December 3, 2024

Riverain Technologies, Inc.
℅ Jonathan Jackson
Director of RAQA
3130 South Tech Boulevard
MIAMISBURG, OH 45342

Re: K242188
Trade/Device Name: ClearRead CT CAC
Regulation Number: 21 CFR 892.1750
Regulation Name: Computed Tomography X-Ray System
Regulatory Class: Class II
Product Code: JAK
Dated: November 13, 2024
Received: November 14, 2024

Dear Jonathan Jackson:

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 (the 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 available 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.

Additional information about changes that may require a new premarket notification are provided in the FDA guidance documents entitled "Deciding When to Submit a 510(k) for a Change to an Existing Device" (https://www.fda.gov/media/99812/download) and "Deciding When to Submit a 510(k) for a Software Change to an Existing Device" (https://www.fda.gov/media/99785/download).

Your device is also subject to, among other requirements, the Quality System (QS) regulation (21 CFR Part 820), which includes, but is not limited to, 21 CFR 820.30, Design controls; 21 CFR 820.90, Nonconforming product; and 21 CFR 820.100, Corrective and preventive action. Please note that regardless of whether a change requires premarket review, the QS regulation requires device manufacturers to review and approve changes to device design and production (21 CFR 820.30 and 21 CFR 820.70) and document changes and approvals in the device master record (21 CFR 820.181).

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 Part 803) for devices or postmarketing safety reporting (21 CFR Part 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 Part 4, Subpart A) for combination products; and, if applicable, the electronic product radiation control provisions (Sections 531-542 of the Act); 21 CFR Parts 1000-1050.

All medical devices, including Class I and unclassified devices and combination product device constituent parts are required to be in compliance with the final Unique Device Identification System rule ("UDI Rule"). The UDI Rule requires, among other things, that a device bear a unique device identifier (UDI) on its label and package (21 CFR 801.20(a)) unless an exception or alternative applies (21 CFR 801.20(b)) and that the dates on the device label be formatted in accordance with 21 CFR 801.18. The UDI Rule (21 CFR 830.300(a) and 830.320(b)) also requires that certain information be submitted to the Global Unique Device Identification Database (GUDID) (21 CFR Part 830 Subpart E). For additional information on these requirements, please see the UDI System webpage at https://www.fda.gov/medical-devices/device-advice-comprehensive-regulatory-assistance/unique-device-identification-system-udi-system.

Also, please note the regulation entitled, "Misbranding by reference to premarket notification" (21 CFR 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,

Lu Jiang

Lu Jiang, Ph.D.
Assistant Director
Diagnostic X-Ray Systems Team
DHT8B: Division of Radiologic Imaging
Devices and Electronic Products
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: 07/31/2026
See PRA Statement below.

510(k) Number *(if known)*
K242188

Device Name
ClearRead CT CAC

Indications for Use *(Describe)*
ClearRead CT CAC is image processing software designed to aid physicians in assessing coronary artery calcification on non-gated, non-contrast, standard, or low-dose chest CT scans of adult patients 30 years of age or older.
The primary output of ClearRead CT CAC is the Agatston score. ClearRead CT CAC locates calcified coronary lesions and assigns them to one of several coronary arteries: the right coronary artery (RCA), the left main artery (LM), the left anterior descending artery (LAD), and the left circumflex artery (LCX). The software calculates the Agatston score as the sum for each artery while also providing the total across all coronary arteries. The total Agatston score is calibrated to 3.0mm slice thickness and is used to derive a CAC category and the arterial age. The provided segmentations are for illustrative purposes only and are not intended for diagnostic use.
ClearRead CT CAC provides adjunctive information and is not intended to be used without clinical expert review.

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.

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K242188

510(k) Summary

Submitter Information:

Company Name: Riverain Technologies, Inc.

Company Address: 3130 South Tech Blvd.

Miamisburg, OH 45342-4860

Contact Person: Jonathan Jackson

Director of RAQA

Riverain Technologies, Inc.
937.531.5092

jjackson@riveraintech.com

Device Information:

Trade Name: **ClearRead CT CAC**

Regulation Number: 21 CFR 892.1750

Regulation Name: Computed tomography x-ray system

Regulatory Class: Class II

Product Code: JAK

Device Description: **ClearRead CT CAC** is a computer aided quantification system intended to aid in the assessment of coronary artery calcification.

The system receives chest Computed Tomography (CT) studies as input, in DICOM® format, and generates output in DICOM (or other) format.

Intended Purpose: **ClearRead CT CAC** is intended to aid physicians in assessing Coronary Artery Calcification while reviewing non-gated, non-contrast, standard, and low-dose chest CT exams.

Indications for Use: **ClearRead CT CAC** is image processing software designed to aid physicians in assessing coronary artery calcification on non-gated, non-contrast, standard, or low-dose chest CT scans of adult patients 30 years of age or older.

The primary output of **ClearRead CT CAC** is the Agatston score. **ClearRead CT CAC** locates calcified coronary lesions and assigns them to one of several coronary arteries: the right coronary artery (RCA), the left main artery (LM), the left anterior descending artery (LAD), and the left circumflex artery (LCX). The software calculates the Agatston score as the sum for each

artery while also providing the total across all coronary arteries. The total Agatston score is calibrated to 3.0mm slice thickness and is used to derive a CAC category and the arterial age. The provided segmentations are for illustrative purposes only and are not intended for diagnostic use.

ClearRead CT CAC provides adjunctive information and is not intended to be used without clinical expert review.

Predicate Device: **Bunkerhill, Inc.**

(K230223)
iCAC Device
Class II

Comparison to Predicate Device Technical Characteristics

Riverain Technologies, Inc. is of the opinion that **ClearRead CT CAC** is substantially equivalent, both in intended use as well as to the technical characteristics of the listed predicate device. Differences in the design and performance of the cited predicate device do not affect either the safety or the effectiveness of **ClearRead CT CAC** for its intended use. **Table 1** shows the predicate devices listed along with the subject device, including the Product Code as well as the Indications for Use for each device.

	Predicate: **iCAC Device** (Bunkerhill, Inc.) K230223	**Subject Device:** **ClearRead CT CAC** (Riverain Technologies, Inc.)
Product Code	JAK	JAK
Indications for Use	iCAC is a software device intended for use in estimating presence and quantity of coronary artery calcium for patients aged 30 years and above during routine care. The device automatically analyzes non-gated, non-contrast chest computed tomography (CT) images collected during routine care and outputs a visual representation of estimated coronary artery calcium segmentation (intended for	ClearRead CT CAC is image processing software designed to aid physicians in assessing coronary artery calcification on non-gated, non-contrast, standard, or low-dose chest CT scans of adult patients 30 years of age or older. The primary output of ClearRead CT CAC is the Agatston score. ClearRead CT CAC locates calcified coronary lesions and assigns them to one of several

	informational purposes only) and both exact and four-category quantitative estimates of the patient's coronary artery calcium burden in Agatston units. The output of the subject device is made available to the physician on-demand as part of his or her standard workflow. The device generated calcium score or score group can be viewed in the patient report at the discretion of the physician, and the physician also has the option of viewing the device-generated calcium segmentation in a diagnostic image viewer. The subject device output in no way replaces the original patient report or the original chest CT scan; both are still available to be viewed and used at the discretion of the physician. The device is intended to provide information to the physician to provide assistance during review of the patient's case. Results of the subject device are not intended to be used on a stand-alone basis and are solely intended to aid and provide information to the physician. In all cases, further action taken on a patient should only come at the recommendation of the physician after further reviewing the patient's results.	coronary arteries: the right coronary artery (RCA), the left main artery (LM), the left anterior descending artery (LAD), and the left circumflex artery (LCX). The software calculates the Agatston score as the sum for each artery while also providing the total across all coronary arteries. The total Agatston score is calibrated to 3.0mm slice thickness and is used to derive a CAC category and the arterial age. The provided segmentations are for illustrative purposes only and are not intended for diagnostic use. ClearRead CT CAC provides adjunctive information and is not intended to be used without clinical expert review.
Intended User	Radiologists	Radiologists
Modality	Routine, non-contrast, non-gated chest CT Series	Non-contrast, non-gated, standard, or low-dose chest CT scans
Anatomical Region	Chest	Chest

Clinical Condition	Coronary Artery Calcification	Coronary Artery Calcification
Quantification of Calcium Burden	Yes	Yes
Segmentation of Calcium	Yes	Yes
Number of Detection Categories	4	4
Calculation of Exact Calcium Score	Yes	Yes
Type of Information	Adjunctive	Adjunctive
Intended location	Medical Facility	Medical Facility
Prescriptive Use	Yes	Yes
Measurement Scale	Agatston Units	Agatston Units
Image Format	DICOM	DICOM
Slice Thickness	Up to 5mm	Up to 3mm
Calcification Detection	Automatic	Automatic
Default Threshold of Calcium	130 HU (Hounsfield Units)	130 HU (Hounsfield Units)
Coronary Artery Calcification Quantification Method	CAC detection category (based on Agatston score), exact Agatston score.	CAC detection category and arterial age based on the measured Agatston score.
Annotation of Detected Calcium	Yes	Yes

Generate Patient Report	Optional to copy result to clipboard, insert in report, DICOM Secondary Capture	Optional to copy result to clipboard, insert in report, DICOM Secondary Capture
Report of the Calcium Score	Yes, Coronary Calcium Detection Category and exact Agatston score 4 categories (for detection category): • 0 • 1-99 • 100-399 • 400 +	Yes, Coronary Calcium Detection Category and measured Agatston score 4 categories (for detection category): • 0 • 1-99 • 100-399 • 400 +

Table 1: Predicate Devices vs. Subject Device

Key features identified that differ from the predicate are discussed below.

Slice Thickness

ClearRead CT CAC operates slice thickness up to 3mm, whereas the predicate device indicates use up to 5mm slice thickness. A limit of 3mm is in keeping with the current standards used for gated protocols, to which the Agatston score is calibrated to. For values exceeding 3mm, it is unclear how the performance of the measurement or detection of CAC scores degrades and, therefore, is excluded from consideration.

Testing Summary

Non-clinical Testing

Non-clinical tests were conducted during the development process in accordance with the Riverain Technologies Design Control Process, which is compliant with the FDA Quality System Regulations, ISO 13485:2016 with MDSAP, and the following standards.

- IEC 62304:2006/AMD1:2016, Medical devices – Software life cycle processes
- IEC62366-1:2015, Medical device – Part1: Application of usability engineering to medical devices
- ISO14971:2019, Medical devices – Application of Risk Assessment to Medical Devices
- NEMA PS 3.1-3-20, Digital Imaging and Communications in Medicine (DICOM) Set 2016
- Guidance for Industry and Food and Drug Administration Staff - Cybersecurity in Medical Devices: Quality System Considerations and Content of Premarket Submissions, Issues September 27, 2023

Testing verified the requirements according to the **ClearRead CT CAC** device specifications.

The **ClearRead CT CAC** Risk Assessment was created for this device, with risk control measures implemented to mitigate identified hazards. Documentation required for software with

a Moderate Level of Concern is included as part of this submission. Device labeling, together with the results from verification and validation testing, demonstrate that the device is safe and effective.

Approximately 400 cases were collected and held out from development of any kind to estimate the test performance of the CAC scoring system. Regions associated with coronary artery calcification were manually outlined, including the particular artery, from which the ground truth Agatston score was obtained.

To assess the measurement of the Agatston score, we used weighted kappa scores (weighted, owing to the ordinal nature of the categories) and Bland-Altman analysis. Pre-test acceptance criteria were defined based on existing literature and internal investigation from visually inspected validation performance. If kappa scores were greater than 0.85, these would be considered excellent. Actual CAC scores are those derived from the use of the ground truth mask, while predicted scores come from the ClearRead CT CAC system. **Figure 1** below shows a plot of the predicted versus true CAC categories. A weighted kappa score of 0.958 was achieved, demonstrating good agreement between the automatic method and manual processing.

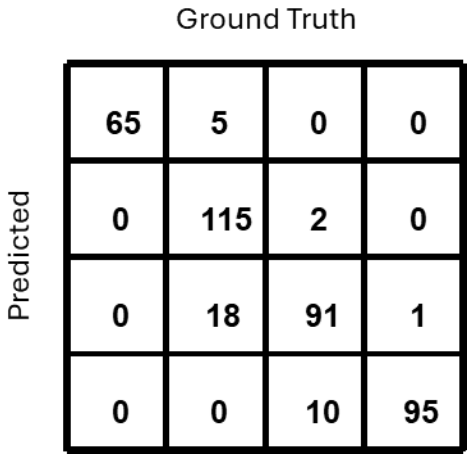

Figure 1: Confusion table of predicted versus ground truth CAC categories

A Bland-Altman plot, as shown in **Figure 2,** demonstrates strong agreement with the true score compared to the estimated score.

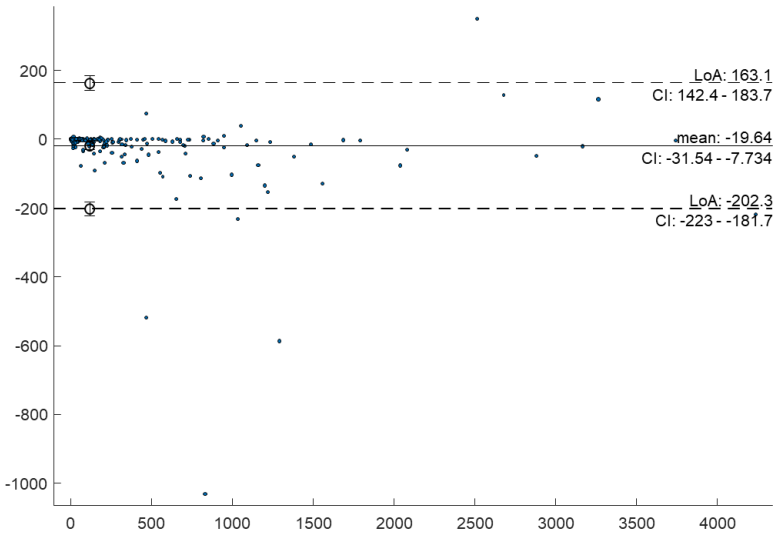

Figure 2: Bland-Altman analysis plot for the Agatston scores within the internal test set

Clinical Performance Testing

A clinical study was performed to validate the clinical efficacy of **ClearRead CT CAC**.

This study was a standalone model performance assessment of **ClearRead CT CAC**. This software, as a medical device product, was developed using machine learning to measure the amount of arterial calcification in non-contrast chest CT cases. This assessment involved comparing the algorithm outputs to ground-truth measurements on non-contrast, non-gated chest CT cases to determine the algorithm accuracy in automated measurements of the Agatston score (scaled to 3mm slice thickness). The Agatston score was measured overall and for the four component arteries of the right coronary artery, left anterior descending artery, left circumflex artery, and left main coronary artery.

In total, 491 cases were used in the clinical assessment of the device: 143 cases with no sign of coronary artery calcification and 348 with evidence of CAC, as determined by a consensus ground truth review by three radiologists. These nearly 500 cases included samples from four CT manufacturers across five clinical sites. In the CAC positive cases, selection was performed to ensure the entire range of scores was spanned.

For clinical assessment, the following predefined endpoints were used:

- Primary endpoint: the accuracy of **ClearRead CT CAC** in calculating the Agatston score category (0, 1-99, 100-399, ≥400) as defined by the quadratic weighted Kappa coefficient when compared with ground truth radiologist Agatston score category.
- Secondary endpoint: the accuracy of **ClearRead CT CAC** in calculating the overall continuous Agatston score as assessed by Bland-Altman analysis.
- Secondary endpoint: the accuracy of **ClearRead CT CAC** in segmenting the overall coronary artery calcification as assessed by Dice score comparison.

The results of the primary and secondary endpoints are as follows:

- Primary endpoint: kappa of 0.959 (95% CI: 0.943-0.975). In addition to kappa scoring, percentage agreement scores for CAC positive (PPA) and negative (NPA) cases were

assessed. These calculations assessed the proportion of cases correctly identified in the relevant category (for PPA) or in all other categories (for NPA). **Figure 3** summarizes all percentage agreement scores as stratified by CAC category.

- Secondary endpoint: Bland-Altman analysis (see **Figure 4** for a data plot) yielding limits of agreement (LoA) of -12.20 ± 437.84.
- Secondary endpoint: Dice score comparison (see **Table 2)** between the annotator ground truth and automatic outputs, giving average scores of 0.910 (0.893,0.927) and 0.892 (0.871,0.911), respectively.

	Ground truth radiologist category	
	Category 0	Not category 0
Device category		
Category 0	126	3
Not category 0	17	345
	PPA 88.1	NPA 99.1
	95% CI (82.5,93.2)	95% CI (98.0,100.0)

	Ground truth radiologist category	
	Category 1-99	Not category 1-99
Device category		
Category 1-99	116	17
Not category 1-99	9	349
	PPA 92.8	NPA 95.4
	95% CI (87.7,96.9)	95% CI (93.0,97.4)

	Ground truth radiologist category	
	Category 100-399	Not category 100-399
Device category		
Category 100-399	74	12
Not category 100-399	10	395
	PPA 88.1	NPA 97.1
	95% CI (80.5,94.4)	95% CI (95.2,98.5)

	Ground truth radiologist category	
	Category $\geq$ 400	Not category $\geq$ 400
Device category		
Category $\geq$ 400	137	6
Not category $\geq$ 400	2	346
	PPA 98.6	NPA 98.3
	95% CI (96.3,100.0)	95% CI (96.9,99.4)

Figure 3: Tabularized percentage agreement scores stratified by CAC category

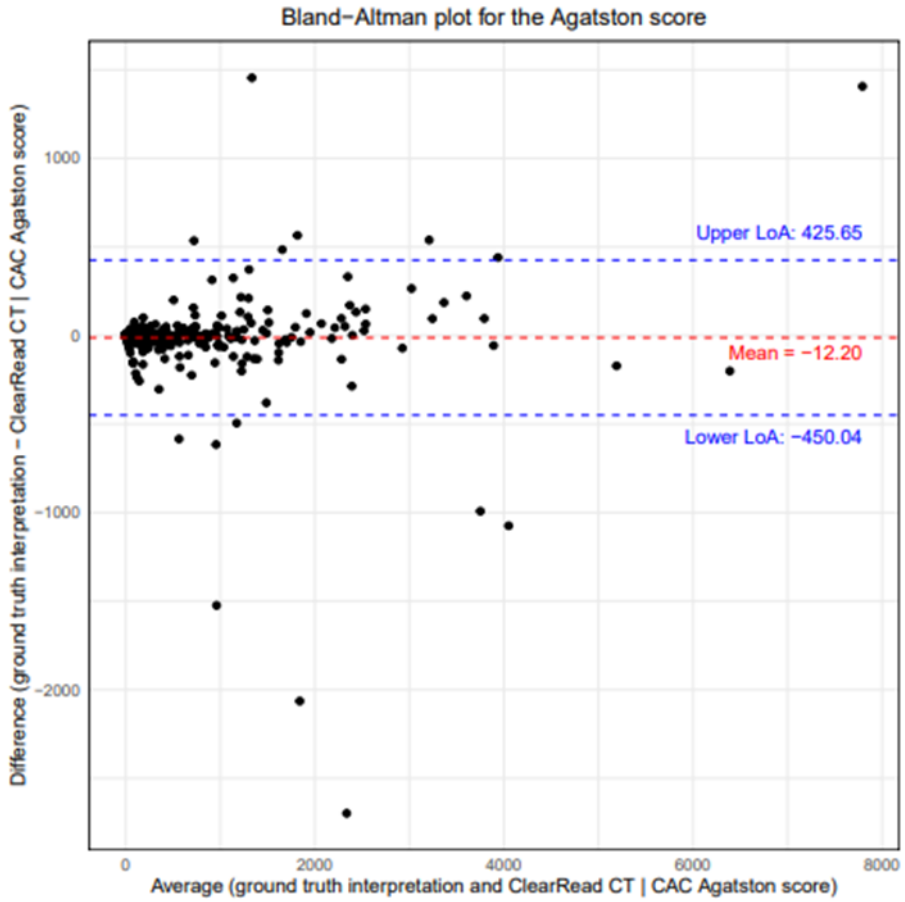

Figure 4: Bland-Altman plot from clinical testing

Average Dice score (95% CI)			Wilcoxon test
Device versus GT	GT versus GT	Difference	p-value
0.892 (0.871,0.911)	0.910 (0.893,0.927)	-0.008 (-0.024,0.007)	0.121

Table 2: Dice score comparison to the consensus ground truth

Conclusion

In preparing this 510(k) submission, Riverain Technologies has carefully considered the relevant statutory and regulatory requirements and believes that the information contained within satisfies the requirements for demonstrating substantial equivalence in terms of design features, fundamental technology, indications for use, and the safety and effectiveness of the device. Additionally, verification and validation testing demonstrate the safety and efficacy of the device to meet its intended use and specifications when operated as intended, with no detrimental impact on the benefit/risk ratio of the device.