end-user, end-use and country destination restrictions issued by the U.S. and other governments.

18.2 Appendix B: Summary of Ex Vivo and Clinical Studies

The Infraredx near-infrared (NIR) imaging system was developed to identify lipid core plaques of interest (LCPs) in coronary arteries. The LCP detection algorithm for this system was developed from data collected in autopsy hearts in an *ex vivo* study (CDEV3). In parallel, NIR measurements of coronary arteries were collected *in vivo* in a clinical pivotal study (SPECTACL). The *ex vivo* study prospectively assessed the accuracy of the NIR readings compared to histology, while the clinical study prospectively assessed the equivalence of the *in vivo* and *ex vivo* measurements. Later a prospective *in vivo* clinical outcomes study (LRP Study) was performed to prospectively assess the ability of NIR readings to identify patients and vessel segments at risk of major adverse cardiac events (MACE).

18.2.1 Ex Vivo Study (CDEV3)

Study Objective

The objective of the *ex vivo* study was to calibrate and prospectively validate the Infraredx NIR imaging system for the detection of LCPs. Calibration and validation of the system was accomplished using coronary arteries from autopsy human hearts in which pre-defined histologic criteria served as the comparator method.

Study Design

Calibration and validation of the Infraredx system was performed by acquiring co-registered spectroscopic and histologic data from 84 human hearts, 33 of which were used in the development of the calibration and 51 in the final validation. The calibration dataset was used to construct a multivariate discrimination model to detect the presence of LCP from NIR scan measurements. This model was then prospectively validated by testing its LCP detection performance on the validation dataset.

Each arterial segment in the calibration and validation was mounted in a fixture designed to permit perfusion with blood and precise registration of the site of NIR measurement with subsequent histologic sections. All scans were performed with an automated pullback and rotation device that pulled the optical tip along the length of the artery at 0.5 mm/s with a rotation speed of 240 rpm. Individual spectra were collected at a rate of approximately 40 Hz. With an average segment length of nearly 50 mm, this configuration resulted in an average of close to 4000 points of tissue interrogated per segment.

LCP was defined as fibroatheroma with lipid core greater than 60 degrees in non-contiguous circumferential extent, greater than 200 microns thick on average, and covered by a fibrous cap having a mean thickness of 0 to 450 microns. One histologic section was analyzed for every 2 mm cross-section (block) of artery. Histologic features of the arteries were classified by a pathologist according to the “modified AHA classification” scheme (Virmani R, Kolodgie FD, Burke AP, Farb A, Schwartz SM. Lessons From Sudden Coronary Death : A Comprehensive Morphological Classification Scheme for Atherosclerotic Lesions. *Arterioscler Thromb Vasc Biol.* 2000; 20(5):1262-1275).

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Table 18-1. Donor Demographics, Medical History, and Cause of Death

Characteristics	(n=51)
Demographic Profile	
Male, n (%)	36 (71)
Mean +/- SD age, years	65.9 ± 15
Medical History, n (%)	
Hypertension	31 (61)
Chronic smoker	21 (41)
Diabetes mellitus	17 (33)
Prior presentation CHF	16 (31)
Prior MI	11 (22)
Prior CABG	4 (8)
Cause of Death, n (%)	
<i>Cardiovascular related</i>	40 (78)
<i>Non-cardiovascular related</i>	8 (16)
<i>Unknown</i>	3 (6)

Study Endpoints

The diagnostic accuracy of the Infraredx system was assessed in three study endpoints using the area under the curve (AUC) of the Receiver Operating Characteristic (ROC) curve for two clinical uses: localized detection of LCP and determination of overall lipid core burden of a scanned artery segment.

Primary Endpoint: Image Accuracy in Detecting LCP without regard to cap thickness

Localized detection accuracy was assessed for all adequate 2 mm blocks of scanned artery using ROC analysis of the block Chemogram intensity values versus the paired histologic comparisons for blocks having a lumen diameter less than or equal to 3.0 mm. The block Chemogram intensity is the 90th percentile intensity of the Chemogram pixels in a 2 mm block of scanned artery, which visually corresponds to the 10% most yellow pixels in the block. The histologic comparison was presence or absence of LCP in each 2 mm block. Percent positive and negative agreement of the thresholded block Chemogram values were computed as the threshold was varied over all possible thresholds to sweep out the ROC curve, and the area under the ROC curve (AUC) was computed. For the primary endpoint, no restriction was imposed on the plaque cap thickness in the LCP definition.

Secondary Endpoint 1: Image Accuracy in Detecting LCP with cap thickness < 0.45 mm

This secondary endpoint used the same hypothesis and analysis methods as the primary endpoint but restricted the LCP definition to those with a cap thickness less than 0.45 mm on average. LCPs with cap thickness greater than or equal to 0.45 mm were analyzed as part of the negative group.

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Secondary Endpoint 2: Lipid Core Burden Index Accuracy

This secondary endpoint of the CDEV3 validation study supported a secondary use of the system: overall assessment of lipid core burden in a scanned artery segment using the Lipid Core Burden Index (LCBI). Accuracy of this measure was assessed for all adequate scanned artery segments using ROC analysis of the LCBI values versus the paired histologic comparisons. All lumen diameters were included in the analysis. LCBI is the fraction of Chemogram pixels of a scanned segment with intensity greater than 0.6, which visually corresponds to a transition from red to dark orange color on the Chemogram. The histologic comparison was presence or absence of any-sized fibroatheroma in the scanned segment. Percent positive and negative agreement of the threshold LCBI values were computed as the threshold was varied over all possible thresholds to sweep out the ROC curve, and the area under the ROC curve (AUC) was computed.

Study Results

The overall system AUC for detecting LCP without regard to cap thickness was found to be 0.80 (95% confidence interval 0.76 – 0.85) in arteries with lumen diameters less than or equal to 3.0 mm. When detecting LCP with caps less than 0.45 mm thick, the AUC was also 0.80 (95% confidence interval 0.76 – 0.84). The AUC for detecting the presence of any fibroatheroma along an artery segment using the LCBI was 0.86 (97.5% confidence interval 0.80 – 0.91) for all artery diameters. Table 2 summarizes the diagnostic accuracy results for the 3 study endpoints. **Figure 18-1** shows the corresponding percent agreement values as functions of the Block Chemogram intensity threshold (Primary Endpoint and Secondary Endpoint 1) or LCBI threshold (Secondary Endpoint 2).

Table 18-2: Accuracy Results for the Three Ex Vivo Study Endpoints

Study Endpoint	AUC
Primary Endpoint: Image accuracy in detecting LCP without regard to cap thickness ¹	0.80 (95% CI: 0.76-0.85)
Secondary Endpoint 1: Image accuracy in detecting LCP with cap thickness < 0.45 mm ¹	0.80 (95% CI: 0.76-0.84)
Secondary Endpoint 2: Lipid core burden index accuracy ²	0.86 (97.5% CI: 0.80-0.91)

¹ 51 hearts, 122 segments, 1909 2mm blocks; average lumen diameter <= 3 mm

² 51 hearts, 120 segments

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18.2.2 Clinical Pivotal Study (SPECTACL)

Study Objective

The overall study objective of SPECTACL was to assess the similarity of measurements obtained under clinical conditions to those acquired from autopsy specimens. Histopathologic comparisons were not available for the clinical patients, thereby precluding the direct evaluation of the accuracy of the *in vivo* NIR arterial images. Thus, the study used the spectral data underlying the images to demonstrate that the information acquired *in vivo* was similar to the information used in the *ex vivo* study.

Study Design

SPECTACL was a prospective multi-center clinical trial of patients undergoing elective or non-emergent percutaneous coronary intervention of a *de novo* native coronary artery lesion. Patients with stable or progressive angina, as well as patients with stabilized acute coronary syndrome, were enrolled. The SPECTACL clinical study was designed to show that the spectral features of data acquired in patients were substantially similar to the spectral features of data collected in the *ex vivo* study.

Study Period, Clinical Sites, and Enrollment

The SPECTACL pivotal study was carried out over a 21-month period at 6 clinical sites in the United States and Canada. A total of 106 patients were enrolled in the study during this period. NIR images were not obtained in 17 of these patients, resulting in data from 89 patients for analysis. Reasons for failure to acquire NIR images included inability to track vessel (7), device failure (7), procedural error (2), and improper accessory setup (1).

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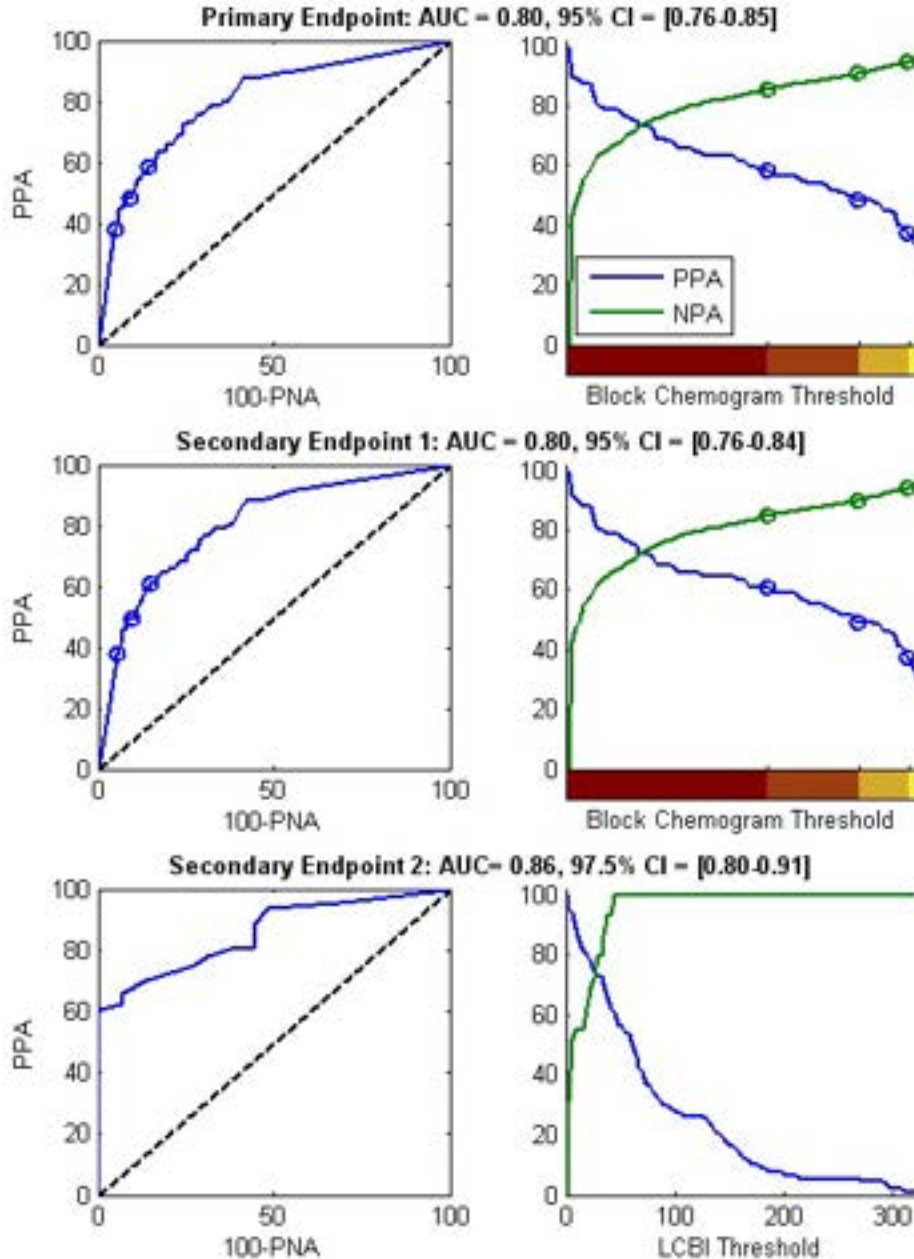


Figure 18-1. ROC curves (left column) and percent positive and negative agreement curves versus test threshold (right column) for the 3 study endpoints. A: *Primary endpoint - No cap thickness threshold*. Accuracy of the Chemogram versus histology in 2 mm blocks (51 hearts, 122 segments and 1909 2 mm blocks). The three color thresholds on the Block Chemogram (delineating red, dark orange, light orange and yellow) result in the positive and negative agreement percentages denoted by the circles. B: *Secondary endpoint 1 - A cap thickness threshold of 450 microns*. C: *Secondary Endpoint 2 - Accuracy of the Lipid Core Burden Index (LCBI) versus histology (51 hearts, 120 segments)*. PPA: percent positive agreement. PNA: percent negative agreement.

Among the 89 patients, data for 30 of the patients were un-blinded during the course of the clinical study for algorithm development. As a result, NIR images from 59 patients remained for a prospective evaluation of similarity of *in vivo* and *ex vivo* NIR measurements.

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Table 18-3: Ex vivo Demographics and Clinical Characteristics

Demographics	n=18 hearts (%)
Age (years)	
Mean +/- SD age	65 ± 14
Gender	
Male	13 (72)
Race	
Caucasian	17 (94)
African American	0
Asian	1 (6)
Pacific Islander	0
Native American	0
Other	0
Clinical History	
Family history of coronary artery disease	9 (50)
Hypertension	14 (78)
Diabetes mellitus	6 (33)
Tobacco Use	9 (50)
Prior myocardial infarction	1 (6)
Cerebral vascular accident/Transient ischemic attack	9 (50)
Congestive heart failure	3 (17)
Cause of Death	
<i>Cardiovascular related</i>	11 (61)
<i>Non-cardiovascular related</i>	3 (17)
<i>Unknown</i>	4 (22)

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Table 18-4: In vivo Patient Demographics, Clinical History, and Clinical Presentation

Demographics	n = 106 (%) ¹	n = 48 (%) ²
Age (years)		
Mean +/- SD	61.7 ± 10.0	61.4 ± 9.2
Gender		
Male	86 (81)	38 (79)
Race		
Caucasian	95 (90)	40 (83)
African American	5 (5)	2 (4)
Asian	1 (1)	1 (2)
Pacific Islander	0 (0)	0 (0)
Native American	0 (0)	0 (0)
Other	4 (4)	4 (8)
Unknown/Unreported	1 (1)	1 (2)

¹ Total number of enrolled patients

² Number of patients in prospective validation set with spectrally adequate pullbacks (see **Study Results**)

Clinical History	n = 106 (%)	n=48 (%)
Hyperlipidemia	70 (66)	36(75)
Hypertension	74 (70)	36(75)
Diabetes mellitus	23 (22)	11(23)
Prior myocardial infarction	16 (15)	5(10)
Prior percutaneous intervention	28 (26)	13(27)
Coronary artery bypass graft	3 (3)	0(0)
Cerebral vascular accident/Transient ischemic attack	0 (0)	0(0)
Peripheral vascular disease	4 (4)	2(4)
Family history of coronary artery disease	46 (43)	19(40)
Chest pain in last 7 days	67 (63)	33(69)
Stable angina	54 (51)	27(56)
Congestive heart failure	6 (6)	0(0)

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Clinical Presentation	n = 106	n=48
Post myocardial infarction	15 (14)	8(17)
Unstable angina	10 (9)	7(15)
Stable angina	40 (38)	16(33)
Positive functional study	25 (24)	14(29)
Atypical chest pain	9 (8)	0(0)
Congestive heart failure	1 (1)	0(0)
Other	6 (6)	3(6)

Safety

While the SPECTACL study was not powered to assess the safety of the Infraredx instrument, adverse event monitoring ensured that the safety profile was similar to that seen with similar catheters. Since the Infraredx catheter is similar to the IVUS catheter in physical characteristics and use, it was expected that the rates and types of adverse events associated with the Infraredx device in the SPECTACL study would be similar to the well-documented experience with IVUS catheters in a similar PCI patient group.

Study Endpoint

The SPECTACL primary endpoint was judged prospectively by assessing the fraction of patients with a pullback similar to the autopsy data in the LCP algorithm training set. Individual patient pullbacks were deemed similar to the *ex vivo* measurements if greater than 80% of the spectra of adequate quality in the pullback met thresholds on similarity metrics, as described below.

Spectral Adequacy

Spectrally inadequate pullbacks were considered to be of poor quality as a result of obstructions or data acquisition errors and were excluded from similarity analysis. The spectral adequacy of individual spectra was determined on the basis of several outlier metrics. These metrics were designed to identify obstructions in the path of the optical beam that could distort the spectral measurement. Obstruction outliers included:

- Spectra collected with the guide wire obstructing the arterial wall.
- Spectra collected with the optical tip inside the guide catheter.
- Spectra flagged by the oscillation metric (e.g. poor optical connections, micro-bubbles in priming saline of primed catheters).
- Spectra flagged by the wall visibility metric (arterial wall not visible due to too much intervening blood).

For the purpose of assessing data quality, a pullback was subdivided into contiguous 2 mm blocks and each was evaluated for spectral adequacy. A block was judged to be spectrally adequate if greater than 75% of the spectra within the block were adequate. A pullback, in turn, was determined to be spectrally adequate if greater than 75% of the blocks within the pullback were adequate.

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Spectral Similarity

Two multivariate metrics were used for assessing the similarity between a spectrum and those in the model calibration set: the Mahalanobis distance (MD) and the spectral F-ratio (SFR). The former is a measure of the covariance-weighted distance between a point and the centroid of a set of points in multi-dimensional space. For a prediction spectrum x and the mean spectrum y of the calibration set, the MD metric is given by (in squared units)

$$MD=(x-y)'S^{-1}(x-y), \quad (1)$$

where S^{-1} is the inverse of the covariance matrix of the training set. Since the data in the system application are bimodal (positive or negative for LCP), separate MDs were calculated relative to each class. That is, one MD was computed with respect to the subset of calibration spectra with positive LCP reference (MD+), and the other was calculated with respect to the subset of calibration spectra with negative LCP reference (MD-). A given validation spectrum is assigned the smaller of the two distances (MD+ or MD-).

The SFR is a measure of the sum of squared residuals of the validation spectrum to the average sum of squared residuals of the calibration set. The spectral residual is the difference between the estimated spectrum constructed in a lower dimensional projection space spanned by the model and the actual measured spectrum. For spectral residuals e_{val} and e_{cal} corresponding to the validation and calibration spectra, respectively, the SFR is given by

$$SFR = m \left(\sum_{k=1}^n e_{valk}^2 \right) / \left(\sum_{i=1}^m \sum_{k=1}^n e_{cali,k}^2 \right), \quad (2)$$

for m calibration spectra and n wavelengths in a spectrum.

A pullback was judged similar if at least 80% of the adequate spectra in the pullback were below the thresholds for both the MD and SFR metrics. MD and SFR thresholds were established in the ex vivo calibration as part of the algorithm parameters.

Hypothesis Testing

The null hypothesis to be tested was:

$$H_0: p \leq 0.67$$

$$H_a: p > 0.67$$

where p is the proportion of patients showing spectral similarity between clinical recordings and the autopsy dataset. The null hypothesis was to be rejected, and therefore the primary endpoint met, if the lower bound of the 95% confidence interval exceeded 0.67.

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Study Results

A total of 59 patient pullbacks (one pullback per patient) were assessed in the validation. Eleven pullbacks were judged to be of inadequate spectral quality due to poor optical connection, excessive bubbles in the saline of primed catheters, blood flow disturbances, or obscuration of the arterial wall by excessive blood. Among the 48 pullbacks of adequate quality, 40 were found to be spectrally similar to the ex vivo spectra for a success rate of 0.83 (95% confidence interval, 0.70-0.93). This success rate satisfied the primary endpoint of the SPECTACL pivotal study by demonstrating that the lower bound on the 95% confidence interval exceeded 0.67. Figure 18-2 plots the percent similarity of each of the 48 pullbacks. The dashed horizontal line represents the median spectral similarity value (96%) of the pullbacks. The solid horizontal line indicates the lower bound for judging the spectral similarity of a pullback.

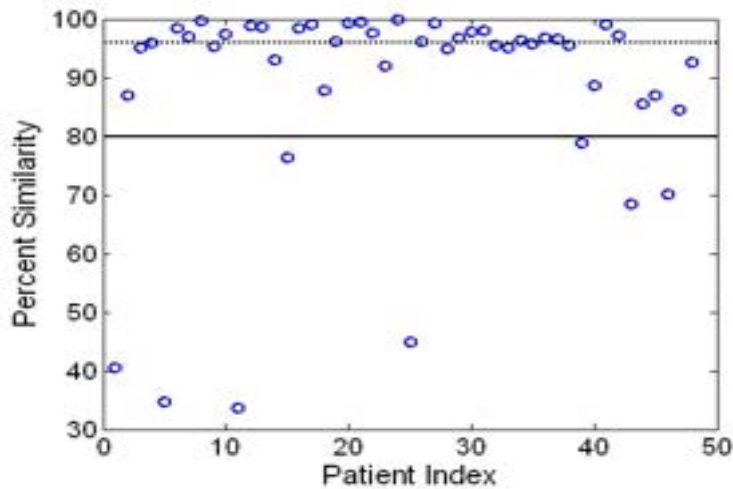


Figure 18-2: Percent similarity of adequate pullbacks. Dashed line is median percent similarity (96%). Percent similarity is defined as the percentage of spectra in a pullback that are within both the MD and SFR metric thresholds. Solid black line is 80% minimum threshold for defining a spectrally similar pullback. Forty of the 48 pullbacks (0.83) have a percent similarity above the threshold. Comparison of the SPECTACL study *in vivo* spectra is made relative to CDEV3 *ex vivo* calibration spectra (18 hearts).

An additional plot illustrating the similarity of the spectra collected in patients with those measured in autopsy specimens is given in Figure 18-3. The figure plots the MD metric for a random 1% of the spectra in each of the CDEV3 calibration (18 hearts), SPECTACL and CDEV3 validation data sets. The significant overlap among the different sets of data illustrates the similarity between *ex vivo* and *in vivo* spectra measured with the Infraredx NIR imaging system.

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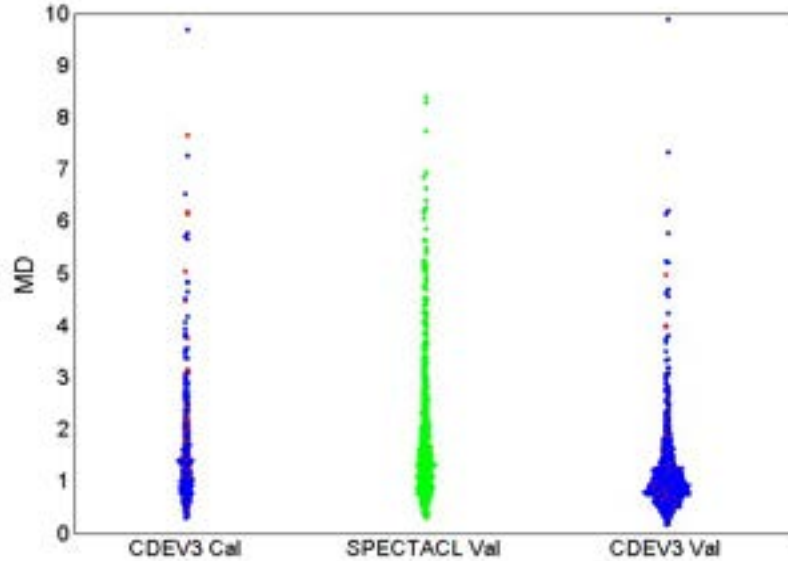


Figure 18-3: Similarity between CDEV3 ex vivo and SPECTACL in vivo spectra by MD. Red indicates positive for LCP by histology; blue indicates negative for LCP by histology; green indicates no histology. CDEV3 Cal = calibration model data (18 hearts, 51 segments, 790 spectra); SPECTACL Val = clinical pivotal study data (48 patients, 48 segments, 1770 spectra); CDEV3 Val = validation data (51 hearts, 126 segments, 3416 spectra). Each cluster represents 1% of the spectra selected at random from each set.

Safety

During the SPECTACL pivotal study, NIR spectra were collected in 89 patients. Combined with an additional 10 patients scanned in a prior feasibility study, the NIR imaging catheter was inserted in a total of 99 patients. No adverse events were determined to be related to the device as a result of these procedures.

18.2.3 Clinical Outcomes Study (LRP Study)

Study Objective

The overall study objective of the Lipid-Rich Plaque (LRP) Study was to determine in patients undergoing multi-vessel NIRS-IVUS imaging, the relationship between LRPs detected by intracoronary NIRS at non-stenotic sites and the prediction of subsequent coronary events from new culprit lesions at both the patient level (vulnerable patients) and the segment level (vulnerable plaque).

Study Design

The LRP Study was a multicenter, prospective study of patients with stable ischemic heart disease or a stabilized acute coronary syndrome (ACS) examined with angiography and NIRS-IVUS imaging for one or more suspected culprit lesions. After successful percutaneous coronary intervention (PCI) of all angiographically flow-limiting lesions, intravascular imaging with the combined NIRS-IVUS catheter was performed in

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at least two vessels and a minimum length of 50mm of coronary artery. The NIRS-IVUS data was then sent to a central core lab to determine presence or absence of LRPs.

All enrolled patients with a large LRP ($\text{maxLCBI}_{4\text{mm}} \geq 250$) as detected by NIRS were contacted at 2, 6, 12, and 24 months to determine if a new coronary event had occurred. A randomly selected half of the patients with a small, or no LRP ($\text{maxLCBI}_{4\text{mm}} < 250$), received an identical follow-up.

Study Period, Clinical Sites, and Enrollment

The LRP study enrollment took place over 25 months at 44 clinical sites in the United States and Europe. A total of 1563 patients were enrolled in the study during this period. NIRS data was not analyzable in 11 of these patients, resulting in data from 1552 patients for primary analysis. The primary analysis included 1271 patients that were assigned to the follow-up group.

Study Hypotheses and Endpoints

The study was designed to test two primary hypotheses with related endpoints.

Vulnerable Patient Hypothesis - During a 24-month follow-up after NIRS-IVUS imaging, there will be an association between the baseline value of $\text{maxLCBI}_{4\text{mm}}$ (over all coronary artery segments included in the analysis) and the incidence of non-index culprit MACE (NC-MACE) events.

Vulnerable Patient Endpoint – To test the association between $\text{maxLCBI}_{4\text{mm}}$ in all imaged arteries and future non-culprit MACE. First a univariate proportional hazards regression model in which $\text{maxLCBI}_{4\text{mm}}$ is the only independent variable and NC-MACE is the outcome was analyzed. The null hypothesis was tested by the Wald test that the regression coefficient in a proportional hazards regression model was significantly different from 0. This analysis determined whether $\text{maxLCBI}_{4\text{mm}}$ is a risk factor for NC-MACE.

This univariate analysis was the definitive test of the primary Vulnerable Patient Hypothesis. In supportive analyses, validity of the proportional hazards assumption was assessed. The proportional hazard assumptions were assessed prior to running the model; if rejected, however, the Lin-Wei estimator would have been utilized for inference.

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After the univariate analysis was determined to be positive, an additional multivariate analysis to assess the incremental prognostic value of NIRS detection of LRPs beyond conventional measures of risk was performed by fitting proportional hazards regression models that include the maxLCBI_{4mm} value and other identified prognostic variables unrelated to NIRS IVUS imaging.

To identify the variables to be included in the multivariate model, a step-up regression blinded to the NIRS and IVUS data was performed to identify the prognostic factors (including, but not limited to ACS, diabetes, renal insufficiency, hypertension, age>65, male gender, elevated cholesterol at baseline, and elevated cholesterol during the follow-up period) other than NIRS or IVUS data associated with the NC-MACE outcome. With this model, maxLCBI_{4mm} was added to assess its incremental prognostic value.

Vulnerable Plaque Hypothesis -During a 24-month follow-up, there will be an association between the maxLCBI_{4mm} of a proximal, mid, or distal segment of a coronary artery and the incidence of a follow-up culprit lesion in that segment leading to a NC-MACE event.

Vulnerable Plaque Endpoint – To test the association between maxLCBI_{4mm} in a segment and incidence of future NC- MACE in the same segment.

In the Vulnerable Plaque Hypothesis, each individual coronary artery segment is treated as a separate unit of observation. A study participant may provide results for an average of up to 12 segments.

To test this hypothesis, a proportional hazards regression model was fit with maxLCBI_{4mm} in the coronary artery segment as the measure of exposure and NC-MACE during 24 months caused by a new culprit lesion in that segment as the outcome. This analysis was performed with adjustment for the potential clustering effect within patient utilizing the Wei, Lin and Weissfeld (WLW) methodology. The primary vulnerable plaque analysis was the univariate analysis determining whether maxLCBI_{4mm} is a statistically significant risk factor for NC-MACE events.

Key Secondary Endpoints – There were key secondary endpoints analyzed for both the vulnerable patient and the vulnerable plaque analysis.

- (1) To test the association between a threshold of maxLCBI_{4mm} > 400 in a patient and incidence of future NC-MACE events.
- (2) To test the association between a threshold of maxLCBI_{4mm} > 400 in a coronary artery segment and incidence of future NC-MACE event located within that segment.

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Results

The 1271 patients in the follow up group had an average follow-up of 732 ± 27 days.

Baseline Characteristics

The baseline characteristics of the study cohort were typical for patients referred for PCI and are displayed in *Table 18-5*. The median age was 64 years, 69.5% were male, and 36.7% had diabetes mellitus. Stable angina with or without positive stress testing was the predominant clinical presentation of the patients. PCI was performed in 87.5% of the patients.

Table 18-5: Demographics, Clinical and Presentation Characteristics of the Patients

Variable	Value	n or %
Age (years)	64 ± 10.3	1271
Median	64	
Interquartile range	57-71	
Male sex	883/1271	69.5%
Diabetes	464/1266	36.7%
Diabetes requiring insulin	162/1243	13%
Smoking history (any)	687/1249	55%
Current smokers	282/1249	22.6%
Hypertension	1019/1267	80.4%
Hyperlipidemia	1013/1261	80.3%
Family history of coronary artery disease	782/1386	56.4%
Prior myocardial infarction	294/1253	23.5%
Prior PCI	569/1267	44.9%
Clinical presentation		
Stabilized STEMI	32/1271	2.5%
Non-STEMI	182/1271	14.3%
Unstable angina	468/1271	36.8%
Stable angina or positive stress test	589/1271	46.3%
BMI	30.2 ± 6.5	1262
Cholesterol panel*		
Total cholesterol mg/dl	163.5 ± 45.6	875
LDL mg/dl	91.7 ± 40.4	846
HDL mg/dl	44.7 ± 15.2	867
Triglycerides mg/dl	152.3 ± 127.5	859
Number of diseased vessels	1 ± 0.7	1227
<70% in any epicardial artery	268/1227	21.8%
One	702/1227	57.2%
Two	228/1227	18.6%
Three	29/1227	2.4%
PCI performed at Index [#]	1111/1270	87.5%

*Aggregated (baseline cholesterol values or first cholesterol values within 24 months if patient was on statin therapy at enrollment).

[#]Summary of PCI details in *Table 18-6* and *Table 18-7*

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Baseline Imaging

In the followed population, the mean number of arteries scanned per patient was 2.1 ± 0.5 with ≥ 50 mm of eligible vessel in 89.5% of the vessels. Overall the total scanned artery length was 139 ± 45.2 mm and the total analyzable NIRS data in non-stented vessel was 97.8 ± 43.4 mm (Table 18-6). The mean maxLCBI_{4mm} of these scanned vessels was 359.2 ± 175.1 , and 38.8% of the scanned arteries had maxLCBI_{4mm} more than 400. In the enrolled population (1552) the mean maxLCBI_{4mm} of these scanned vessels was 318.7 ± 184.4 and 31.9% of the scanned arteries had maxLCBI_{4mm} > 400. The mean length of the Ware segment was 21.2 ± 9.1 mm with most scanned Ware segments in the left anterior descending artery. The mean Ware maxLCBI_{4mm} was 165 ± 177.1 and in 11.5% of the patients the maxLCBI_{4mm} was greater than 400. In the enrolled population of Ware segments (6884), the mean Ware segment maxLCBI_{4mm} was 147.5 ± 169.7 .

Table 18-6: Core Laboratory Data, Patient

Variable	Patient Level	
	Value	n or %
Patient-level maxLCBI _{4mm} in a blinded artery scan	738/1271	58.1%
Patient-level maxLCBI _{4mm} in an un-blinded artery scan	533/1271	41.9%
Artery Imaged		
LM	5/1271	0.4%
LAD	1148/1271	90.3%
RCA	546/1271	43.0%
LCX	967/1271	76.1%
≥ 50 mm of Eligible Vessel	1137/1271	89.5%
Number of Vessels Scanned	2.1 ± 0.5	1271
Total Artery Length Scanned, mm	139 ± 45.2	1271
Total Eligible Vessel Length, mm*	97.8 ± 43.4	1271
Patient-level maxLCBI _{4mm}	359.2 ± 175.1	1271
Median	353	
Interquartile range	257-476	
Patient-level maxLCBI _{4mm} > 400	493/1271	38.8%
Number of Ware segments	5.2 ± 1.8	1271

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Table 18-7: Core Laboratory Data, Vessel Segments

Variable	Ware Segment Level# Value	n or %
Scanned Artery		
LM	6/5755	0.1%
LAD	2656/5755	46.2%
RCA	1277/5755	22.2%
LCX	1807/5755	31.4%
Segment Location		
Proximal	2248/5755	39.1%
Mid	1927/5755	33.5%
Distal	1246/5755	21.7%
Far Distal	334/5755	5.8%
Ware Segment Length		
=30 mm	2159/5755	37.5%
<30 mm	3482/5755	60.5%
>30 mm	114/5755	2%
Ware Segment Length (mm)	21.2 ± 9.1	5755
Plaque-level maxLCBI _{4mm}	165 ± 177.1	5755
Median	113	
Interquartile range	0-283	
Plaque-level maxLCBI _{4mm} > 400	664/5755	11.5%

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Major Adverse Cardiac Events

During the follow-up of the 24 months, 3 event types were followed. The cumulative incidence function for non-culprit MACE was 8.8% (n = 103), culprit or previously stented MACE was 8.7% (n = 104), and events with indeterminate coronary location was 2.3% (n = 28), Figure 18-4.

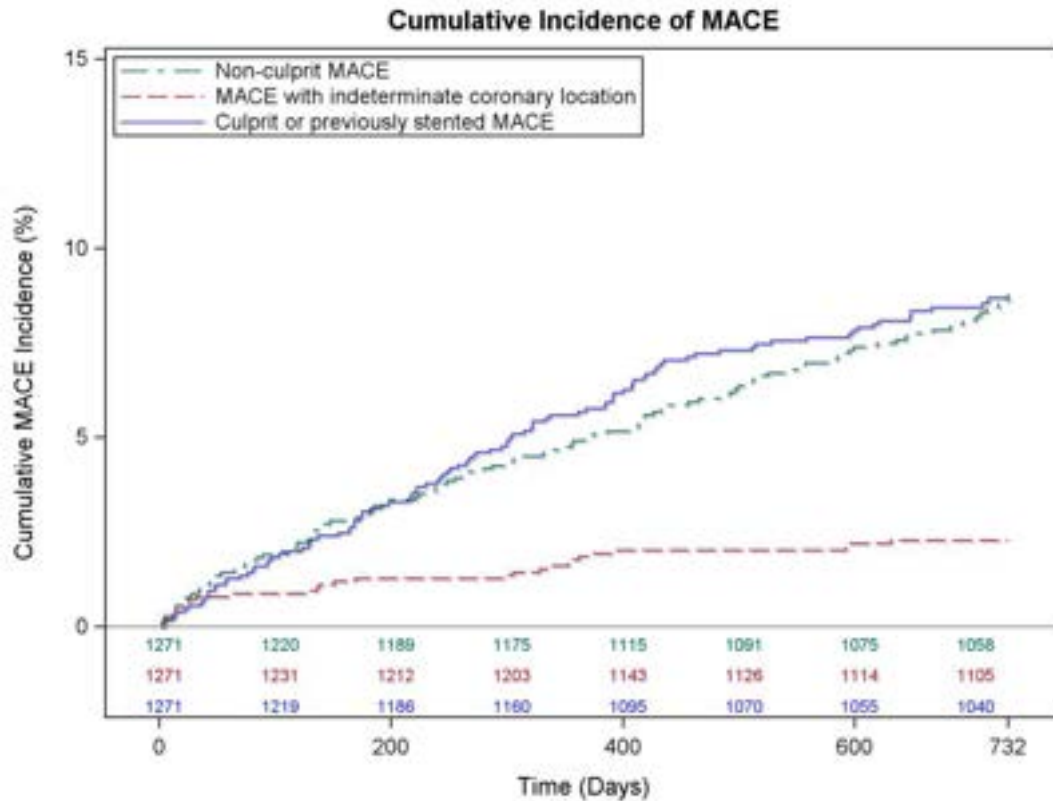


Figure 18-4: Cumulative incidence function by MACE type. Non-culprit MACE – 8.8%; Culprit or previously stented MACE – 8.7%; MACE with indeterminate coronary location – 2.3%.

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Vulnerable Patient and Vulnerable Plaque Level Endpoints

The independent correlates of non-culprit MACE during the follow-up are displayed in Table 3. For the maxLCBI_{4mm} as a continuous variable, the adjusted hazard ratio was 1.17 (95% CI [1.04-1.31], p=0.005) for experiencing NC- MACE event within 24 months with each 100 unit increase in maxLCBI_{4mm}. Patients with maxLCBI_{4mm} greater than 400 had an adjusted hazard ratio of 1.84 (95% [1.22-2.77], p=0.003) to experience NC-MACE relative to patients with less than or equal to 400.

Table 18-8: Co-primary endpoint proportional hazards models

Vulnerable Patient Level Unadjusted and Adjusted Cox Proportional Hazards Model		
Variable	Hazard Ratio [95% CI]	
	maxLCBI_{4mm} continuous	maxLCBI_{4mm} > 400
Unadjusted LCBI alone		
maxLCBI _{4mm}	1.21 [1.09-1.35]	2.18 [1.48-3.23]
Multivariable-Adjusted Model		
maxLCBI _{4mm}	1.17 [1.04-1.31]	1.84 [1.22-2.77]
Age	0.99 [0.97-1.01]	0.99 [0.97-1.01]
Male sex	0.81 [0.53-1.23]	0.83 [0.54-1.26]
Diabetes	1.29 [0.85-1.97]	1.29 [0.85-1.97]
Hypertension	2.13 [1.04-4.34]	2.11 [1.04-4.31]
Chronic renal insufficiency	2.00 [1.15-3.49]	2.00 [1.15-3.49]
History of smoking	1.44 [0.95-2.18]	1.45 [0.96-2.19]
Prior PCI	1.45 [0.97-2.18]	1.43 [0.96-2.15]
Presentation with ACS	1.22 [0.72-2.06]	1.23 [0.73-2.08]
Vulnerable Plaque Level Unadjusted and Adjusted Cox Proportional Hazards Models*		
Variable	Hazard Ratio [95% CI]	
Unadjusted LCBI alone		
maxLCBI _{4mm} - continuous	1.45 [1.28-1.64]	
maxLCBI _{4mm} >400	4.12 [2.32-7.32]	
Multivariable-Adjusted Model		
maxLCBI _{4mm} >400	4.31 [2.37-7.83]	

*Patient cluster adjusted via Wei Lin Weissfeld methodology

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The estimated cumulative incidence functions for patients above and below the pre-specified maxLCBI_{4mm} threshold of 400 is presented in Figure 18-5.

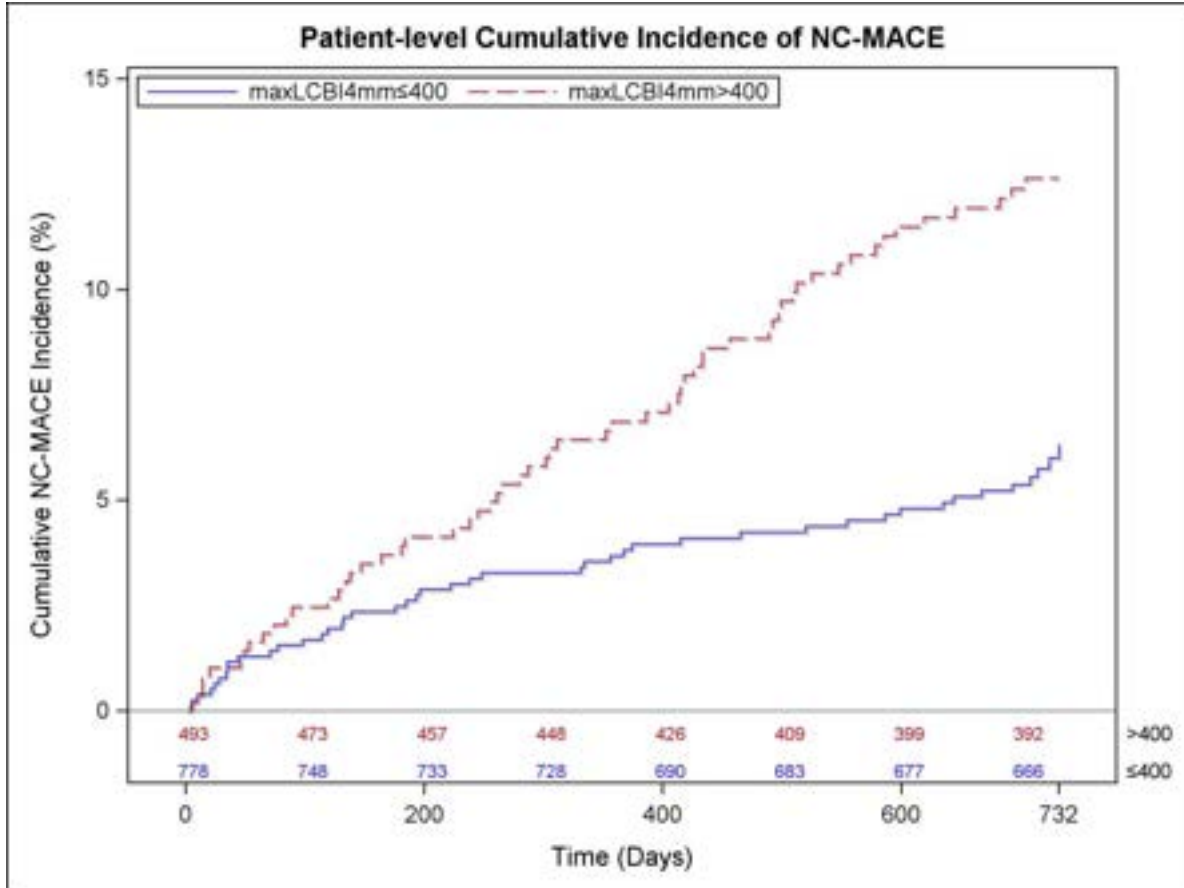


Figure 18-5: Patient level cumulative incidence of NC-MACE; Less than or equal to 400 – 5.8%; Greater than 400 – 12.6%, P<0.001.

Table 18-9 shows the cumulative incidence of NC-MACE at the patient follow-up time points of 2, 6, 12, and 24 months.

Table 18-9: Patient-Level Cumulative Incidence of NC-MACE (%)

	2 months	6 months	12 months	24 months
Patients with large LRP (maxLCBI _{4mm} ≥ 400) (Vulnerable patients)	1.3	2.5	3.7	5.8
Patients with small or no LRP (maxLCBI _{4mm} < 400)	1.6	3.7	6.9	12.6

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For the plaque level, the unadjusted hazard ratio for experiencing a subsequent event in a coronary segment within 24 months was 1.45 (95% CI [1.28-1.64], $P < 0.001$) with each 100 unit increase in maxLCBI_{4mm}. A coronary segment with maxLCBI_{4mm} greater than 400 had an unadjusted hazard ratio of 4.12 (95% CI [2.32-7.32], $P < 0.001$). The cumulative incidence functions for Ware segments above and below the pre-specified maxLCBI_{4mm} threshold of 400 is shown in **Figure 18-6**.

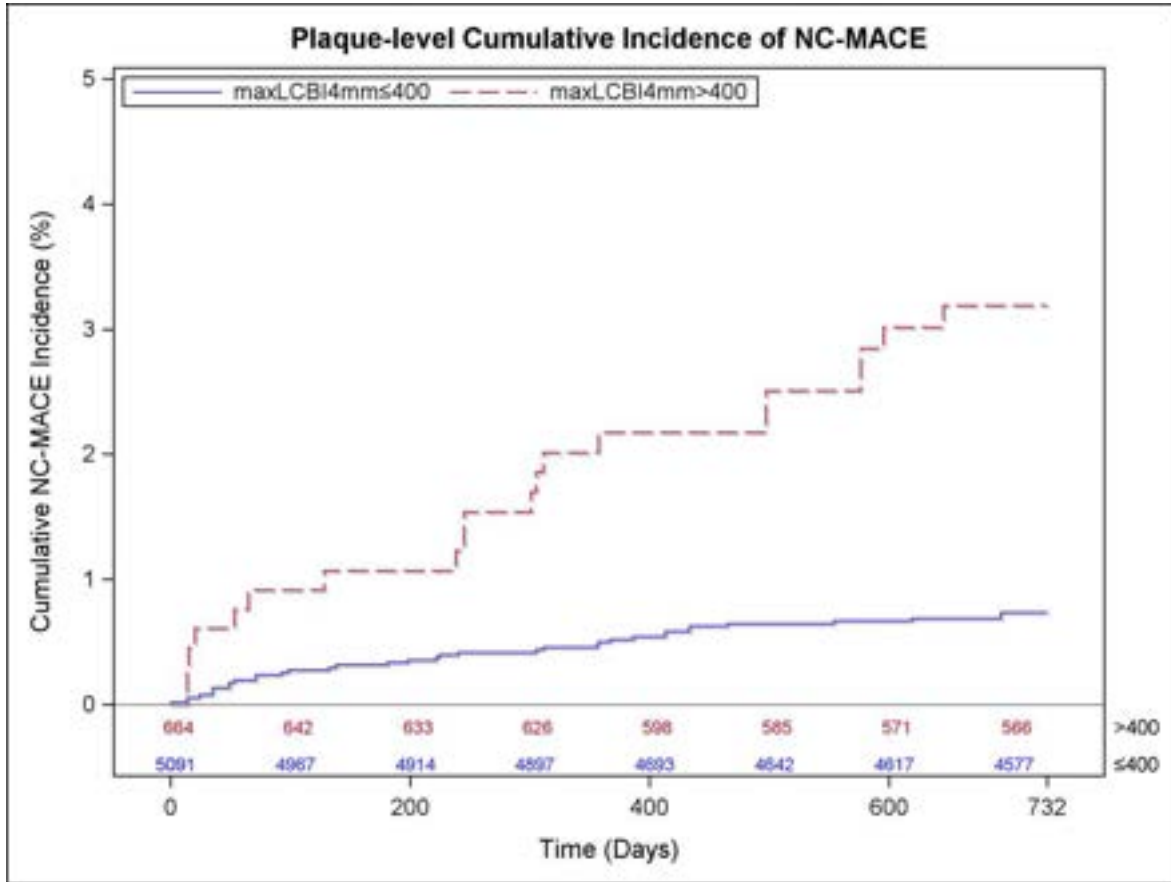


Figure 18-6: Plaque level cumulative incidence of NC-MACE; Less than or equal to 400 – 0.7%; Greater than 400 – 3.2%, $P < 0.001$.

Safety

During the LRP Study, NIRS-IVUS imaging was performed in 1563. Six patients (0.3%) were adjudicated by a clinical events committee to be related to the device.

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18.3 Appendix C: Reference Literature

Table 18-10: Reference Literature

- 1 Gardner CM, Tan H, Hull EL, et al. Detection of lipid core coronary plaques in autopsy specimens with a novel catheter-based near-infrared spectroscopy system. *JACC Cardiovasc Imaging* 2008; 1: 638–48.
- 2 Waxman S, Dixon SR, L'Allier P, et al. In vivo validation of a catheter-based near-infrared spectroscopy system for detection of lipid core coronary plaques: initial results of the SPECTACL study. *JACC Cardiovasc Imaging* 2009; 2: 858–68.
- 3 Waksman R, Di Mario C, Torguson R, et al. Identification of patients and plaques vulnerable to future coronary events with near-infrared spectroscopy intravascular ultrasound imaging: a prospective, cohort study. *Lancet* 2019; 394: 1629–37.
- 4 Erlinge D, Maehara A, Ben-Yehuda O, et al. Identification of vulnerable plaques and patients by intracoronary near-infrared spectroscopy and ultrasound (PROSPECT II): a prospective natural history study. *Lancet*.2021;397:985-995.

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18.4 Appendix D: Acoustic Output (I) Compliance to IEC 60601-2-37:2007

System Model: Makoto® Intravascular Imaging System (TVC-MC10)
 Transducer: Dualpro® IVUS+NIRS Imaging Catheter (TVC-C195-42), DualproNIRS™ Imaging Catheter (TVC-C195-42J), DualproPlus® IVUS+NIRS Imaging Catheter (TVC-C195-52 and TVC-C195-52J), or Infraredx Claripro® HD-IVUS Imaging Catheter (TVC-E195-42), 50 MHz

Operating Mode: B mode
 Application(s): Vascular

Table 18-11: Acoustic Output (I) Compliance to IEC 60601-2-37:2007

Probes Model	TI Type	TI Value (unitless)	MI (unitless)
TVC-C195-42	TIS	0.43	0.36
TVC-C195-42J	TIS	0.43	0.36
TVC-E195-42	TIS	0.43	0.36
TVC-C195-52	TIS	0.43	0.36
TVC-C195-52J	TIS	0.43	0.36

This data reports the worst case. As neither MI nor TI are greater than 1.0, no further tables need to be filled-in.

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18.5 Appendix E: Acoustic Output (II) Reporting Table for Track 1

System Model: Makoto® Intravascular Imaging System (TVC-MC10)
 Transducer Model: Dualpro® IVUS+NIRS Imaging Catheter (TVC-C195-42),
 DualproNIRS™ Imaging Catheter (TVC-C195-42J),
 DualproPlus® IVUS+NIRS Imaging Catheter (TVC-C195-52
 and TVC-C195-52J), or Infraredx Clarispro® HD-IVUS
 Imaging Catheter (TVC-E195-42), 50 MHz

Operating Mode: B-Mode
 Application: Intravascular

Table 18-12: Acoustic Output (II) Reporting Table for Track 1:

Acoustic Output			MI	Ispta.3 (mW/cm ²)	Isppa.3 (W/cm ²)	
Global Maximum Value			0.36	98	257	
Associated acoustic parameter	P _{r,a}	(Mpa)	2.6			
	W	(mW)		1.73	1.73	
	f _c	(MHz)	51.97	51.97	51.97	
	Z _{sp}	(cm)	0.1		0.1	
	Beam Dimensions	x-6 (cm)				0.0123
		y-6 (cm)				0.0317
	PD	usec	.1356		0.1356	
	PRF	Hz	61440		61440	
	EDS	Az. (cm)			0.31	
Elev. (cm)				0.05		
Operating control conditions	No operator settings affect acoustic output					

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18.6 Appendix F: Ultrasound Indications for Use Table

System Model: Makoto® Intravascular Imaging System (TVC-MC10)
 Transducer Model: Dualpro® IVUS+NIRS Imaging Catheter (TVC-C195-42),
 DualproNIRS™ Imaging Catheter (TVC-C195-42J),
 DualproPlus® IVUS+NIRS Imaging Catheter (TVC-C195-52
 and TVC-C195-52J), or Infraredx Claripro® HD-IVUS
 Imaging Catheter (TVC-E195-42), 50 MHz

Table 18-13: Ultrasound Indications for Use Table

Clinical Application		Mode of Operation						
General	Specific	B	M	PWD	CWD	Color Doppler	Combined (Specify)	Other* (Specify)
Ophthalmic	Ophthalmic							
Fetal Imaging & Other	Fetal							
	Abdominal							
	Intra-Operative (Specify)							
	Intra-operative (Neuro)							
	Laparoscopic							
	Pediatric							
	Small Organ (Specify)							
	Neonatal Cephalic							
	Adult Cephalic							
	Trans-rectal							
	Trans-vaginal							
	Trans-urethral							
	Trans-esoph. (non-Card.)							
	Musculo-skeletal (Conventional)							
	Musculo-skeletal (Superficial)							
	Intravascular							
	Other							
Cardiac	Cardiac Adult	X						
	Cardiac Pediatric							
	Intravascular (Cardiac)	X						
	Trans-esoph. (Cardiac)							
	Intra-Cardiac							

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	Other (Specify)							
Peripheral Vessel	Peripheral vessel	X						
	Other (Specify)							

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18.7 Appendix G: Measurement Precision and Accuracy

Table 18-14: Measurement Precision and Accuracy

IVUS Measurement	Specification/Acceptance Criteria	Test Result*
IVUS/NIR co-registration Precision	The standard deviation of angular offsets between the NIR and IVUS channels is less than or equal to 25 degrees.	6 degrees
	The standard deviation of longitudinal offsets between NIR and IVUS channels is less than 0.5 mm.	0.17 mm
IVUS Measurement Precision	For lumen diameters less than 5 mm, the standard deviation in the measured lumen diameter is less than or equal to 0.125 mm.	0.10 mm
	For lumen diameters less than or equal to 4 mm with vessel diameters less than or equal to 7.5 mm, the standard deviation of the measured plaque cross sectional area (CSA) due to uncertainties in the vessel (EEM) and lumen boundaries and the effects of NURD shall be less than or equal to 2.79 mm ²	1.56 mm ²
IVUS Measurement Accuracy	For lumen diameters less than or equal to 4 mm with vessel diameters less than or equal to 7.5 mm, the error in the accuracy of the measured plaque cross sectional area (CSA) due to uncertainties in the vessel (EEM) and lumen boundaries and the effects of NURD shall be less than or equal to -9%, +14% of measured value ± 0.10 mm ² .	1.74 %
	For lumen diameters between 1.8 mm and 5 mm inclusive, the error in the accuracy of measured lumen area due to uncertainties in the lumen boundary where the ultrasound only traverses through blood shall be less than or equal to $\pm 5\%$ of the measurement ± 0.10 mm ² .	1.89 %
Imaging Depth	The design of the system shall be compatible with measurement of structures at depth up to 8 mm and areas up to 200 mm ² .	Pass

* Average of the result at minimum (0.5 mm/s) and maximum (2.0 mm/s) automated pullback acquisition speeds.

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18.8 Appendix H: Electromagnetic Compliance

Table 18-15: Electromagnetic Compliance

Guidance and manufacturer's declaration – electromagnetic emissions			
The Makoto® Intravascular Imaging System Model TVC-MC10 is intended for use in the electromagnetic environment specified below. The customer or the user of the TVC-MC10 should assure that it is used in such an environment.			
Emissions test	Test Level	Compliance	Electromagnetic environment – guidance
Conducted emissions IEC/EN 61000-4-6	150KHz to 30MHz, Class A	150KHz to 30MHz, Class A	The Makoto® Intravascular Imaging System Model TVC-MC10 uses RF energy only for its internal function. Therefore, its RF emissions are very low and are not likely to cause any interference in nearby electronic equipment.
Radiated emissions IEC/EN 61000-4-3	30MHz to 1.8GHz, Class A	30MHz to 1.8GHz, Class A	
Harmonics IEC/EN 61000-3-2:2001/A2:2014	Class A Device	Per Clause 5 of standard	The Makoto® Intravascular Imaging System Model TVC-MC10 is suitable for use in all establishments other than domestic and those directly connected to the public low-voltage power supply network that supplies buildings used for domestic purposes.
Flicker IEC/EN 61000-3-3:2013	Per Clause 5 of standard	Per Clause 5 of standard	

RFID Specifications (Transmission / Reception):

- Frequency: 902.8MHz to 927.2MHz
- Effective Radiated Power: ≤0.2W

Table 18-16: Guidance and manufacturer's declaration – electromagnetic immunity

Guidance and manufacturer's declaration – electromagnetic immunity			
The Makoto® Intravascular Imaging System Model TVC-MC10 is intended for use in the electromagnetic environment specified below. The customer or the user of the TVC-MC10 should assure that it is used in such an environment.			
Immunity test	Test level	Compliance level	Electromagnetic environment - guidance
Electrostatic discharge (ESD)	±8 kV contact discharge	±8 kV contact discharge	Floors should be wood, concrete or ceramic tile. If floors

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IEC/EN 61000-4-2	±2, 4, 8 & 15kV air discharge	±2, 4, 8 & 15kV air discharge	are covered with synthetic material, the relative humidity should be at least 30%.
Electrical fast transient/burst IEC/EN 61000-4-4	±2 kV for AC Mains ±1 kV I/O Lines 5/50 5KHz & 100KHz	±2 kV for AC Mains ±1 kV I/O Lines 5/50 5KHz & 100KHz	Mains power quality should be that of a typical commercial or hospital environment.
Surge Line to Line (AC Power) IEC/EN 61000-4-5	±.5 kV line to line ±2 kV line to Ground	±.5 kV line to line ±2 kV line to Ground	Mains power quality should be that of a typical commercial or hospital environment.
Voltage dips & Interruptions IEC/EN 61000-4-11	0% U_T 0.5 cycle 0% U_T 1 cycle 70% U_T 25 cycles 0% U_T 5 s	0% U_T 0.5 cycle 0% U_T 1 cycle 70% U_T 25 cycles 0% U_T 5 s	If the user of the Model TVC-MC10 requires continued operation during power mains interruptions, it is recommended that the TVC-MC10 be powered from an uninterruptible power supply or a battery.
Magnetic Immunity IEC/EN 61000-4-8	30 A/m	30 A/m	Power frequency magnetic fields should be at levels characteristic of a typical location in a typical commercial or hospital environment.
Note: U_T is the AC mains voltage prior to application of the test level.			

Table 18-17: Guidance and manufacturer's declaration – electromagnetic immunity

Guidance and manufacturer's declaration – electromagnetic immunity			
The Makoto® Intravascular Imaging System Model TVC-MC10 is intended for use in the electromagnetic environment specified below. The customer or the user of the TVC-MC10 should assure that it is used in such an environment.			
Immunity test	Test level	Compliance level	Electromagnetic environment - guidance
Radiated Immunity IEC/EN 61000-4-3	80 MHz to 2.7 GHz, 3 V/m Spot frequencies 385MHz – 5.75GHz, Pulse Modulation	80 MHz to 2.7 GHz, 3 V/m Spot frequencies 385MHz – 5.75GHz, Pulse Modulation	Portable and mobile RF communications equipment should be used no closer to any part of the Makoto® Intravascular Imaging System Model TVC-MC10, including cables, than the recommended separation distance calculated from the equation applicable to the frequency of the transmitter.

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Proximity field from RF wireless communication equipment IEC/EN 61000-4-3	See Section 5.3.7 or Table 9 from the standard excerpted below.	See Section 5.3.7 or Table 9 from the standard excerpted below.	<p>Recommended separation distance</p> <p>Minimum separation distances for higher Immunity Test Levels shall be calculated using the following equation:</p> $E = \left(\frac{6}{d}\right) \sqrt{P}$ <p>where P is the maximum output power of the transmitter in watts (W), d is the distance in m, and E is the immunity test level in V/m.</p>
Conducted Immunity (AC Power) (I/O Lines) IEC/EN 61000-4-6	0.015 - 80 MHz 3 V _{RMS} & 6 V _{RMS} in ISM Band, 1KHz, AC Mains	0.015 - 80 MHz 3 V _{RMS} & 6 V _{RMS} in ISM Band, 1KHz, AC Mains	Over the frequency range 150 kHz to 80 MHz, field strengths should be less than 3 V/m.

Table 18-18: Recommended separation distances between portable and mobile RF communications

<p>Recommended separation distances between portable and mobile RF communications equipment and the Makoto® Intravascular Imaging System Model TVC-MC10</p>
<p>The Makoto® Intravascular Imaging System Model TVC-MC10 is intended for use in an electromagnetic environment in which radiated RF disturbances are controlled. The customer or the user of the Model TVC-MC10 can help prevent electromagnetic interference by maintaining a minimum distance between portable and mobile RF communications equipment (transmitters) and the Makoto® Intravascular Imaging System Model TVC-MC10 as recommended below, according to the maximum output power of the communications equipment. This table is excerpted from IEC/EN 61000-4-3</p>

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Table 18-19: Test specifications for Enclosure Port Immunity to RF wireless communications equipment

Test specifications for Enclosure Port Immunity to RF wireless communications equipment						
Test Frequency (MHz)	Band ^{a)}	Service ^{a)}	Modulation ^{b)}	Maximum power (W)	Distance (m)	Immunity Test Level (V/m)
385	380-390	TETRA 400	Pulse Modulation ^{b)} 18 MHz	1.8	0.3	27
450	430-470	GMRS 460, FRS 460	FM ^{c)} ± 5 kHz deviation 1 kHz sine	2	0.3	28
710	704-787	LTE Band 13, 17	Pulse Modulation ^{b)} 217 MHz	0.2	0.3	9
745						
780						
810	800-960	GSM 800/900, TETRA 800, IDEN 820, CDMA 850, LTE Band 5	Pulse Modulation ^{b)} 18 MHz	2	0.3	28
870						
930						
1720	1700-1990	GSM 1800; CDMA 1900; GSM 1900; DECT; LTE Band 1, 3, 4, 25; UMTS	Pulse Modulation ^{b)} 217 MHz	2	0.3	28
1845						
1970						
2450	2400-2570	Bluetooth, WLAN, 802.11 b/g/n, RFID 2450, LTE Band 7	Pulse Modulation ^{b)} 217 MHz	2	0.3	28
5240	5100-5800	WLAN, 802.11 a/n	Pulse Modulation ^{b)} 217 MHz	0.2	0.3	9
5500						
5785						
<p>NOTE: If necessary to achieve the immunity Test Level, the distance between the transmitting antenna and the ME Equipment or ME System may be reduced to 1 m. The 1 m test distance is permitted by IEC 61000-4-3.</p> <p>a) For some services, only the uplink frequencies are included. b) The carrier shall be modulated using a 50 % duty cycle square wave signal. c) As an alternative to FM modulation, 50 % pulse modulation at 18 Hz may be used because while it does not represent actual modulation, it would be worst case.</p>						

18.9 Appendix I: ABC and Guide Catheter Detection (GCD) Algorithm Performance Evaluation Summary

The following tables present the performance evaluation of ABC and GCD algorithms on blinded test data.

The ABC acceptance criteria were established based on an approved protocol and report which conducted an inter- and intra-reader variability study with three expert readers, 30 samples, and two trials. This study provided a benchmark for expected variability in manual contouring, ensuring that the algorithm's performance aligns with clinical practice standards.

Performance was assessed using error metrics, including diameter difference, area difference, and Hausdorff distance (HD) for lumen and EEM contours. For guide catheter detection, performance was evaluated based on detection accuracy, sensitivity, and specificity.

Table 18-20: ABC Performance Results

ABC Performance Evaluation Results on Test Data				
Performance Metric	Contour	Acceptance Criteria	ABC Performance Evaluation on Test Data	Result
Bland-Altman Plot Diameter Difference Limits of Agreement (95% CI) (mm)	Lumen	+/- 0.59	[-0.37, 0.41]	PASS
Bland-Altman Plot Diameter Difference Limits of Agreement (95% CI) (mm)	EEM	+/- 0.74	[-0.54, 0.52]	PASS
Bland-Altman Plot Area Difference Limits of Agreement (95% CI) (mm ²)	Lumen	+/- 3.46	[-2.3, 2.48]	PASS
Bland-Altman Plot Area Difference Limits of Agreement (95% CI) (mm ²)	EEM	+/- 6.18	[-4.5, 4.0]	PASS

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Forward Hausdorff Distance 95% CI (mm)	Lumen	< 0.63	[0.27, 0.29]	PASS
Forward Hausdorff Distance 95% CI (mm)	EEM	< 0.66	[0.31, 0.35]	PASS
Reverse Hausdorff Distance 95% CI (mm)	Lumen	< 0.63	[0.26, 0.28]	PASS
Reverse Hausdorff Distance 95% CI (mm)	EEM	< 0.66	[0.29, 0.32]	PASS

Table 18-21: Frame Level GCD Results

Frame Level GCD Results			
Metric	Value	Acceptance Criteria	Result
AUC	0.98	0.9	PASS
Sensitivity	0.86		
Specificity	1.00		

Table 18-22 Scan Level GCD Results

Scan Level GCD Results			
Metric	Value	Acceptance Criteria	Result
Total Individual Scan Level GCD Failures*	2		
Sensitivity	0.93	0.9	PASS
Specificity	0.93	0.9	PASS

* False negatives and false positives

These results demonstrate that the subject device performs within clinically acceptable limits, as determined by inter-reader variability in manual contouring and predefined acceptance thresholds.

For scan level accuracy assessments, true positives were defined as results where a GC was correctly predicted within +/- 2 mm of the true location. True negatives were defined as results where no GC was predicted, when no GC was present according to ground truth. False positives were defined as scans where the predicted GC location was outside of the +/- 2 mm window of the true GC location, or when no GC was present according to the ground truth. False negatives were defined as scans where no GC location was predicted, while the truth showed a GC. Scans containing less than 2 mm of total GC length were defined as negatives for ground truth.

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The following table provides a detailed breakdown of the test dataset, including the number of unique patients, frames, and scans. The test dataset consists of 18 unique patients, ensuring that the algorithm is evaluated on an independent dataset with no patient overlap from the calibration dataset. Among the 18 patients, 29 total scans were used for testing, with 12 of these from Japanese hospitals (5 patients across 3 sites), and 17 from US hospitals (13 patients across 3 sites). At the frame level, there were 381 frames included from Japanese hospitals and 609 frames included from US hospitals.

To ensure that the test dataset encapsulates clinically relevant disease states, patients are characterized based on the presence of calcium and stent struts, both of which are key indicators of disease severity. Calcium presence affects EEM contouring accuracy due to shadowing artifacts, while the presence of stent struts introduces additional challenges in segmentation. The test dataset also includes patient cases with guidewire and side branches, further ensuring that real-world imaging complexities are represented.

Table 18-23: Test Data Summary and Characteristics

Test Data Summary and Characteristics							
Data Group	Frames	Patients	Scans	% Calcium Presence*	% Guidewire Presence*	% Side Branch Presence*	% Stent Strut Presence*
Test	981	18	29	38.9%	96.6%	9.2%	20.7%

*These percentages refer to % of frames

The fixed acquisition parameters of the Makoto Intravascular Imaging System™ are intrinsic to the Dualpro/Clarispro 014 IVUS transducer and TVC-M10/MC10i imaging system, and are not user-modifiable.

- **Penetration Depth:** The system offers a penetration depth of approximately 8 mm, corresponding to a 16 mm maximum field of view. This depth is preset to ensure optimal visualization of vascular structures. Notably, penetration depth is inversely related to ultrasound frequency.
- **Focus:** The focusing characteristics of the ultrasound beam are determined by the transducer's intrinsic properties. Key parameters include:
 - **Focal Length:** This is the distance from the transducer to the point where the ultrasound beam is most narrowly focused, optimizing lateral resolution. The focal length is influenced by the transducer's diameter and the ultrasound frequency.
 - **Focal Point Diameter:** This refers to the beam's width at its narrowest point. Larger transducer diameters and higher frequencies result in a reduced focal point diameter.
- **Frequency:** The transducer operates at a nominal frequency of 50 MHz, with a variation range between 48 MHz and 53 MHz.

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- Operation Mode: The Makoto imaging system (TVC-MC10/MC10i) operates in B-mode, presenting images in a Cartesian coordinate system with fixed number of pixels along both the X and Y axes. These settings are pre-configured and cannot be modified by the user.

The reference standard for the testing dataset was established using six expert IVUS readers who served as ground truth annotators. The annotation process was standardized through the use of IVUS Tracing Guidelines and a proprietary in-house developed tracing software to ensure consistency and reproducibility. Annotators followed specific instructions for contour and structure identification, including:

- Guide catheter and stent regions: Identification of relevant structures.
- Guidewire marking: Placement of marking points at the brightest point or closest GW position.
- Lumen and EEM contours: Marking points used to delineate the lumen and EEM boundaries.
- Calcium arcs: Placement of marks on the luminal edge of each calcified feature.
- Stent struts: Marking the center of each identifiable stent strut.

The test dataset was annotated by 6 expert readers, two of whom did not participate in annotating the calibration dataset. While four annotators were shared between calibration and test datasets, the impact of this overlap was mitigated through randomized site allocation and diverse annotation styles to ensure the model did not learn specific annotator tendencies.

The differences in the truthing process between calibration and test datasets were designed to reduce potential bias and ensure an independent performance evaluation. Although some annotators and sites overlapped, there was no patient overlap, and the diverse set of readers provided variability in annotation styles, preventing the model from overfitting to a single annotation methodology.

Several steps were taken to ensure that the test dataset remained independent from the training dataset, preventing data leakage and enabling an unbiased evaluation of model performance.

First, there was no patient overlap between the calibration and test datasets, ensuring that the model was assessed on previously unseen patient cases. This prevented the algorithm from memorizing specific anatomical features or imaging patterns from training patients, reinforcing its generalizability.

Second, the test dataset was collected from 6 clinical sites. While 3 of these test sites overlapped with calibration sites, half of the test sites were entirely new, ensuring that the model encountered imaging conditions not previously seen during training. This approach helped validate the model's ability to generalize across different imaging environments.

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Third, a diverse set of annotators was used in both the calibration and test datasets to introduce variability in annotation behaviors. The test dataset was annotated by 6 readers, two of whom were not involved in the calibration dataset. This diversity ensured that the model was not exposed to a single annotation style, allowing it to generalize across different annotation behaviors commonly seen in clinical practice.

Additionally, annotators were randomly assigned data from different sites, preventing systematic biases related to site-specific annotation tendencies. The inclusion of multiple annotators with varied annotation styles further ensured that the truthing process for the test dataset remained independent of model development, preventing annotation bias from influencing test results.

Finally, the test dataset was blinded, meaning the algorithm developers had no exposure to the test patient cases during training or tuning (and the annotators had no exposure to the algorithm). This ensured that model evaluation reflected real-world clinical performance rather than learned biases from prior exposure. These measures collectively ensured that the test dataset provided an independent, unbiased assessment of model performance, supporting regulatory requirements for substantial equivalence.