May 12, 2023

Cardio Flow Design Inc.
% Teruyasu Nishino
CEO
22-3 Ichibancho, Chiyoda-ku
Tokyo, 1020082
JAPAN

Re: K222854
Trade/Device Name: iTFlow
Regulation Number: 21 CFR 892.2050
Regulation Name: Medical image management and processing system
Regulatory Class: Class II
Product Code: LLZ
Dated: March 12, 2023
Received: March 28, 2023

Dear Teruyasu Nishino:

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,

Daniel M. Krainak, Ph.D.
Assistant Director
Magnetic Resonance and Nuclear Medicine Team
DHT8C: Division of Radiological Imaging
and Radiation Therapy Devices
OHT8: Office of 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: 06/30/2023
*See PRA Statement below.*

510(k) Number *(if known)*
K222854

Device Name
iTFlow

Indications for Use *(Describe)*
The iTFlow software will be utilized in situations where visualization of blood flow in a heart and its major vessels are required for a cardiac diagnosis. iTFlow allows for the viewing, post-processing, and the quantitative evaluation of cardiovascular MRI data (in DIRECTOR-compliant format)
It enables:
- The import of DICOM-compliant MR Images.
- The support of a clinical diagnosis by the quantitative analysis of the imported images.
- Quantitative measurement of the size, area, blood flow, volume and mass of the heart and adjacent vessels.
-Advanced correction options such as offset correction, background phase correction, and anti-aliasing.
-Data visualization as a graph or output as an image or numerical data.

iTFlow software will assist clinicians with proper training in cardiac treatment decision making and in providing a conclusive diagnosis for patients. It is intended to analyze cardiovascular MRI image data, that are acquired via electrocardiogram gated acquisition, gradient echo cine sequence, and phase contrast time-resolved multi-slice sequence, without any-contrast medium for MR angiography. Patient populations are not restricted.

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.**

This section applies only to requirements of the Paperwork Reduction Act of 1995.

***DO NOT SEND YOUR COMPLETED FORM TO THE PRA STAFF EMAIL ADDRESS BELOW.***

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# 510(k) Summary K222854

## 1. Submitter Information

Submitter:

| | |
|---|---|
| Name | Cardio Flow Design Inc. |
| Address | 22-3 Ichibancho, Chiyoda-ku, Tokyo<br>JAPAN<br>102-0082 |
| Correspondence Person | Teruyasu Nishino |
| Contact Information | Email: kanri@cfd.life<br>Phone: +81 42-649-3492 |
| US agent | Benjamin Patrick Dyer |
| Contact information | Email: bendyer.cfd@gmail.com |

## 2. Proposed Device

Proposed Device:

| | |
|---|---|
| Proprietary Name | iTFlow |
| Common Name | iTFlow |
| Classification Name | System, Image Processing, Radiological |
| Regulation Number | 21 CFR 892.2050 |
| Product Code | LLZ |
| Regulatory Class | II |

## 3. Predicate Device

Primary Predicate Device:

| | |
|---|---|
| Proprietary Name | cvi42 |
| Premarket Notification | K141480 |
| Classification Name | System, Image Processing, Radiological |
| Regulation Number | 21 CFR 892.2050 |
| Product Code | LLZ |
| Regulatory Class | II |

Secondary Predicate Device:

| | |
|---|---|
| Proprietary Name | cmr42 |
| Premarket Notification | K082628 |
| Classification Name | 21 CFR 892.2050) |
| Regulation Number | 21 CFR 892.2050 |

| | |
|---|---|
| Product Code | LLZ |
| Regulatory Class | II |

## 4. Device Description

iTFlow is a post-processing analysis software device for viewing and quantifying cardiovascular MR images (4D Flow MRI). The device is intended to visualize and quantify MRI data imported in DICOM format. The software has features for loading, saving, generating screen displays, and aggregating quantitative data from cardiovascular images acquired from magnetic resonance (MR) scanners. iTFlow is intended for use in both pediatric (neonate, infant, child, and adolescent) and adult populations.

The following visualization, quantification and data-reporting functionalities are provided by the software:

Visualization:

- 2D image review
- 3D image review by means of volume rendering
- Multi-planar reconstruction (MPR) views (axial, coronal and sagittal)
- Blood flow visualization using vectors, - Cine play
- Streamlines, and pathlines
- Visualization of segmented region.

Quantification:

- Anatomy segmentation.
- Linear distance measurements.
- Flow rate at user-specified locations (e.g., aorta, aortic valve, pulmonary valve, mitral valve, tricuspid valve, and superior vena cava).
- Volume of segmented area and volume related parameters include stroke volume, ejection fraction, cardiac output, end-diastolic volume, end-systolic volume.

Data reporting:

- Visualized image and quantified value can be exported into a report in DICOM format.

## 5. Intended Use

iTFlow is a software package, for which the intended use is viewing, post-processing and the quantitative evaluation of cardiovascular MRI data (in DICOM-compliant format). The software

has the capability to analyze multi-slice, multi-phase and velocity encoded phase contrast MRI scans, known as 4D Flow MRI, to visualize and analyze the blood flow (velocity, flow patterns, pulse wave analysis) inside a heart and its major vessels. By optionally focusing on specific anatomy segments, volume related parameters may be computed for each segment.

## 6. Indications for use

The iTFlow software will be utilized in situations where visualization of blood flow in a heart and its major vessels are required for a cardiac diagnosis. iTFlow allows for the viewing, post-processing, and the quantitative evaluation of cardiovascular MRI data (in DIRECTOR-compliant format)

It enables:

- The import of DICOM-compliant MR Images.
- The support of a clinical diagnosis by the quantitative analysis of the imported images.
- Quantitative measurement of the size, area, blood flow, volume and mass of the heart and adjacent vessels.
-Advanced correction options such as offset correction, background phase correction, and anti-aliasing.
-Data visualization as a graph or output as an image or numerical data.

iTFlow software will assist clinicians with proper training in cardiac treatment decision making and in providing a conclusive diagnosis for patients. It is intended to analyze cardiovascular MRI image data, that are acquired via electrocardiogram gated acquisition, gradient echo cine sequence, and phase contrast time-resolved multi-slice sequence, without any-contrast medium for MR angiography. Patient populations are not restricted.

## 7. Technology

This device is a software to visualize and quantify 4D Flow MRI data.

4D Flow MRI is an MRI imaging method for analyzing blood flow using the phase contrast method.
Using 4D Flow MRI, phase contrast images are obtained sequentially in 3D during the cardiac cycle.

Phase contrast images indicate the distribution of fluid velocity along with the gradient magnetic field. Blood velocity distribution in three axes can be obtained from the phase contrast image of the horizontal direction, the vertical direction, and the cross-section passing direction with respect to the imaging cross section.

The software reads these phase images representing the anatomy of the blood vessel and computes the three axes of the phase contrast images to visualize the blood flow as a vector.

The computed blood flow velocity can be displayed as vectors overlaid on a 2D anatomy image or can be displayed as a streamline in a 3D view.

It is also possible to measure changes in ventricular volume from the heartbeat by tracking the movement of the segmented heart lumen.

The quantified data can be displayed as a graph or output as an image or numerical data.

## 8. Comparison of Technological Characteristics with the Predicate Device

iTFlow and the other two predicate devices belong to class II medical device and all of them are used for analyzing image of MRI. All of them are designed to do quantitative analysis of cardiac blood flow and volume.

Primary Predicate Device:

| Feature/Function | Proposed Device: | Predicate Device Primary | Discussion of Differences |
|---|---|---|---|
| Trade Name | iTFlow | cvi42 | - |
| 510K number | - | K141480 | - |
| Regulation Number | 21 CFR 892.2050 | 21 CFR 892.2050 | same |
| Regulation Name | Medical image management and processing system. | Medical image management and processing system. | same |
| Regulatory Class: | II | II | same |
| Product Code | LLZ | LLZ | same |
| 510k clearance Date: | - | August 22, 2014 | - |
| 510k sponsor | Cardio Flow Design Inc. | Circle Cardiovascular Imaging Inc. | - |
| Segmentation of region of interest | Yes | Yes | same |
| Phase error correction | Yes | Yes | same |
| Quantitative Analysis, flow | Yes | Yes | same |
| Quantitative Analysis, volume | Yes | Yes | same |

Secondary Predicate Device:

| Feature/Function | Proposed Device: | Predicate Device Secondary | Discussion of Differences |
|---|---|---|---|
| Trade Name | iTFlow | cmr42 | - |
| 510K number | - | K082628 | - |
| Regulation Number | 21 CFR 892.2050 | 21 CFR 892.2050 | same |
| Regulation Name | Picture archiving and communications system | Picture archiving and communications system | same |
| Regulatory Class: | II | II | same |
| Product Code | LLZ | LLZ | same |
| 510k clearance Date: | - | Nov.20,2008 | - |
| 510k sponsor | Cardio Flow Design Inc. | Circle Cardiovascular Imaging Inc. | - |
| Segmentation of region of interest | Yes | Yes | same |
| Phase error correction | Yes | Yes | same |
| Quantitative Analysis, flow | Yes | Yes | same |
| Quantitative Analysis, volume | Yes | Yes | same |

iTFlow has no significant differences compared with the predicate devices. The intended use and basic technology are similar to the predicate devices. Therefore, Cardio Flow Design Inc. believes that they are substantially equivalent.

## 9. Performance Data

Safety and performance of the iTFlow has been evaluated and verified in accordance with software specifications and applicable performance standards through software verification and validation testing, as well as software usability testing. Additionally, the software validation activities were performed in accordance with *IEC 62304:2006 Ed. 1.1 Medical device software – Software life cycle processes* in addition to the FDA Guidance documents, *"Guidance for the Content of Premarket Submissions for Software Contained in Medical Devices".*

## 10. Numerical phantom test result

The software algorithms are validated by comparing with computer simulation.
A virtual aortic geometry was created, and numerical flow analysis was performed using OpenFOAM. The computed results were converted into DICOM data for comparison with iTFlow. The report found no difference in flow visualization between iTFlow and CFD (computational fluid dynamics), but the flow rate in small vessels were underestimated in iTFlow due to the filter used to integrate the flow velocity. This underestimation can be avoided by manually modifying the region of interest, and this limitation has been labeled in user's manual. Overall, the report suggests that iTFlow can be a useful tool for flow visualization and quantification with some limitations.

## 11. Conclusions

Based on the information provided in this premarket notification, and based on the indications for use, technological characteristics, performance testing and technological comparison to the predicate devices, Cardio Flow Design, Inc. believes that the iTFlow is as safe, as effective, and substantially equivalent in performance to the predicate devices.