April 1, 2022

KeyaMed NA Inc.
% Kelliann Payne
Partner
Hogan Lovells US LLP
1735 Market Street, Floor 23
Philladelphia, Pennsylvania 19103

Re: K213657
Trade/Device Name: DEEPVESSEL FFR
Regulation Number: 21 CFR 870.1415
Regulation Name: Coronary Vascular Physiologic Simulation Software Device
Regulatory Class: Class II
Product Code: PJA
Dated: March 1, 2022
Received: March 1, 2022

Dear Kelliann Payne:

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,

LCDR Stephen Browning
Assistant Director
Division of Cardiac Electrophysiology,
Diagnostics and Monitoring Devices
Office of Cardiovascular Devices
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: 06/30/2023
See PRA Statement on last page

510(k) Number *(if known)*

K213657

Device Name

DEEPVESSEL FFR

Indications for Use *(Describe)*

DEEPVESSEL FFR is a coronary physiological simulation software for the clinical quantitative and qualitative analysis of previously acquired Computed Tomography DICOM data for clinically stable symptomatic patients with coronary artery disease. It provides DVFFR (a CT-derived FFR measurement) computed from static coronary CTA images using deep learning neural networks that encode imaging, structural, and functional characteristics of coronary arteries through learning.

DEEPVESSEL FFR analysis is intended to support the functional evaluation of coronary artery disease.
The results of the analysis are provided to support qualified clinicians to aid in the evaluation and assessment of coronary arteries. DEEPVESSEL FFR results are intended to be used by qualified clinicians in conjunction with the with the patient's clinical history, symptoms, and other diagnostic tests, as well as the clinician's professional judgment.

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.

510(k) SUMMARY

Keya Medical's DEEPVESSEL FFR

K213657

Submitter

KeyaMed NA Inc.
107 Spring Street
Seattle, WA 98104, USA

Phone: 1 (206) 508-1036
Contact Person: Xiaoxiao Liu
Date Prepared: March 25, 2022

Name of Device: DEEPVESSEL FFR

Classification Name: Coronary Vascular Physiologic Simulation Software

Regulatory Class: Class II

Product Code: PJA

Predicate Device: HEARTFLOW, INC.'s FFR$_{CT}$ V2.0 (K161772)

Device Description

DEEPVESSEL FFR is a coronary physiological simulation software for the clinical quantitative and qualitative analysis of previously acquired Computed Tomography DICOM data for clinically stable symptomatic patients with coronary artery disease. It estimates FFR values from static coronary CTA images with extracted coronary tree structures using deep learning neural networks. DEEPVESSEL FFR analysis is intended to support the functional evaluation of CAD.

The software processes these images semi-automatically, and it generates a 3D model of the coronary artery tree and computes DVFFR (CT-derived FFR) values. Qualified image analysts interact with the software by providing manual edits to the 3D coronary artery tree segmentations when needed, and oversees outputs along the processing steps. DVFFR analysis results are sent electronically to the physicians via a third-party service portal application.

DVFFR software is independent of imaging equipment, imaging protocols and equipment vendors; the clinical validation study report includes the specific imaging scanner types and imaging acquisition parameters used in the clinical validation of the product.

Intended Use / Indications for Use

DEEPVESSEL FFR is a coronary physiological simulation software for the clinical quantitative and qualitative analysis of previously acquired Computed Tomography DICOM data for clinically stable

symptomatic patients with coronary artery disease. It provides DVFFR (a CT-derived FFR measurement) computed from static coronary CTA images using deep learning neural networks that encode imaging, structural, and functional characteristics of coronary arteries through learning.

DEEPVESSEL FFR analysis is intended to support the functional evaluation of coronary artery disease. The results of the analysis are provided to support qualified clinicians to aid in the evaluation and assessment of coronary arteries. DEEPVESSEL FFR results are intended to be used by qualified clinicians in conjunction with the with the patient's clinical history, symptoms, and other diagnostic tests, as well as the clinician's professional judgment.

Summary of Technological Characteristics

DEEPVESSEL FFR is a software medical device that is designed to be used by qualified image analysts (trained and certified professionals) to analyze coronary CTA images of clinically stable symptomatic patients with CAD. It calculates CT-derived FFR values from static coronary CTA images using deep learning neural networks. DEEPVESSEL FFR analysis is intended to support the functional evaluation for clinical stable CAD patients.

The software generates the DVFFR analysis results in two main steps. The first step generates a 3D coronary artery tree model from the CTA image automatically using deep learning-based segmentation algorithms. Manual corrections of the segmentation results are allowed when necessary to confirm the accuracy of the 3D coronary artery tree segmentation. In the second step, the deep learning framework consists of a multi-layer perceptron network (MLP) and a bidirectional multi-layer recursive neural network (BRNN), which utilize the segmentation results and the CTA image, to estimate semi-continuous FFR values along the coronary artery centerlines. The output of the analysis is a PDF report with detailed DVFFR assessment and branch-by-branch visualizations, along with a 3D DVFFR tree model where the DVFFR values are mapped on top of the surface model.

DEEPVESSEL FFR and the predicate device have similar technological characteristics, utilizing computational models to generate CT-derived FFR value for interpretation.

Table 1. Key Feature Comparison

	Subject Device **DEEPVESSEL FFR 1.0**	**Predicate Device** **HeartFlow FFR_{CT} V2.0** **(K161772)**
Manufacturer	Keya Medical	HeartFlow, Inc.
Intended Use/Indications for use	DEEPVESSEL FFR is a coronary physiological simulation software for the clinical quantitative and qualitative analysis of previously acquired Computed Tomography DICOM data for clinically stable symptomatic patients with coronary artery disease. It provides DVFFR (a CT-derived FFR measurement) computed from static coronary CTA images using deep learning neural networks that encode imaging, structural, and functional characteristics of coronary arteries through learning. DEEPVESSEL FFR analysis is intended to support the functional evaluation of coronary artery disease. The results of the analysis are provided to support qualified clinicians to aid in the evaluation and assessment of coronary arteries. DEEPVESSEL FFR results are intended to be used by qualified clinicians in conjunction with the with the patient's clinical history, symptoms, and other diagnostic tests, as well as the clinician's professional judgment.	HeartFlow FFRCT is a coronary physiologic simulation software for the clinical quantitative and qualitative analysis of previously acquired Computed Tomography DICOM data for clinically stable symptomatic patients with coronary artery disease. It provides FFRCT, a mathematically derived quantity, computed from simulated pressure, velocity and blood flow information obtained from a 3D computer model generated from static coronary CT images. FFRCT analysis is intended to support the functional evaluation of coronary artery disease. The results of this analysis are provided to support qualified clinicians to aid in the evaluation and assessment of coronary arteries. The results of HeartFlow FFRCT are intended to be used by qualified clinicians in conjunction with the patient's clinical history, symptoms, and other diagnostic tests, as well as the clinician's professional judgment.
Intended End User	Clinicians	Clinicians
Clinical Condition	Coronary Artery Disease	Coronary Artery Disease
Input	Coronary CTA DICOM image data	Coronary CTA DICOM image data
Output	3D Model & Analysis Report	3D Model & Analysis Report

Performance Data

The following testing have been conducted to demonstrate the substantial equivalence:

Software: Software verification and validation activities were performed according to written procedures and FDA Guidance document Guidance for the Content of Premarket Submissions for Software Contained in Medical Devices. Verification and validation testing confirmed that the pre-defined acceptance criteria have been fulfilled.

Human Factors Evaluations: Two human factors studies were conducted in accordance with FDA's Guidance Applying Human Factors and Usability Engineering to Medical Devices, 2016. The studies evaluated the critical tasks associated with use of the device for both physicians and analysts. The findings from the study demonstrated that all critical tasks were completed without use error or difficulty. These study results concluded that the DEEPVESSEL reports are safe and effective for the physician user group for the intended uses and use environment. Additionally, the analyst user group were able to safety and accurately use the DVFFR software and generate reports.

Reproducibility/Repeatability Evaluations: Reproducibility & Repeatability (R&R) testing was performed on a group of CT scans with diverse disease conditions and image qualities to evaluate the variation of repeated analyses of DEEPVESSEL FFR with different image analysts (reproducibility) at different days with a washout-period in between to avoid memory effects (repeatability). Testing results met the pre-specified variability metric threshold and thus demonstrated acceptable performance.

Clinical Studies: The software was also validated via a multi-national (US and EU), multicenter clinical validation study with intended patient population to ensure the clinical effectiveness. The primary endpoints of the study were per-vessel sensitivity and specificity of DVFFR to detect ischemic condition comparing with invasive FFR measurement. DVFFR analysis was conducted on a total of 244 patients with 311 target vessels from 8 clinical sites (4 from EU and 4 from US).

At the vessel level, the observed sensitivity of DVFFR was 86.9% with a two-sided lower bound 95% CI of 80.6%, and the observed specificity of DVFFR was 86.7% with a two-sided lower bound 95% CI of 82.0**%.** Both 95% CI lower bounds for sensitivity and specificity exceeded the performance target of 75% and 70%, respectively， as shown in Table 1.

Table 1. **Per-vessel** sensitivity and specificity of DVFFR

	Estimate, % (two-sided 95% CI)	Lower Bound of the two-sided 95% CI	Target Rate	Met/Not Met
Sensitivity	86.9% (80.6%–92.7%)	80.6%	75%	Met
Specificity	86.7% (82.0%–91.1%)	82.0%	70%	Met
Positive: measured or estimated FFR values ≤ 0.80				

The observed diagnostic accuracy, PPV (positive predictive value) and NPV (negative predictive value) of DVFFR were 86.8% (95% CI: 83.0%–90.4%), 79.4% (95% CI: 71.8%–86.2%) and 91.9% (95% CI: 87.7%–95.6%), respectively. The results are summarized in Table 2.

Table 2. **Per-vessel** diagnostic accuracy, PPV and NPV of DVFFR

	Accuracy (two-sided 95% CI)	**PPV** (two-sided 95% CI)	**NPV** (two-sided 95% CI)
DVFFR	86.8% (83.0%–90.4%)	79.4% (71.8%–86.2%)	91.9% (87.7%–95.6%)

At the patient level, the observed sensitivity, specificity, accuracy, PPV, and NPV were 87.4% (95% CI: 79.4%–93.1%), 83.7% (95% CI: 76.5%–89.4%), 85.2% (95% CI: 80.2%–89.4%), 79.6% (95% CI: 71.0%–86.6%), and 90.1% (95% CI: 83.6%–94.6%), respectively, as shown in Table 3.

Table 3. **Patient-level** diagnostic performance of DVFFR

	Sensitivity (95% CI)	**Specificity** (95% CI)	**Accuracy** (95% CI)	**PPV** (95% CI)	**NPV** (95% CI)
DVFFR	87.4% (79.4%–93.1%)	83.7% (76.5%–89.4%)	85.2% (80.2%–89.4%)	79.6% (71.0%–86.6%)	90.1% (83.6%–94.6%)
At the patient level, if a patient had more than one ischemic lesion, ICA-FFR value for this patient would be determined as the minimum ICA-FFR measurement from all the coronary arteries. Similarly, patient-level DVFFR value is the minimum DVFFR measurements from all the vessels measured for the patient.					

The study demonstrated that DEEPVESSEL FFR yielded good diagnostic performance and met the pre-specified criteria for study success.

Conclusions

DEEPVESSEL FFR, a coronary physiological simulation software, is substantially equivalent to the predicate device, HeartFlow FFRct V2.0 (K161772). DEEPVESSEL FFR and HeartFlow FFRct V2.0 (K161772) share the same intended use and very similar indications for use, technological characteristics, and principles of operation. The only differences between the subject and predicate devices are the algorithms used to calculate the CT-derived FFR values, and these differences do not raise new questions of safety or effectiveness.