The Importance of Spatial Resolution for High-quality Cardiac CT Exams

By Vincent Norlock, Global Product Manager, and Jiahua Fan, PhD, Senior Scientist

Spatial resolution is important to the diagnostic quality of a cardiac CT exam because it directly translates to accurate, clear images—giving the physician the data to help correctly establish the extent of coronary artery disease (CAD) in those who have it, while clearing those without it.

Accuracy of CTA

Clinical trials have demonstrated that CCTA is a highly-accurate means of excluding coronary artery stenosis and that Coronary CT angiography (CCTA) is more likely to aid in the detection of CAD and less likely to overestimate its extent than some other testing modalities.

Challenges to more accurate CCTA reading

Accurate estimation of CAD is challenged by the presence of coronary calcium, stents, moderate-to-severe stenosis, and the visualization of bypass grafts.

Calcium

A highly calcified coronary stenosis can cause a “blooming” effect in CT images. The blooming appears to expand the boundaries of the stenosis into the surrounding voxels, increasing the apparent size of the blockage. A 2009 study using earlier, standard definition CT at Karolinska University Hospital specifically called out the limitation on PPV caused by vessel calcification. The study found that the “poor” image quality segments were the result of calcification and it was the main reason for poor image quality in the LAD.

Images comparing earlier generations of CT to the Discovery® CT750 HD demonstrate that high resolution scanning reduces the blooming effect from calcium and aids in clearer visualization of the vessel lumen (Figure 1). This helps to overcome the appearance of increased severity in lesions with highly calcified plaque.
Intracoronary stents

The introduction of coronary stents provided a reliable means of combating the effects of CAD. However, the artifacts potentially induced in the CT image by the stent may enlarge the stent boundaries and thereby increase the apparent visual size of the stenosis.

A study at Cornell University\(^2\) compared an earlier generation CT system to the Discovery CT750 HD. This study reported that the Discovery CT750 HD not only delivered impressive lumen area visualization, but also lower image noise. Both of these factors are important for the physician to accurately assess the extent of in-stent restenosis.

Moderate-to-severe stenosis

The cited studies show that agreement with invasive angiography decreases with moderate-to-severe stenosis. Previously, overestimation of the appearance of the severity decreased the specificity, especially in smaller vessels.\(^3\)

The Discovery CT750 HD has the ability to accurately image vessels as small as 1 mm and provide the clinical reader with reliable information when diagnosing stenosis in the distal vessels.

Bypass grafts

The position and variation of coronary bypass grafts can add to the challenges listed above. The Discovery CT750 HD delivers clear images for accurate assessment of coronary anatomy and bypass graft conditions in a single scan. The high resolution cardiac scan modes allow for sharp visualization of both grafts and coronaries.
Comparing CT models

In 2010, the UK's National Health Service's ImPACT group published a report, *Market review: Advanced CT scanners for coronary angiography*. The ImPACT group gave each CT manufacturer requests for specific spatial resolution measurements along with instructions on how they were to be acquired. Each company then provided the ImPACT group at the NHS with results obtained from their own in-house testing.

While not participating in this ImPACT report, GE made the same measurements on the Discovery CT750 HD systems. A comparison of these results is shown in Table 1A and Table 1B.

The data show Discovery CT750 HD has the ability to resolve 18.2 lp/cm in the z-direction, allowing fine cardiac details to be seen. This high resolution is driven by the properties of the GE Gemstone detector and dynamic deflection of the X-ray beam. When used in combination with GE’s ASiR noise reduction technology, the Discovery CT750 HD delivers high definition cardiac scanning at optimized dose and noise performance.

Spatial resolution is not merely helpful in cardiac CT; it provides critical diagnostic assessments. The data show the Discovery CT750 HD has the highest cardiac spatial resolution of commercially available CT scanners. The Discovery CT750 HD allows clinicians to visualize vessels as small as 1 mm and, in some cases with ASiR less than 1 mSv, in one exam they can count on.

### Comparison of specificity and sensitivity in cardiac imaging

#### Table 1A

<table>
<thead>
<tr>
<th>Scan plane (x-y) spatial resolution, manufacturers specification [lp/cm]</th>
<th>Philips Brilliance™ iCT</th>
<th>Siemens SOMATOM Definition Flash™</th>
<th>Toshiba Aquilion™ ONE</th>
<th>GE Discovery CT750 HD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reconstruction filter</td>
<td>CA</td>
<td>CB</td>
<td>CC</td>
<td>CD</td>
</tr>
<tr>
<td>50% MTF</td>
<td>3.1</td>
<td>3.4</td>
<td>4.4</td>
<td>4.8</td>
</tr>
<tr>
<td>10% MTF</td>
<td>5.3</td>
<td>6.3</td>
<td>7.0</td>
<td>8.5</td>
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<tr>
<td>2% MTF</td>
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<td>8.0</td>
<td>8.5</td>
<td>10.5</td>
</tr>
</tbody>
</table>

*Off-center resolution (125 mm):*  
CA−0.95; CB&CC−0.9; CD−0.8  
Data not available  

#### Table 1B

<table>
<thead>
<tr>
<th>Longitudinal (z) spatial resolution, manufacturer’s specification [lp/cm]</th>
<th>GE Discovery CT750 HD</th>
</tr>
</thead>
<tbody>
<tr>
<td>50% MTF</td>
<td>6.8</td>
</tr>
<tr>
<td>10% MTF</td>
<td>13.7</td>
</tr>
<tr>
<td>2% MTF</td>
<td>18.2</td>
</tr>
</tbody>
</table>

**Source:** Table 1A. Market review: Advanced CT scanners for coronary angiography, CEPI0043 March 2010. Table 1B. GE Healthcare.

### References


3. Diagnostic Performance of 64-Multidetector Row Coronary Computed Tomographic Angiography for Evaluation of Coronary Artery Stenosis in Individuals Without Known Coronary Artery Disease: Results From the Prospective Multicenter ACCURACY Trial, *Journal of the American College of Cardiology* Volume 52, Issue 21, 18 November 2008, Pages 1724-1732

How did GE make these measurements?

Using the ImPACT assessment guidelines, GE Engineer Priti Madhav created a testing protocol for Discovery CT750 HD. Together with Alyssa Nowak, CT Product Development Specialist, the in-plane and longitudinal resolution of both axial and helical cardiac scans was evaluated.

In-plane (x-y) measurements were made with a GEPP phantom. Longitudinal (z) measurements in cardiac axial mode were made using a slope 4-wire phantom while a gold foil phantom was used for cardiac helical measurements.

These measurements not only characterize the spatial resolution of the CT hardware but also the image reconstruction kernels used. In our tests, we measured only those kernels normally used for cardiac scanning.