



PHILIPS

Computed
Tomography

White paper

Precise Cardiac

Motion-compensated reconstruction for coronary imaging

Overview

Philips Precise Cardiac is a novel approach with the ability to compensate for cardiac motion in CT imaging, improving visualization of the coronary arteries. This can help salvage some of the coronary segments deemed non-diagnostic using standard cardiac reconstructions, increasing diagnostic confidence in coronary CTA exams.

Background

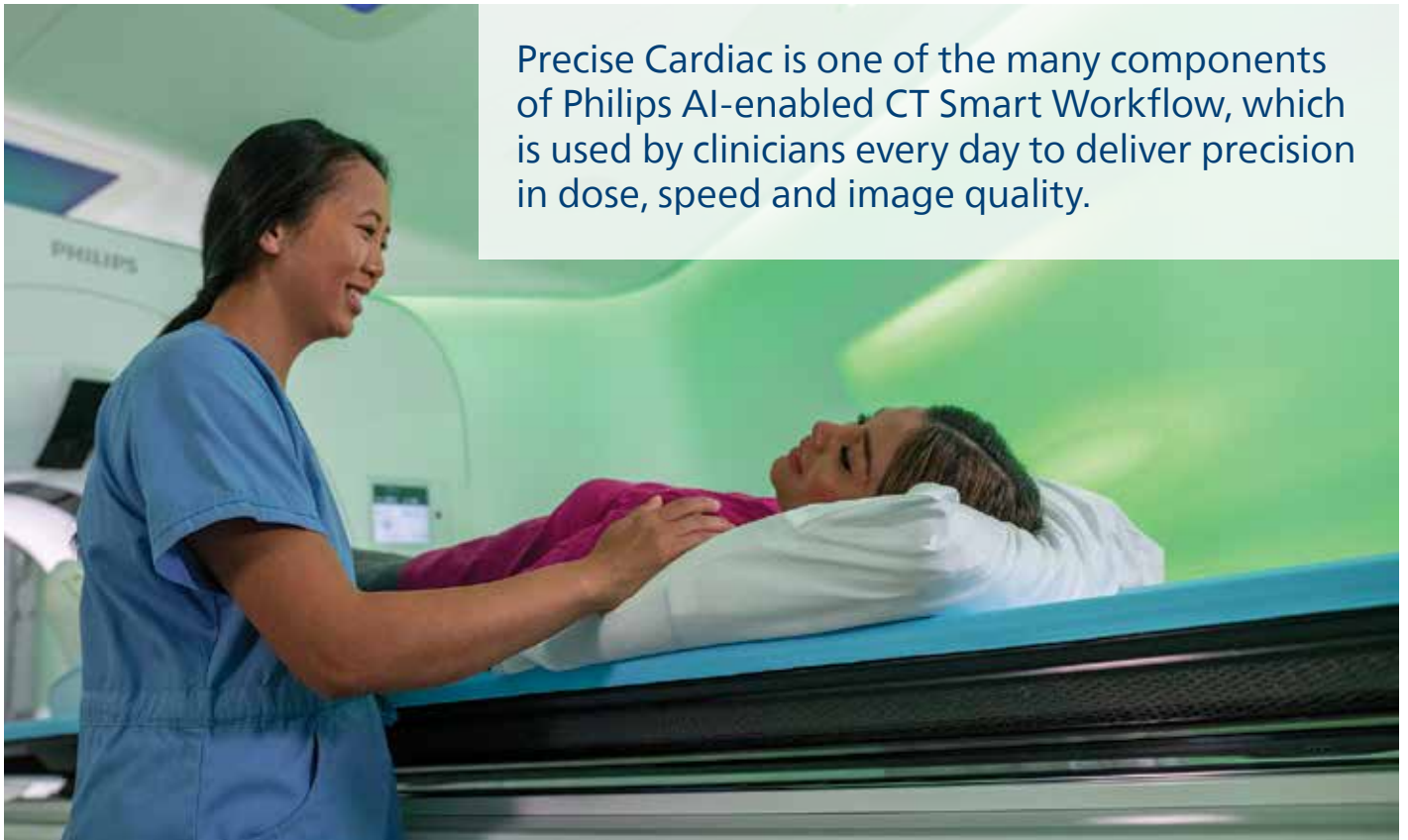
Coronary computed tomography angiography (coronary CTA) has become the preferred noninvasive modality for the detection and rule-out of coronary artery disease (CAD), by providing an assessment of the coronary anatomy and visualization of atherosclerotic plaque to aid in detection of lesions that may limit blood flow to the myocardium.

However, there are multiple challenges in imaging coronary arteries with the use of CT. These arteries are small with a caliber approaching 1 mm or less at their most distal ends, and they exhibit complex 3D motion during the cardiac cycle, which contributes to motion artifacts during cardiac imaging.^{1,2} In addition, the limited temporal resolution of coronary CTA is insufficient to address these motion artifacts, resulting in non-evaluable coronary segments, which impacts diagnostic performance.

While motion artifacts are more pronounced and common at higher and variable heart rate (HR), they could also occur at lower HR as well. A common clinical practice to counter this is to administer medication to lower and stabilize the HR. Additionally, one technical approach is to increase the rotation speed of the gantry to improve the native temporal resolution of the system. However, this approach is not practical beyond a certain limit because of the severe gravitational forces imposed upon the system.

Despite improvements in patient management, native scanner temporal resolution and conventional reconstruction techniques, coronary artery motion artifacts remain a clinical challenge, and their occurrence is difficult to predict.

Philips CT Smart Workflow



Precise Cardiac is one of the many components of Philips AI-enabled CT Smart Workflow, which is used by clinicians every day to deliver precision in dose, speed and image quality.

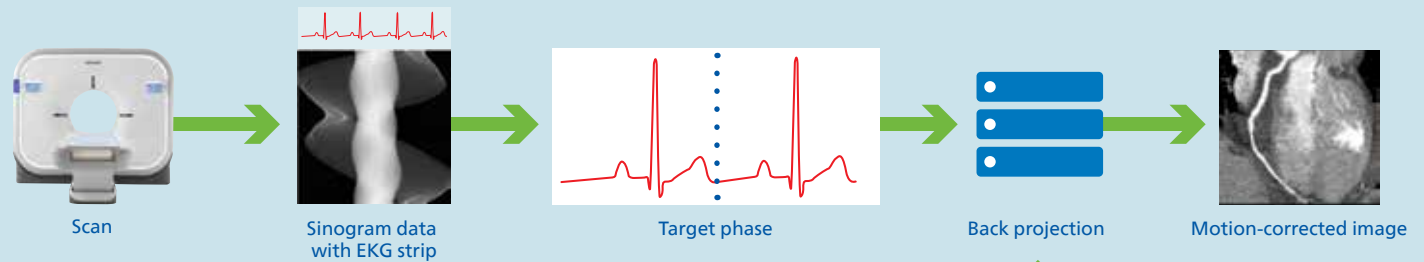
Precise Cardiac

As a technology innovation leader in cardiac imaging, Philips has introduced a novel reconstruction approach complementing adaptive reconstruction techniques. The motion-compensated reconstruction of Precise Cardiac offers a novel, zero-click technique generating a single series of motion-corrected images applicable to both modes of coronary CTA scans (retrospectively gated helical and prospectively gated axial [Step & Shoot Cardiac]).³⁻⁷

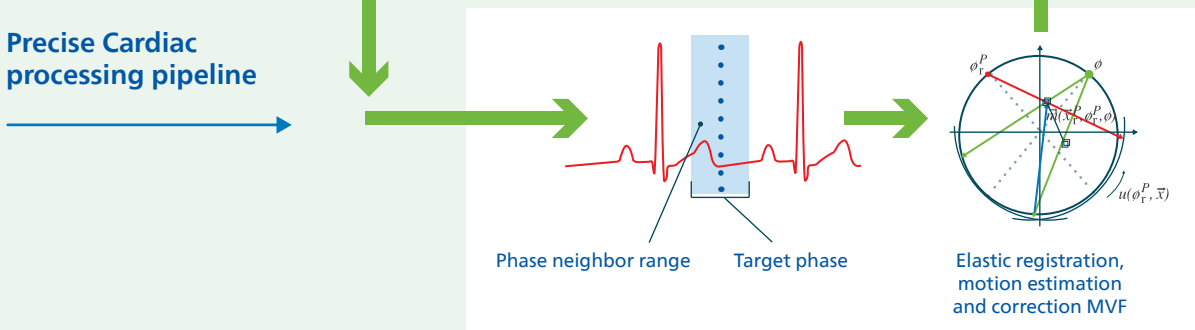
Precise Cardiac employs efficient filtering techniques in a predefined region around the targeted cardiac phase to identify relevant objects and dynamically track their motion behavior in the localized portion of the cardiac cycle. By taking into account the displacement of structures and performing the relevant corrections as part of the back-projection process, motion-corrected images are generated. Precise Cardiac is built into the CT console workflow, avoiding the need for any manual intervention, data transfer or additional workstations.

Precise Cardiac processing steps

Standard cardiac processing pipeline



Precise Cardiac processing pipeline



Motion vector field (MVF) describes the motion of the heart around a target phase

Figure 1 T The processing pipeline shows how Precise Cardiac corrects for cardiac motion to improve visualization in cardiac scans.



Independent evaluation

Phantom evaluation

A recent study³ evaluated the performance of Precise Cardiac in reducing CCTA motion artifacts by imaging a dynamic phantom at various velocities. This work found that:

- Precise Cardiac was shown to reduce motion artifacts, producing an image that is not significantly different than one with zero motion.
 - Precise Cardiac reduced coronary motion artifacts across a wide range of velocities commonly encountered in clinical practice.
 - An 11x reduction in motion artifacts was demonstrated on the Philips Spectral CT 7500 system. These experiments were repeated on a Philips CT 5300 system and a 6x reduction in motion artifacts was demonstrated.
 - Prior investigations have shown that the degree of motion artifact reduction (11x or 6x) is a surrogate for corresponding gains in effective temporal resolution, i.e., creating data as if scanned with a significantly better temporal resolution.
- The artifact reduction resulted in an 11x gain in effective temporal resolution for Spectral CT 7500, which would result in an effective temporal resolution of 12.3 ms.
 - The artifact reduction resulted in a 6x gain in effective temporal resolution for CT 5300, which would result in an effective temporal resolution of 29.2 ms.
 - Precise Cardiac may improve CCTA assessment by reducing coronary motion artifacts, especially in patients with elevated HR or who have contraindications to beta blockers and do not attain the targeted HR.

Clinical evaluation

A pilot study⁸ of 28 patients demonstrated the effectiveness of this approach in improving the quality of visualization of all coronary arteries, while maintaining the signal-to-noise ratio (SNR) and contrast-to-noise ratio (CNR).

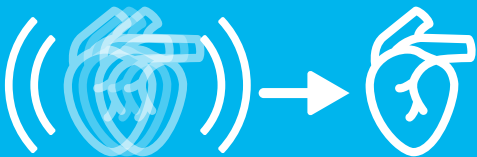
The mean HR of the patients during the scan was 86 ± 11 bpm (range: 68–114 bpm). The resulting visualization scores were higher with the use of motion-compensated reconstruction for all coronary artery segments compared to the routine gated reconstructions.



Offers 6–11x gain in effective temporal resolution



Improves coronary CTA assessment in patients by reducing coronary artery motion artifacts, especially those with elevated heart rates



Removes motion artifacts for rapidly moving coronaries, producing an image that is not significantly different than one with zero motion



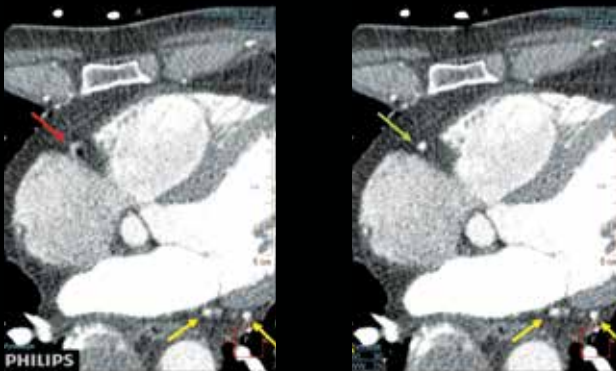
Performance

The use of Precise Cardiac demonstrates significant improvements in image quality of the coronary arteries, compared with standard cardiac reconstructions. Correcting for motion in the coronary arteries potentially saves a repeat scan for a patient.

Clinical image comparisons

Middle-aged patient admitted with chest pain and shortness of breath, average HR: 61 bpm

Philips Incisive CT



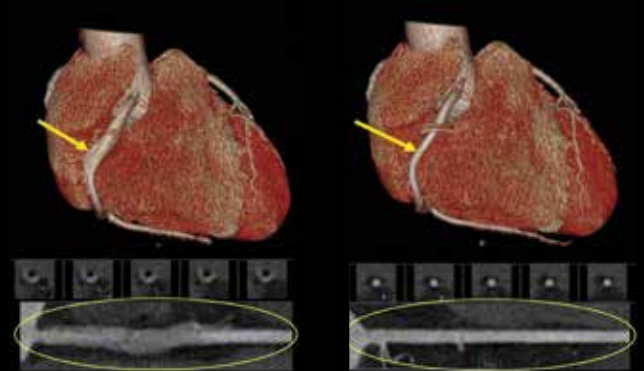
Without Precise Cardiac

With Precise Cardiac

Scan parameters – 120 kVp, 697 mAs, CTDI_{vol} 56.5 mGy, DLP 678 mGy* cm, effective dose 9.5 mSv (k=0.014)

Precise Cardiac eliminated motion observed in RCA, HR: 77 bpm

Philips Spectral CT 7500



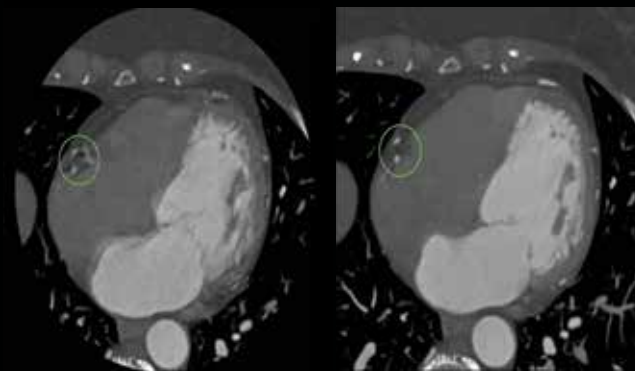
Without Precise Cardiac

With Precise Cardiac

Sample images acquired in a clinical study of the Spectral CT 7500 system at Tel Aviv Sourasky Medical Center (Ichilov), Israel.

Precise Cardiac eliminated motion observed in RCA, HR: 60 bpm

Philips CT 5300



Without Precise Cardiac

With Precise Cardiac

Scan parameters – 80 kVp, 893 mAs, CTDI_{vol} 20.73 mGy, DLP 369 mGy* cm, effective dose 5.1 mSv (k=0.014)



Conclusion

Philips Precise Cardiac is a novel technological innovation that compensates for cardiac motion to improve visualization of the coronary arteries during CT imaging. Precise Cardiac can help salvage some coronary segments previously deemed nondiagnostic using standard cardiac reconstructions, thus increasing the diagnostic confidence in coronary CTA exams.

References

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Results from case studies are not predictive of results in other cases. Results in other cases may vary.

