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Validation of routine high-resolution computed tomography scans against gated cardiac CT for the assessment of coronary artery calcification

1. Introduction

Coronary artery calcification (CAC) estimated with electrocardiography-gated cardiac computed tomography (Cardiac CT) is a marker of coronary plaque burden and a strong predictor of cardiovascular events. Studies have demonstrated the validity and prognostic value of CAC scoring also using non-gated CT scans.[1–3] Still, CAC is often not reported from clinical CT scans of the thorax despite recommendation from the Radiological Society of North America.[3]

High-resolution CT (HRCT) is a CT technique using a narrow collimation and a high spatial frequency reconstruction algorithm.[4] HRCT scans are sensitive in detection and characterization of diffuse lung disease. In patients with systemic sclerosis, HRCT scans are routinely performed due to a high risk of interstitial lung disease. No studies have evaluated the applicability of HRCT for the assessment of CAC scores. We aimed to validate the use of routinely performed HRCT scans in the detection of CAC.

2. Methods

2.1. Patients

This cross-sectional study included 43 patients with systemic sclerosis (27 females, mean age 62 years (SD: 7.6)), who had undergone HRCT as well as Cardiac CT within 18 months between January 2012 and December 2022 (median time between scans 4.2 months (IQR: 2.0–9.0)).

2.2. Data sources

HRCT and Cardiac CT scans were collected from regional archiving systems. HRCT scans were stored in the original slice thickness (0.68–1.00 mm) and in a reconstructed slice thickness of 3 mm. ECG-gated Cardiac CT images were stored in the original slice thickness of 3 mm.

2.3. CAC scoring

HRCT scans were analyzed with original (range 0.68–1.00 mm) and 3 mm slice thicknesses by two readers (FE and EN). Cardiac CTs were analyzed randomly by one of two readers (FE and EN).

The CAC score was assessed with dedicated software (VitreaCore 6.5.1, Canon Medical Systems Corporation) in two ways; (I) a simple visual scoring method ranging from no calcium over minimal and moderate to heavy calcium burden,[2] and (II) calculation of the continuous CAC score according to the Agatston method.[5] In agreement with Chiles et al.,[2] the CAC scores were divided into four categories: 0, 1–99, 100–999, and ≥1000.

2.4. Statistical analysis

For the simple visual score and Agatston CAC categories, weighted Kappa coefficients (κ) with standard error (SE) were calculated. Agatston CAC scores measured using the HRCT scans and Cardiac CTs were compared using Bland-Altman plots. The statistical comparison between modalities was made using intraclass correlation coefficients (ICC) (two-way random effects).

3. Results

3.1. CAC score using HRCT

The correlations between the simple visual scores assessed by HRCT and Cardiac CT were generally strong (κ between 0.63 (SE: 0.11) and 0.77 (SE: 0.11)). When comparing the simple visual scores by HRCT and Cardiac CT, a maximum of 11 (1 mm images) and 14 (3 mm images) patients moved up at least one CAC category compared to the corresponding CAC score on Cardiac CT. However, only one patient changed more than one category.

The mean differences between the CAC scores assessed on the 1 mm HRCT scan and the corresponding Cardiac CT were 172 (95 % LOA: −507, 850) and 163 (95 % LOA: −584, 910) for reader 1 and 2, respectively (Fig. 1). When comparing Cardiac CT with the 3 mm HRCT scan, the mean differences were 104 (95 % LOA: −374, 581) and 112 (95 % LOA: −399, 623), respectively (Fig. 1). Eight patients were reclassified using 1 mm images, while 9–10 were reclassified using 3 mm images. No patients changed more than one category. The corresponding weighted κ when comparing categorical Agatston categories ranged from 0.82 (SE: 0.10) - 0.83 (SE: 0.10) (1 mm images) and 0.78 (SE: 0.11) - 0.81 (SE: 0.11) (3 mm images).

4. Discussion

This study is the first to evaluate CAC scoring using HRCT scans. Overall, we observed a high degree of agreement between the CAC score and the simple visual scores when comparing non-gated HRCT and gated Cardiac CT.

In agreement with previous studies using non-gated CT scans, HRCT systemically overestimated CAC compared to Cardiac CT.[1] Compared to these studies, we observed a higher variance using HRCT. This might be

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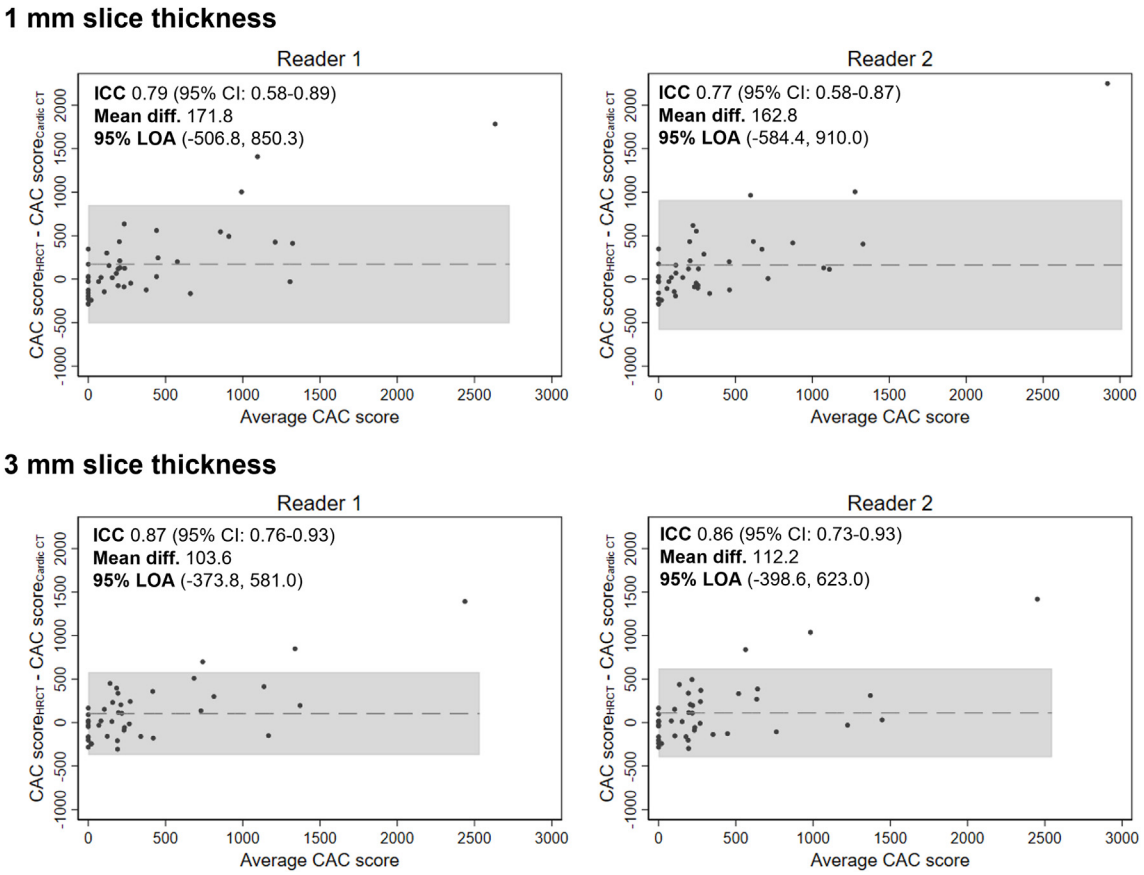

Fig. 1. Bland-Altman plots vizualising the agreement of CAC scores assessed on HRCT scans with 1 mm and 3 mm slice thickness and Cardiac CT.

attributable to the thinner slice thickness and sharp reconstruction kernel, potentially leading to the generation of artifacts and a decreased imaging quality. In agreement, reconstructed 3 mm HRCT scans were slightly more accurate than the 1 mm HRCT scans. Secondly, the time delay between the two scans could in some cases have led to a progression of CAC in between scans, which would impact the correlations. Lastly, the limited study size is a limitation.

4.1. Conclusion

CAC scoring based on HRCT shows good agreement with CAC based on Cardiac CT. Hence, HRCT could be useful in terms of opportunistic screening for subclinical CAD which may impact clinical management.

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Declaration of competing interest

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The other authors have no conflicts of interest to disclose.

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