Perspectum Diagnostics Ltd
Jaco Jacobs
Chief Quality and Regulatory Compliance Officer
23-38 Hythe Bridge Street
Oxford, Oxfordshire OX1 2ET
UNITED KINGDOM

June 27, 2019

Re: K190017
Trade/Device Name: LiverMultiScan (LMSv3)
Regulation Number: 21 CFR 892.1000
Regulation Name: Magnetic Resonance Diagnostic Device
Regulatory Class: Class II
Product Code: LNH
Dated: May 31, 2019
Received: June 3, 2019

Dear Jaco Jacobs:

We have reviewed your Section 510(k) premarket notification of intent to market the device referenced above and have determined the device is substantially equivalent (for the indications for use stated in the enclosure) to legally marketed predicate devices marketed in interstate commerce prior to May 28, 1976, the enactment date of the Medical Device Amendments, or to devices that have been reclassified in accordance with the provisions of the Federal Food, Drug, and Cosmetic Act (Act) that do not require approval of a premarket approval application (PMA). You may, therefore, market the device, subject to the general controls provisions of the Act. Although this letter refers to your product as a device, please be aware that some cleared products may instead be combination products. The 510(k) Premarket Notification Database located at https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfpmn/pmn.cfm identifies combination product submissions. The general controls provisions of the Act include requirements for annual registration, listing of devices, good manufacturing practice, labeling, and prohibitions against misbranding and adulteration. Please note: CDRH does not evaluate information related to contract liability warranties. We remind you, however, that device labeling must be truthful and not misleading.

If your device is classified (see above) into either class II (Special Controls) or class III (PMA), it may be subject to additional controls. Existing major regulations affecting your device can be found in the Code of Federal Regulations, Title 21, Parts 800 to 898. In addition, FDA may publish further announcements concerning your device in the Federal Register.

Please be advised that FDA's issuance of a substantial equivalence determination does not mean that FDA has made a determination that your device complies with other requirements of the Act or any Federal statutes and regulations administered by other Federal agencies. You must comply with all the Act's

requirements, including, but not limited to: registration and listing (21 CFR Part 807); labeling (21 CFR Part 801); medical device reporting (reporting of medical device-related adverse events) (21 CFR 803) for devices or postmarketing safety reporting (21 CFR 4, Subpart B) for combination products (see https://www.fda.gov/combination-products/guidance-regulatory-information/postmarketing-safety-reporting-combination-products); good manufacturing practice requirements as set forth in the quality systems (QS) regulation (21 CFR Part 820) for devices or current good manufacturing practices (21 CFR 4, Subpart A) for combination products; and, if applicable, the electronic product radiation control provisions (Sections 531-542 of the Act); 21 CFR 1000-1050.

Also, please note the regulation entitled, "Misbranding by reference to premarket notification" (21 CFR Part 807.97). For questions regarding the reporting of adverse events under the MDR regulation (21 CFR Part 803), please go to https://www.fda.gov/medical-devices/medical-device-safety/medical-device-reporting-mdr-how-report-medical-device-problems.

For comprehensive regulatory information about medical devices and radiation-emitting products, including information about labeling regulations, please see Device Advice (https://www.fda.gov/medical-devices/device-advice-comprehensive-regulatory-assistance) and CDRH Learn (https://www.fda.gov/training-and-continuing-education/cdrh-learn). Additionally, you may contact the Division of Industry and Consumer Education (DICE) to ask a question about a specific regulatory topic. See the DICE website (https://www.fda.gov/medical-devices/device-advice-comprehensive-regulatory-assistance/contact-us-division-industry-and-consumer-education-dice) for more information or contact DICE by email (DICE@fda.hhs.gov) or phone (1-800-638-2041 or 301-796-7100).

Sincerely,

For

Thalia T. Mills, Ph.D.
Director
Division of Radiological Health
OHT7: Office of In Vitro Diagnostics
and Radiological Health
Office of Product Evaluation and Quality
Center for Devices and Radiological Health

Enclosure

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Food and Drug Administration

Indications for Use

Form Approved: OMB No. 0910-0120
Expiration Date: 06/30/2020
See PRA Statement below.

510(k) Number *(if known)*
K190017

Device Name
LiverMultiScan (LMSv3)

Indications for Use *(Describe)*

LiverMultiScan (LMSv3) is indicated for use as a magnetic resonance diagnostic device software application for non-invasive liver evaluation that enables the generation, display and review of 2D magnetic resonance medical image data and pixel maps for MR relaxation times.

LiverMultiScan (LMSv3) is designed to utilize DICOM 3.0 compliant magnetic resonance image datasets, acquired from compatible MR Systems, to display the internal structure of the abdomen including the liver. Other physical parameters derived from the images may also be produced.

LiverMultiScan (LMSv3) provides a number of tools, such as automated liver segmentation and region of interest (ROI) placements, to be used for the assessment of selected regions of an image. Quantitative assessment of selected regions include the determination of triglyceride fat fraction in the liver (PDFF), T2* and iron-corrected T1 (cT1) measurements. PDFF may optionally be computed using the LMS IDEAL or three-point Dixon methodology.

These images and the physical parameters derived from the images, when interpreted by a trained clinician, yield information that may assist in diagnosis.

Type of Use *(Select one or both, as applicable)*

☒ Prescription Use (Part 21 CFR 801 Subpart D) ☐ Over-The-Counter Use (21 CFR 801 Subpart C)

CONTINUE ON A SEPARATE PAGE IF NEEDED.

Date Prepared: 26th June 2019

1. Submitter Details

Owner Address: Perspectum Diagnostics Ltd
23-38 Hythe Bridge Street
Oxford,
Oxfordshire,
OX1 2ET
United Kingdom

Owner/Operator Number: 10056574

Establishment Registration Number: 3014232555

Contact Person: Dr Jaco Jacobs
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2. Subject and Predicate Device

	Subject Device	Predicate Device
510(k) number	K190017	K172685
Legal Manufacturer	Perspectum Diagnostics Ltd	Perspectum Diagnostics Ltd
Owner/Owner Operator	Perspectum Diagnostics Ltd	Perspectum Diagnostics Ltd
Device Name	LMSv3	LMSv2
Proprietary/Common	LiverMultiScan	LiverMultiScan
Panel	Radiology	Radiology
Regulation	21 CFR 892.1000	21 CFR 892.1000
Risk Class	Class II	Class II
Product Class code	LNH	LNH
Classification	Magnetic Resonance Diagnostic Device	Magnetic Resonance Diagnostic Device

3. Subject Device Description

LiverMultiScan (LMSv3) is a standalone software application for displaying 2D Magnetic Resonance (MR) medical image data acquired from compatible MR Scanners. LiverMultiScan runs on general-purpose workstations with a colour monitor, keyboard and mouse.

The main functionality of LiverMultiScan (LMSv3) includes:

- Reading DICOM 3.0 compliant datasets stored on workstations, and display of the data acquisition information
- Post-processing of MRI data to generate parametric maps of Proton Density Fat Fraction PDFF), T2*, T1 and iron-corrected T1 (cT1) of the liver.
- Quantification, and calculation of PDFF, T2* and cT1 metrics using tools such as automatic liver segmentation and ROI (region of interest) placement.

- Generation of a summary report demonstrating the quantitative assessment results of fat fraction in the liver (PDFF), T2* and iron-corrected T1 (cT1).

LiverMultiScan (LMSv3) is intended to be used by trained operators. Reports generated by trained operators are intended for use by interpreting clinicians, including, but not limited to, radiologists, gastroenterologists, and hepatologists.

LiverMultiScan (LMSv3) is intended to be used as an aid to diagnosis. The results demonstrated by LMSv3 shall only be used as an additional input to existing procedures and diagnostic workflows. The responsibility for diagnosis and treatment decisions remains with the clinicians.

LiverMultiScan (LMSv3) is a post-processing, standalone software device which has no direct or indirect contact with the human body.

LiverMultiScan (LMSv3) presents a moderate level of concern.

Intended Use

Subject Device, LMSv3

"LiverMultiScan (LMSv3) is indicated for use as a magnetic resonance diagnostic device software application for non-invasive liver evaluation that enables the generation, display and review of 2D magnetic resonance medical image data and pixel maps for MR relaxation times.

LiverMultiScan (LMSv3) is designed to utilize DICOM 3.0 compliant magnetic resonance image datasets, acquired from compatible MR Systems, to display the internal structure of the abdomen including the liver. Other physical parameters derived from the images may also be produced.

LiverMultiScan (LMSv3) provides a number of tools, such as automated liver segmentation and region of interest (ROI) placements, to be used for the assessment of selected regions of an image. Quantitative assessment of selected regions includes the determination of triglyceride fat fraction in the liver (PDFF), T2* and iron-corrected T1 (cT1) measurements. PDFF may optionally be computed using the LMS IDEAL or three-point Dixon methodology.

These images and the physical parameters derived from the images, when interpreted by a trained clinician, yield information that may assist in diagnosis."

4. Subject and Predicate Comparison

4.1. Intended Use Comparison

The subject device and the predicate device are both indicated for use in the non-invasive evaluation of the liver, which enables the generation, display and review of 2D magnetic resonance medical image data and pixel maps for MR relaxation times. Both devices are designed to utilize DIXCOM 3.0 data as input and provide a range of tools to display and process data to determine triglyceride fat fraction in the liver, T2* and iron-corrected T1 measurements.

4.2. Subject and Predicate Device Comparison

The following characteristics were compared between the subject device and the predicate device in order to demonstrate substantial equivalence.

Comparison of subject and Predicate Device		
Characteristic	LMSv3 (Subject device)	LMSv2 (Predicate device)
Intended Use and Indications for Use	"LiverMultiScan (LMSv3) is indicated for use as a magnetic resonance diagnostic device software application for non-invasive liver evaluation that enables the generation, display and review of 2D magnetic resonance medical image data and pixel maps for MR relaxation times. LiverMultiScan (LMSv3) is designed to utilize DICOM 3.0 compliant magnetic resonance image datasets, acquired from compatible MR Systems, to display the internal structure of the abdomen including the liver. Other physical parameters derived from the images may also be produced. LiverMultiScan (LMSv3) provides a number of tools, such as automated liver segmentation and region of interest (ROI) placements, to be used for the assessment of selected regions of an image. Quantitative assessment of selected regions includes the determination of triglyceride fat fraction in the liver (PDFF), T2* and iron-corrected T1 (cT1) measurements. PDFF may optionally be computed using the LMS IDEAL or three-point Dixon methodology. These images and the physical parameters derived from the images, when interpreted by a trained clinician, yield information that may assist in diagnosis."	"LiverMultiScan is indicated for use as a magnetic resonance diagnostic device software application for non-invasive liver evaluation that enables the generation, display and review of 2D magnetic resonance medical image data and pixel maps for MR relaxation times. LiverMultiScan is designed to utilize DICOM 3.0 compliant magnetic resonance image datasets, acquired from compatible MR Systems, to display the internal structure of the abdomen including the liver. Other physical parameters derived from the images may also be produced. LiverMultiScan provides a number of quantification tools, such as Region of Interest (ROI) placements, to be used for the assessment of regions of an image to quantify liver tissue characteristics, including the determination of triglyceride fat fraction in the liver, T2* and iron-corrected T1 measurements. These images and the physical parameters derived from the images, when interpreted by a trained clinician, yield information that may assist in diagnosis."
Target Population	Patients suitable to undergo an MRI scan and not contra-indicated for MRI.	Patients suitable to undergo an MRI scan and not contra-indicated for MRI.
Device User	Trained PD operator	Trained PD operator
Report User	An interpreting clinician or healthcare practitioner	An interpreting clinician or healthcare practitioner
Device Use Environment	Installation of LMSv3 is controlled and installed on general purpose workstations at PD's image analysis centre	Installation of LMsv2 is controlled and installed on general purpose workstations at PD's image analysis centre
Clinical Setting	LMSv3 is a standalone software device that's intended to be installed on general use workstations at PD's image analysis centre. The intended device users will log on to the	LMSv2 is a standalone software device that's intended to be installed on general use workstations at PD's image analysis centre. The intended device users will log on to the

Comparison of subject and Predicate Device		
Characteristic	LMSv3 (Subject device)	LMSv2 (Predicate device)
	workstations, access the device, and use the device on general-use HD monitors. LMSv3 is a post-processing software, the intended device users are trained internal PD operators. The end-users for the output from the device, the pdf report, are clinicians who receive and interpret LMSv3 reports.	workstations, access the device, and use the device on general-use HD monitors. LMSv2 is a post-processing software, the intended device users are trained internal PD operators. The end-users for the output, the pdf report, are clinicians who receive and interpret LMSv2 reports.
Anatomical Location	Abdomen, Liver	Abdomen, Liver
Energy Considerations	Software only application. The device, a standalone software application, does not deliver, monitor or depend on energy delivered to or from patients.	Software only application. The device, a standalone software application, does not deliver, monitor or depend on energy delivered to or from patients.
Design: Purpose	Standalone software application to facilitate the import and visualization of MR data sets encompassing the abdomen, including the liver with functionality independent of the MRI equipment vendor. Software application intended to display and visualize 2D multi-slice, spin-echo MR data sets encompassing the abdomen. The user may process, and review DICOM 3.0 compliant datasets within the system.	Standalone software application to facilitate the import and visualization of MR data sets encompassing the abdomen, including the liver with functionality independent of the MRI equipment vendor. Software application intended to display and visualize 2D multi-slice, spin-echo MR data sets encompassing the abdomen. The user may process, and review DICOM 3.0 compliant datasets within the system and/or across computer networks.
Design: Tools	Allows for the visualisation via parametric maps and quantification of metrics (cT1, T2* and PDFF) from liver tissue and exportation of results & images to a deliverable pdf report*. LMSv3 allows for: cT1 • ROI placed method on the cT1 map with IQR and median metrics from the placed ROI's potentially across multiple acquired slices. • Full segmentation of the outer liver contour and liver vasculature of the cT1 parametric map. IQR and median metrics are reported from the segmentation. T2* • ROI placed method on the T2* map with IQR and median metrics from the placed ROI's potentially across multiple acquired	Allows for the visualisation via parametric maps and quantification of metrics (cT1, T2* and PDFF) from liver tissue and exportation of results & images to a deliverable pdf report. LMSv2 allows for: cT1 • ROI placed method on the cT1 map with IQR and median metrics from the placed ROI's potentially across multiple acquired slices. T2* • ROI placed method on the T2* map with IQR and median metrics from the placed

Comparison of subject and Predicate Device		
Characteristic	LMSv3 (Subject device)	LMSv2 (Predicate device)
	slices T2* parametric maps are calculated from the Gradient Multi-Echo method. PDFF • ROI placed method on the PDFF map with IQR and median metrics from the placed ROI's potentially across multiple acquired slices potentially across multiple acquired slices. • PDFF parametric maps can be calculated using either the LMS IDEAL method [2] or the three-point DIXON method. [1] • Full liver segmentation of the PDFF parametric map where IQR and median metrics are reported from the segmentation.	ROI's potentially across multiple acquired slices T2* parametric maps are calculated from the Gradient Multi-Echo method. PDFF • ROI placed method on the PDFF map with IQR and median metrics from the placed ROI's potentially across multiple acquired slices potentially across multiple acquired slices. • PDFF parametric maps are calculated from the three-point DIXON method. [1]
Design: Algorithms	*Previously cleared algorithms:* • Noise Determination Algorithms • T1 mapping Algorithms • T2* mapping Algorithms • Unwrapping Phase Image Algorithms • Creation of cT1 image Algorithms • Water and Fat Mapping Algorithms *New algorithms:* • IDEAL Processing Algorithms • MAGO Processing Algorithms • Quality Check for Shimming • Automatic Liver Segmentation Algorithms • Segmentation Mapping to T2*/PDFF algorithms *LMSv3 uses identical algorithms cleared in LMSv2 to quantify cT1, T2* and DIXON PDFF using ROI's.*	• Noise Determination Algorithms • T1 mapping Algorithms • T2* mapping Algorithms • Unwrapping Phase Image Algorithms • Creation of cT1 image Algorithms • Water and Fat Mapping Algorithms
Design: MR Relaxometry	T1, iron-corrected T1 (cT1) and T2* mapping.	T1, iron-corrected T1 (cT1) and T2* mapping.
Design: Liver Fat Quantification	Utilizes MR images that exploit the difference in resonance frequencies between hydrogen nuclei in water and triglyceride fat using either LMS IDEAL method or three-point DIXON method.	Utilizes MR images that exploit the difference in resonance frequencies between hydrogen nuclei in water and triglyceride fat using the three-point DIXON method.

Comparison of subject and Predicate Device		
Characteristic	LMSv3 (Subject device)	LMSv2 (Predicate device)
Design: Liver Segmentation	LMSv3 supports automatic multi-slice full liver segmentation of the cT1 and PDFF parametric map. Use of this functionality is at the discretion of the operator instead or in combination with the ROI based method. The cT1 segmented liver is presented in colour level window, while the rest of the cT1 image is presented in greyscale level window with ducts and liver vasculature excluded from the segmented volume.	Does not support whole liver segmentation. See first reference device below, LiverLab.
Design: Regions of Interest (ROI)	Median and interquartile range measurements created from a cross sectional slice of liver tissue. For each parametric map, statistics from multiple Regions of Interest (ROIs) – potentially placed across multiple slices – are summarised. Also supports the display of 'Live' ROI statistics when moving the ROI across the parametric map.	Median and interquartile range measurements created from a cross sectional slice of liver tissue. For each parametric map, statistics from multiple Regions of Interest (ROIs) – potentially placed across multiple slices – are summarised. Also supports the display of 'Live' ROI statistics when moving the ROI across the parametric map.
Design: Parametric Maps	Iron corrected T1 (cT1), T2* and triglyceride fat (i.e. DIXON or IDEAL Proton Density Fat Fraction (PDFF)) parametric maps are supported. PDFF parametric maps are calculated with either MAGNITUDE ONLY-IDEAL, when the data is received from GE and Phillips scanners, and COMPLEX-IDEAL for Siemens. When analysing COPLEX-IDEAL data a field map is also available during analysis. PDFF may also be calculated using the three-point DIXON method.	Iron corrected T1 (cT1), T2* and triglyceride fat (i.e. DIXON Proton Density Fat Fraction (PDFF)) parametric maps are supported.
Design: Visualisation	Iron corrected T1 (cT1), T2* and triglyceride fat (also known as Proton Density Fat Fraction (PDFF)) parametric maps are supported. Iron corrected T1 (cT1) displayed using LMSv3 colourmap, designed to have maximum contrast on liver parenchymal tissue.	Iron corrected T1 (cT1), T2* and triglyceride fat (also known as Proton Density Fat Fraction (PDFF)) parametric maps are supported. Iron corrected T1 (cT1) displayed using LMSv2 colourmap, designed to have maximum contrast on liver parenchymal tissue.
Design: Supported Modalities	DICOM 3.0 compliant MR data from supported MRI scanners.	DICOM 3.0 compliant MR data from supported MRI scanners.
Design: Report	Quantified metrics from liver tissue and image analysis collated in a deliverable pdf report. Histogram of segmented area and proportion of PDFF intensities are included in the final report to give a better understanding on the distribution of PDFF intensities.	Quantified metrics from liver tissue and images analysis collated in a deliverable pdf report.

Comparison of subject and Predicate Device		
Characteristic	LMSv3 (Subject device)	LMSv2 (Predicate device)
Compatibility with the environment	Installation of LMSv3 is controlled and is installed on general purpose workstations at PD's image analysis centre. LMSv3 reads in local files compliant with DICOM 3.0.	Installation of LMSv2 is controlled and is installed on general purpose workstations at PD's image analysis centre. LMSv2 reads in local files compliant with DICOM 3.0.
Performance	Validated with phantom scans, synthetic raw data and volunteer scans covering a range of physiological values for cT1, T2* and PDFF.	Validated with phantom scans, synthetic raw data and volunteer scans covering a range of physiological values for cT1, T2* and PDFF.
Supported MRI Systems	Validated across all listed supported manufacturers and field strengths.	Validated across all listed supported manufacturers and field strengths.
Standards	IEC 62304, IEC 62366, DICOM 3.0, ISO 14971, ISO 13485	IEC 62304, DICOM 3.0, ISO 14971, ISO 13485
System/Operating System	Mac OS	Mac OS
Materials	Not applicable, standalone software.	Not applicable, standalone software.
Biocompatibility	Not applicable, standalone software.	Not applicable, standalone software.
Sterility	Not applicable, standalone software.	Not applicable, standalone software.
Electrical Safety	Not applicable, standalone software.	Not applicable, standalone software.
Mechanical Safety	Not applicable, standalone software.	Not applicable, standalone software.
Chemical Safety	Not applicable, standalone software.	Not applicable, standalone software.
Thermal Safety	Not applicable, standalone software.	Not applicable, standalone software.
Radiation Safety	Not applicable, standalone software.	Not applicable, standalone software.

Table 1. Comparison of similar characteristics between the subject and predicate device.

4.3. Sterilization and Shelf Life

LMSv3 is a post-processing standalone software device thus is non-contact, non-invasive and non-sterile. The shelf life of LMSv3 is indefinite as long as the manufacturer continues to support the device. Both sterilization and shelf life characteristics are equivalent to the predicate device.

4.4. Biocompatibility

LMSv3 is a post-processing standalone software device thus it is non-contact and non-invasive. Biocompatibility testing was not deemed necessary to demonstrate the safety and effectiveness of LMSv3. LMSv3 does not consists of materials that differ from the predicate device.

4.5. Software

LMSv3 was successfully validated and verified against the requirements specification and it's intended use. The results from the validation and verification activities, documented in this submission, corroborate that LMSv3 meets the product requirement specifications and intended use, which is deemed to be substantially equivalent to the predicate (see section below).

Validation and verification activities were conducted in a controlled environment and in compliance with IEC 62304:2006, ISO 13485:2016 and 21 CFR 820. LMSv3 is also in compliance with the DICOM standard.

The verification and validation activities conducted demonstrates that LMSv3 is at least as safe and effective as the predicate device and does not introduce any new risks.

4.6. Electromagnetic and Electrical Safety

LMSv3 is a standalone software device. There are no electromagnetic or electrical safety risks associated with the direct use of the LMsv3 device. Electromagnetic or electrical safety testing was not deemed necessary to demonstrate the safety and effectiveness of LMSv3.

4.7. Discussion

According to the comparisons between the subject device and predicate device, we can conclude that the subject device does not raise any new potential safety risks when compared to the chosen predicate device and performs in accordance with its intended use.

The subject device is substantially equivalent to the predicate device, both regulated under regulation 21 CFR 892.1000. Substantial equivalence is based on the following observations:

- The indications for use and intended uses of both the subject device and predicate device are equivalent
- The subject device and predicate device both support multi-slice MR data acquired using the specific acquisition protocols, from supported MR Systems, to acquire the input data
- The subject and predicate devices include software applications which utilise MR data to visualise and enable quantification of physiological characteristics in the liver to provide measurements which may be used to aid diagnosis
- Both the subject device and the predicate device include applications to facilitate the import and visualization of MR data sets and include tools to enable the manipulation of the views and to enable the quantification and analysis of tissue characteristics in the liver from the MR data
- The subject and predicate device are both standalone software applications to facilitate the import and visualization of MR data sets
- The subject and predicate devices enable the quantification of analysis of tissue characteristics in the liver from the MR data
- The subject and predicate devices both support the region of interest (ROI) measurements derived from MR images and parametric maps of tissue characteristics
- The subject and predicate device use the same algorithms for the ROI measurements on cT1, T2* and DIXON PDFF
- The subject and predicate device facilitate the creation of a medical report containing the images and analysis output derived from quantification of liver tissue parameters intended to be interpreted by a trained clinician
- The reports produced from both the subject and predicate device include tabular display of quantification statistics, parametric map images and include normal range references
- Both the subject and predicate devices are designed to run on general-purpose computing hardware
- Both the subject and predicate device are intended to be used in the same use environment and by trained PD operators
- Performance testing demonstrates that the subject device performs at least as safely and effectively as the proposed predicate device

5. Reference Devices

5.1. First Reference Device

Legal manufacturer:	Siemens AG
Common name:	Software *syngo* MR E11A for the MAGNETOM systems Aera/Skyra
Device name/Trade name:	MAGNETOM Aera MAGNETOM Skyra
Classification Regulation:	21 CFR 892.1000
510(k) Number:	K141977
Regulation Name:	Magnetic Resonance Diagnostic Device
Device Classification:	Class II
Device Panel:	Radiology
Device Product Code:	LNH

5.2. Second Reference Device

Legal manufacturer:	GE Medical Systems
Common name:	IDEAL IQ Software Option
Device name/Trade name:	IDEAL IQ Software Option
Classification Regulation:	21 CFR 892.1000
510(k) Number:	K103411
Regulation Name:	Magnetic Resonance Diagnostic Device
Device Classification:	Class II
Device Panel:	Radiology
Device Product Code:	LNH

We make use of other legally marketed devices as reference devices to abridge differences in technological characteristics between the predicate and subject device and to substantiate claims that no different questions of safety and effectiveness are raised using a reference device that is already 510(k) cleared and legal marketed.

6. Performance Testing

General

LMSv3 underwent full performance testing under controlled conditions to corroborate that it is safe and effective to use. The performance testing conducted demonstrates that LMSv3 is at least as safe and effective as the predicate device and does not introduce any new risks.

6.1. Performance Testing – Bench

Phantom Testing

The phantom performance testing was conducted to verify the accuracy, repeatability and reproducibility of the device measurements on the phantoms which were designed to mimic the human data but provide a wider range.

The results of worst-case scenarios are summarized in the tables below, demonstrating:

- The MOLLI-based T1 measurement produced by LMSv3 is consistent with the literature-reported underestimation of ground truth T1 using MOLLI techniques [3][4].
- LMSv3 measurements of $T2^*$ and IDEAL PDFF are accurate over the expected physiological range of values.
- LMSv3 measurements of DIXON PDFF are relatively accurate over the expected physiological range of values. There are only minor deviations due to the known fat bias associated with the DIXON method.

Phantom Metrics	Accuracy 95% CI Limits of Agreement
T1	Up to 18.89% lower to the ground truth
T2*	- 9.31% to 7.53% of the ground truth
DIXON PDFF < 30%	-7.37 % to 1.72%
DIXON PDFF ≥ 30%	-28.93% to 6.83%
IDEAL PDFF < 30%	-1.17% to 1.43%
IDEAL PDFF ≥ 30%	-5.05% to 10.70%

- LMSv3 measurements of T1, T2* and PDFF are highly repeatable within the same scanner
- LMSv3 measurements of T1, T2* and PDFF are reproducible between different scanners

Phantom Metrics	Repeatability 95% CI Limits of Agreement	Reproducibility 95% CI Limits of Agreement
T1	- 13.88 to 14.47 ms	- 2.66 to 10.78%
T2*	- 0.89 to 1.43 ms	- 3.43 to 2.42 ms
DIXON PDFF < 30%	-0.66 to 0.82 %	-1.86 to 5.95%
DIXON PDFF ≥ 30%	-2.11 to 1.96%	-8.64 to 23.52%
IDEAL PDFF < 30%	-1.27 to 0.87%	-1.99 to 2.80%
IDEAL PDFF ≥ 30%	-3.80 to 1.93 %	-13.46 to 6.98%

6.2. Performance Testing – Clinical

In-vivo

The performance testing using in-vivo volunteer data was conducted to assess the precision of LMSv3, inter- and intra- operator variability and the worst-case variability.

The results of worst-case scenarios are summarized in the tables below and demonstrate the following:

- LMSv3 measurements of cT1, T2* and PDFF are highly repeatable
- LMSv3 measurements of cT1, T2* and PDFF are reproducible between the scanners
- The variation introduced by operator measuring with the segmentation method is well within the prescribed acceptance criteria. There is only minor additional variation introduced by having two operators examining the same metrics using ROI method.
- LMSv3 measurements of cT1, T2* and PDFF under the 'worst case' variability conditions are highly reproducible

Volunteer Metrics	Repeatability 95% CI Limits of Agreement	Reproducibility 95% CI Limits of Agreement
cT1 (ROI)	- 94.38 to 63.38 ms	-89.70 to 120.58 ms
cT1 (Segmentation)	- 76.93 to 59.39 ms	-84.91 to 121.79 ms
T2* (ROI)	- 6.07 to 5.70 ms	-3.68 to 6.35 ms
DIXON PDFF (ROI)	-1.77 to 3.64 %	-6.21 to 2.63%
DIXON PDFF (Segmentation)	-1.20 to 1.06%	-3.14 to 0.88%
IDEAL PDFF (ROI)	-1.92 to 1.54%	-2.66 to 2.77
IDEAL PDFF (Segmentation)	-1.83 to 1.28 %	-1.74 to 1.21

Volunteer Metrics	Intra-Operator 95% CI Limits of Agreement (Range)	Inter-Operator 95% CI Limits of Agreement (Range)
cT1 (ROI)	-27.38 to 28.33ms	- 48.05 to 39.89ms
cT1 (Segmentation)	- 20.81 to 13.06ms	-37.84 to 26.51ms
T2* (ROI)	- 2.29 to 2.91 ms	- 2.64 to 4.90 ms
DIXON PDFF (ROI)	- 0.78 to 1.90 %	- 2.27 to 4.57%
DIXON PDFF (Segmentation)	- 0.29 to 0.45%	- 0.55 to 1.22%
IDEAL PDFF (ROI)	- 1.26 to 1.05%	- 2.09 to 1.82 %
IDEAL PDFF (Segmentation)	- 0.16 to 0.14%	- 0.37 to 0.26%

Volunteer Metrics	Worst-Case Variability 95% CI Limits of Agreement (Range)
cT1 (ROI)	-126.52 to 104.19 ms
cT1 (Segmentation)	- 65.27 to 120.27 ms
T2* (ROI)	-3.68 to 6.35 ms
DIXON PDFF (ROI)	-2.04 to 0.76 %
DIXON PDFF (Segmentation)	-2.72 to 1.24%
IDEAL PDFF (ROI)	-3.75 to 2.83%
IDEAL PDFF (Segmentation)	-1.92 to 1.35%

6.3. Performance Testing - Substantial Equivalence

The substantial equivalence testing conducted on LMSv3 against its predicate device, LMSv2, is summarized in the tables below. The latest version of predicate, LMSv2.1 was used in this testing.

Phantom measurements show the negligible difference between the results of LMSv3 and LMSv2.1. LMSv3 produces T1 value within in 3ms and T2* value within in 0.1ms of the predicate device. PDFF is within 1% of the predicate device when measuring PDFF<30%, and within 2% when measuring PDFF>30%.

Phantom Metric	Results (Range) 95% CI Limits of Agreement
T1	-1.96 to 2.09ms
T2*	-0.08 to 0.08ms
DIXON PDFF (< 30)	-0.18 to 0.10 %
DIXON PDFF (≥ 30)	-1.62 to 1.02 %

In-vivo measurements show that cT1 values produced by LMSv3 lie within 30ms of the predicate device, with T2* values within 2ms. There is negligible difference in the measurement of PDFF between LMSv3 and the predicate.

Volunteer Metric	Results (Range) 95% CI Limits of Agreement
T1	-28.08 to 28.73ms
T2*	-0.43 to 1.69ms
DIXON PDFF	-0.18 to 0.10 %

As all the testing results are well within the acceptance criteria, it is concluded that LMSv3, when used as intended, performs as well as its predicate.

7. Conclusion

In a conclusion, all the information submitted to FDA is able to demonstrate that:

- The subject device, LiverMultiScan (LMSv3) has the same intended use as the predicate device, LiverMultiScan (LMSv2).
- The subject device, LiverMultiScan (LMSv3) has slightly different technological characteristics. However, when used as intended, it does not raise different questions of safety and effectiveness in comparison to the predicate, LiverMultiScan (LMSv2).
- The subject device, LiverMultiScan (LMSv3) is at least as safe and effective as the legally marketed predicate.

References

[1] Dixon W. Simple proton spectroscopic imaging. Radiology 1984;153:189–194.
[2] Reeder, S.B., Pineda, A.R., Wen, Z., Shimakawa, A., Huanzhou, Y., Brittain, J.H., Gold, G.E., Beaulieu, C.H., Pelc, N.J., "Iterative Decomposition of Water and Fat with Echo Asymmetry and Least-Squares Estimation (IDEAL): Application with Fast Spin-Echo Imaging", Magn Reson in Medicine, 2005, 54, pp 636-644.
[3] Piechnik et al. (2010) Journal of Cardiovascular Magnetic Resonance 12:69
[4] Puntmann et al. (2013) Journal of Cardiovascular Magnetic Resonance 15(Suppl1):E18