Introduction
Noninvasive assessment of in-stent restenosis (ISR) by multidetector computed tomography coronary angiography (CTA) has been applied in clinical studies. However, diagnostic performance is hampered by some non-evaluable stented segments and a relatively low positive predictive value. Kumbhari DJ et al. reported meta-analysis about diagnostic efficacy of 64-row CTA on ISR.(1) According to his report, when unassessable segments were included, overall specificity, sensitivity, positive predictive value (PPV) and negative predictive value (NPV) were 87%, 84%, 53%, and 97%, respectively. Although 320-row CTA may improve the diagnostic accuracy of ISR, there have been few prospective studies to investigate it in comparison with invasive coronary angiography (ICA)(2).

The aim of this study was to evaluate the diagnostic accuracy of 320-row CTA for ISR in comparison to ICA.

Methods
Study Population
Between October 2009 and May 2010, 238 patients with 278 lesions underwent percutaneous coronary intervention (PCI) with at least one stent at our institution. At 8 months, 211 patients were scheduled for the follow-up ICA in the present study. The study population consisted of the patients who agreed to undergo 320-row CTA within 35 days prior to the planned ICA.

Image Acquisition
320-row MDCT
Patients underwent 320-row CT scanning with a slice thickness of 0.5 mm and gantry rotation of 350 msec (Aquilion ONE, Toshiba Medical Systems, Otawaara, Japan). Tube voltage was set at 120 KV and tube modulation was 400 mA for all participants. Contrast media (0.07 ml/sec, 370 mg I/ml (Bayer HealthCare, Osaka, Japan) was administered at a flow rate of 4.0 to 5.0 ml/sec. The 320-row CTA was performed end-diastolic prospective scanning with an ECG-gated window of 85%-89% phase of the R-R interval. In patients with heart rate ≤ 65 bpm, single heartbeat was used for image acquisition to allow adaptive half scan and with heart rate > 65 bpm, two or three heartbeats were used for image acquisition to allow adaptive multisegment image reconstruction to be applied for improved temporal resolution.

CT image reconstruction and coronary artery analysis.
The image data sets were reconstructed by using two types of image sets (FC05 and FC04) kernel. The image data were reconstructed using curved planar reconstruction (MPR) and cross sectional image. CTA images were read by consensus of two observers blinded to the ICA results.

Stented coronary segments were visually assessed. Significant in-stent and in-segment stenosis were defined as lesions ≥ 50% minimal luminal diameter reduction on CTA.

ICA procedure and coronary artery analysis.
ICA was performed according to standard techniques.

A cardiologist blinded to the CTA results evaluated ICA. Three coronary segments (in-stent, proximal edge, and distal edge segment) were analyzed by quantitative coronary angiography (CMS version 6.0, Medis Medical Imaging Systems, Leiden, The Netherlands). The proximal and distal edge segments included up to 5 mm on either side of the in-stent segment. Binary in-stent restenosis was defined as stenosis of more than 50% of the reference diameter in the segment.

Table 1. Lesion and Stent Characteristics

<table>
<thead>
<tr>
<th>Segment</th>
<th>n (%)</th>
<th>Stent diameter, mm</th>
<th>Cell shape</th>
<th>Closed cell, n (%)</th>
<th>Open cell, n (%)</th>
<th>Strut thickness</th>
<th>Thin strut &lt;100%, n (%)</th>
<th>Thin strut &gt;100%, n (%)</th>
<th>Stent diameter, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCA</td>
<td>24 (34.8)</td>
<td>29 (42.0)</td>
<td>66 (70.2)</td>
<td>28 (28.3)</td>
<td>35 (37.2)</td>
<td>18 (17.1)</td>
<td>66 (70.2)</td>
<td>28 (29.8)</td>
<td>28 (28.3)</td>
</tr>
<tr>
<td>LM</td>
<td>8 (11.6)</td>
<td>28 (28.3)</td>
<td>35 (37.2)</td>
<td>18 (17.1)</td>
<td>66 (70.2)</td>
<td>28 (28.3)</td>
<td>66 (70.2)</td>
<td>28 (28.3)</td>
<td>28 (28.3)</td>
</tr>
<tr>
<td>LCX</td>
<td>8 (11.6)</td>
<td>28 (28.3)</td>
<td>35 (37.2)</td>
<td>18 (17.1)</td>
<td>66 (70.2)</td>
<td>28 (28.3)</td>
<td>66 (70.2)</td>
<td>28 (28.3)</td>
<td>28 (28.3)</td>
</tr>
</tbody>
</table>

Results
Of the 211 patients, 53 patients (49 [92.5%] men, age 63.8 ± 12 years old, BMI 25.0 ± 3.9 kg/m²) with 69 stented segments were enrolled in this study. During CTA acquisition (mean scan time was 1.6 ± 0.6 sec), the heart rate averaged 57 ± 9 bpm. The total amount of contrast agent was 48.7 ± 8.8 ml. The patients were exposed to mean radiation dose of 10.6 ± 5.4 mSv. The mean interval between CTA and ICA was 17.9 ± 9.3 days.

Figure 1. ISR case

Figure 2. Small stent diameter (<3.3mm)

(A) (B) MPR shows implanted Vision ® stent (3.5mm × 18mm × 2); (C) Cross sectional image of severe stenosis in stent proximal edge to proximal in-stent lesion; (D) Cross sectional image of severe stenosis in mid-distal in-stent lesion; (E) Cross sectional image of non-obstructed stent in distal in-stent lesion; (F) An ICA of the left coronary artery.

Figure 3. Xience® stent
Stent strut of Xience ® stent is less than 100μm.

(A) MPR image of the long axis. Stent diameter is 3.5 mm. (B) Cross sectional image of stent (diameter 3.5mm) (C) MPR image of the long axis. Stent diameter is 3.0 (proximal) to 2.5 (distal) mm. (C-1) Cross sectional image of stent (diameter 3.0mm) (C-2) Cross sectional image of stent (diameter 2.5mm)

Table 2. Validation of 320-row CTA compared with ICA for in-stent restenosis

<table>
<thead>
<tr>
<th>In-stent restenosis</th>
<th>n (%)</th>
<th>PPV</th>
<th>NPV</th>
<th>Diagnostic accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>9/100 (98.3, 95.1-98.9)</td>
<td>52/53 (98.1, 90.8-98.1)</td>
<td>52/53 (98.1, 90.8-98.1)</td>
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<tr>
<td>Specificity</td>
<td>59/60 (98.3, 95.1-98.9)</td>
<td>52/53 (98.1, 90.8-98.1)</td>
<td>52/53 (98.1, 90.8-98.1)</td>
<td></td>
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<tr>
<td>PPV</td>
<td>9/10 (90.0, 70.5-90.0)</td>
<td>9/10 (90.0, 70.5-90.0)</td>
<td>9/10 (90.0, 70.5-90.0)</td>
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<tr>
<td>NPV</td>
<td>59/59 (99.0, 67.7-100)</td>
<td>43/43 (90.0, 67.7-100)</td>
<td>43/43 (90.0, 67.7-100)</td>
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<tr>
<td>Diagnostic accuracy</td>
<td>68/69 (96.6, 93.9-98.6)</td>
<td>52/53 (98.1, 90.8-98.1)</td>
<td>52/53 (98.1, 90.8-98.1)</td>
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</table>

Conclusion
When classifying the unassessable segment as ISR on a patients basis, sensitivity, specificity, PPV and NPV were 100%, 97.7%, 90.0%, and 100%, respectively. The results of this study were better than the result of 64-row CTA (1). Overall our results show an improvement in diagnostic performance to detect ISR by the new generation of 320-row CTA.

The 320-row CTA has a good diagnostic accuracy for ISR in comparison to ICA.

References

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Diagnostic accuracy of 320-row coronary CT angiography in the assessment of coronary in-stent restenosis

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