# Predictors of Restenosis After Placement of Drug-Eluting Stents in One or More Coronary Arteries

Cheol Whan Lee, MD, Duk-Woo Park, MD, Bong-Ki Lee, MD, Young-Hak Kim, MD,
Myeong-Ki Hong, MD, Jae-Joong Kim, MD, PhD, Seong-Wook Park, MD, PhD,
and Seung-Jung Park, MD, PhD*

Although drug-eluting stents (DESs) have been increasingly used in a wide variety of clinical and anatomic situations, limited data are available regarding the predictors of DES failure in unselected lesions. We investigated the incidence and predictors of restenosis after implantation of DESs in routine clinical practice. A total of 1,795 consecutive patients underwent successful implantation of sirolimus-eluting (1,374 patients, 1,788 lesions) or paclitaxel-eluting (421 patients, 517 lesions) stents. Of the 1,743 eligible patients (2,221 lesions), follow-up angiography at 6 months was obtained for 1,228 patients (70.5%, 1,577 lesions). All data were prospectively recorded and analyzed to predict the occurrence of restenosis, defined as a diameter stenosis of ≥50%. Restenosis was documented in 125 patients with 138 lesions (8.8%), and target lesion revascularization was required in 70 patients with 82 lesions (5.2%). The pattern of restenosis was 85 focal (62%), 29 diffuse (21%), 11 diffuse proliferative (8%), and 13 total (9%). Lesion length, stent length, postintervention minimal lumen diameter, preintervention minimal lumen diameter, reference artery size, complex lesions, and use of a paclitaxel-eluting stent were univariate predictors of restenosis. Multivariate analysis showed that the use of a paclitaxel-eluting stent (odds ratio [OR] 4.37, 95% confidence interval [CI] 2.90 to 6.58, p <0.001), postintervention minimal lumen diameter (OR 0.32, 95% CI 0.20 to 0.50, p <0.001), and lesion length (OR 1.02, 95% CI 1.01 to 1.04, p <0.001) were independent predictors of restenosis. In conclusion, the rate of restenosis after DES implantation in routine clinical practice was similar to the rate reported in clinical trials, confirming the efficacy of DES in routine clinical practice.   © 2006 Elsevier Inc. All rights reserved. (Am J Cardiol 2006;97:506–511)

Drug-eluting stents (DESs) have been shown to reduce the risk of restenosis compared with bare metal stents.[1–4] Recently, the use of DESs has grown exponentially in a wide variety of clinical and anatomic situations. Neointimal hyperplasia is strongly inhibited by DESs,[5] but restenosis is still an important clinical problem. Several randomized trials have shown that diabetes, small vessel size, and long lesions may increase the risk of restenosis after DES implantation.[2,3,6] These studies, however, enrolled only patients who fulfilled strict inclusion criteria. Thus, little information is available about the potential predictors of DES failure in unselected lesions.[7,8] We, therefore, determined the incidence of restenosis after DES implantation in a large number of unselected patients in routine clinical practice and sought to identify the predictors of restenosis in this patient cohort.

## Methods

**Study patients:** Between February 2003 and November 2004, a total of 1,795 consecutive patients underwent successful implantation of sirolimus-eluting (1,374 patients, 1,788 lesions) or paclitaxel-eluting (421 patients, 517 lesions) stents at our institution. Angiographic follow-up at 6 months (or earlier in the case of symptoms) was routine in all patients. Patients excluded from angiographic follow-up were those who experienced any major adverse cardiac event during the first 30 days after the procedure, including death, myocardial infarction, or repeat revascularization (4 patients); patients with medical conditions contraindicating angiographic follow-up, including those with severe stroke (2 patients), end-stage renal disease on hemodialysis (28 patients), severe allergic reactions to contrast (4 patients), and severe concomitant diseases (4 patients); and patients >85 years old (10 patients).

**Stenting procedure:** A Cypher stent (Cordis, Miami Lakes, Florida) or Taxus stent (Boston Scientific, Natick,
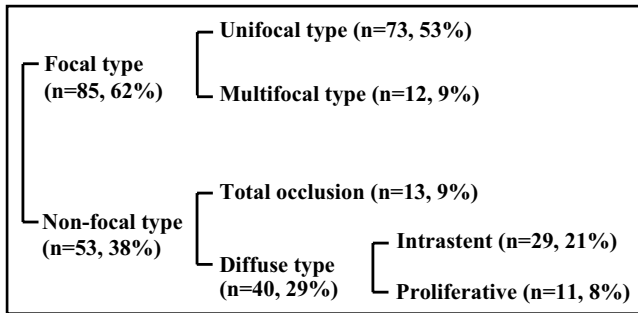
Figure 1. Schematic presentation of 138 restenotic lesions according to angiographic pattern.

Table 1
Clinical characteristics

| Characteristic | Restenosis | | p Value |
| --- | --- | --- | --- |
| | Yes (n = 125) | No (n = 1,103) | |
| No. of coronary lesions | 138 | 1,439 | |
| Age (yrs) | 59.2 ± 10.5 | 59.0 ± 9.5 | 0.811 |
| Men | 95 (68.8%) | 1,047 (72.8%) | 0.325 |
| Current smoker | 44 (33.1%) | 456 (32.3%) | 0.857 |
| Diabetes mellitus | 34 (24.8%) | 384 (26.8%) | 0.613 |
| Total serum cholesterol (≥200 mg/dl) | 20 (21.7%) | 230 (24.2%) | 0.596 |
| Hypertension | 66 (48.2%) | 721 (50.3%) | 0.627 |
| Clinical presentation | | | 0.819 |
| Stable angina pectoris | 74 (53.6%) | 732 (50.9%) | |
| Unstable angina pectoris | 49 (35.5%) | 532 (37.0%) | |
| Acute myocardial infarction | 15 (10.9%) | 173 (12.0%) | |
| Previous myocardial infarction | 17 (12.4%) | 128 (8.9%) | 0.178 |
| Previous percutaneous coronary intervention | 28 (20.3%) | 282 (19.6%) | 0.845 |
| Previous coronary bypass surgery | 4 (2.9%) | 31 (2.2%) | 0.571 |
| Multivessel coronary disease | 98 (71.5%) | 960 (66.7%) | 0.251 |

Table 2
Angiographic and procedural characteristics

| Characteristic | Restenosis | | p Value |
| --- | --- | --- | --- |
| | Yes (n = 125) | No (n = 1,103) | |
| No. of coronary lesions | 138 | 1,439 | |
| Lesion characteristics | | | |
| Target coronary vessel | | | 0.448 |
| Left anterior descending | 75 (54.7%) | 706 (49.2%) | |
| Left circumflex artery | 15 (10.9%) | 228 (15.0%) | |
| Right coronary artery | 38 (27.7%) | 376 (26.2%) | |
| Left main | 7 (5.1%) | 120 (8.4%) | |
| Saphenous vein graft | 1 (0.01%) | 3 (0.002%) | 0.782 |
| Internal mammary artery | 1 (0.01%) | 2 (0.001%) | 0.678 |
| Lesion length | 31.2 ± 15.4 | 24.8 ± 14.2 | <0.001 |
| Type B2/C lesions | 119 (88.1%) | 984 (72.8%) | <0.001 |
| Chronic total occlusion | 13 (9.5%) | 85 (5.9%) | 0.098 |
| Ostial lesion | 4 (3.0%) | 84 (6.0%) | 0.238 |
| Bifurcation | 26 (19.0%) | 275 (19.1%) | 0.964 |
| In-stent restenosis | 11 (8.1%) | 124 (8.6%) | 0.831 |
| Procedural characteristics | | | |
| Balloon/artery ratio | 1.26 ± 0.16 | 1.23 ± 0.17 | 0.087 |
| Maximal inflation pressure (atm) | 14.0 ± 2.83 | 10.0 ± 4.0 | 0.316 |
| Stents per lesion | 1.7 ± 0.8 | 1.4 ± 0.6 | <0.001 |
| Stent length per lesion (mm) | 40.7 ± 23.5 | 31.6 ± 17.2 | <0.001 |
| Cypher stent | 72 (5.8%) | 1174 (95.2%) | <0.001 |
| Taxus stent | 66 (19.9%) | 265 (80.1%) | <0.001 |
| Quantitative coronary angiography | | | |
| Lesion length (mm) | 31.2 ± 15.4 | 24.8 ± 14.2 | <0.001 |
| Reference vessel diameter (mm) | 2.75 ± 0.46 | 2.93 ± 0.51 | <0.001 |
| Preintervention | | | |
| Minimal lumen diameter (mm) | 0.80 ± 0.54 | 0.96 ± 0.57 | 0.002 |
| Diameter stenosis (%) | 70.4 ± 19.1 | 67.1 ± 17.6 | 0.038 |
| Postintervention | | | |
| Minimal lumen diameter (mm) | 2.59 ± 0.47 | 2.85 ± 0.47 | <0.001 |
| Diameter stenosis (%) | 4.1 ± 15.4 | 1.8 ± 12.8 | 0.100 |
| Acute gain (mm) | 1.78 ± 0.59 | 1.89 ± 0.57 | 0.027 |
| Intravascular ultrasound guidance | 95 (69.3%) | 1077 (75.0%) | 0.147 |

Massachusetts) was used in all patients. Stent implantation was performed according to standard techniques, and the operator selected the stents. Complete lesion coverage was recommended, as well as angiographic optimization, with <20% residual stenosis by visual estimate. During the procedure, patients received a bolus of 8,000 U heparin, with a repeat bolus of 2,000 U to maintain the activated clotting time at ≥300 seconds. All patients were pretreated with aspirin and clopidogrel. Aspirin (100 to 200 mg/day) was used indefinitely and clopidogrel (75 mg/day) for ≥6 months.

**Angiographic analysis:** All angiographic analysis was blindly performed by 2 experienced angiographers unaware of the study goal. The percentage of diameter stenosis, minimal lumen diameter, and reference diameter using an on-line quantitative angiographic analysis system (Xcelera Cath, version 1.1, Philips, Eindhoven, The Netherlands) were measured before predilatation, after the stenting procedure, and at followup. The angiographic measurements were made during diastole after intracoronary nitroglycerin administration using the guiding catheter to calibrate magnification. Single matched views with the worst diameter stenosis were compared.

**Definitions:** All demographic, clinical, angiographic, and procedural characteristics were prospectively entered into the Asan Medical Center angiographic database. Restenosis was defined by a diameter stenosis of ≥50% occurring in the segment inside the stent or 5-mm segment proximal or distal to the stent at follow-up angiography. Restenotic lesions were classified as focal (type I, <10 mm), diffuse (type II), proliferative (type III), or total (type IV) occlusion.[9] Late lumen loss was calculated as the difference between the minimal lumen diameter immediately after the procedure and that at 6 months.

**Statistical analysis:** Data are expressed as means ± SDs for continuous variables and as frequencies for the categor-
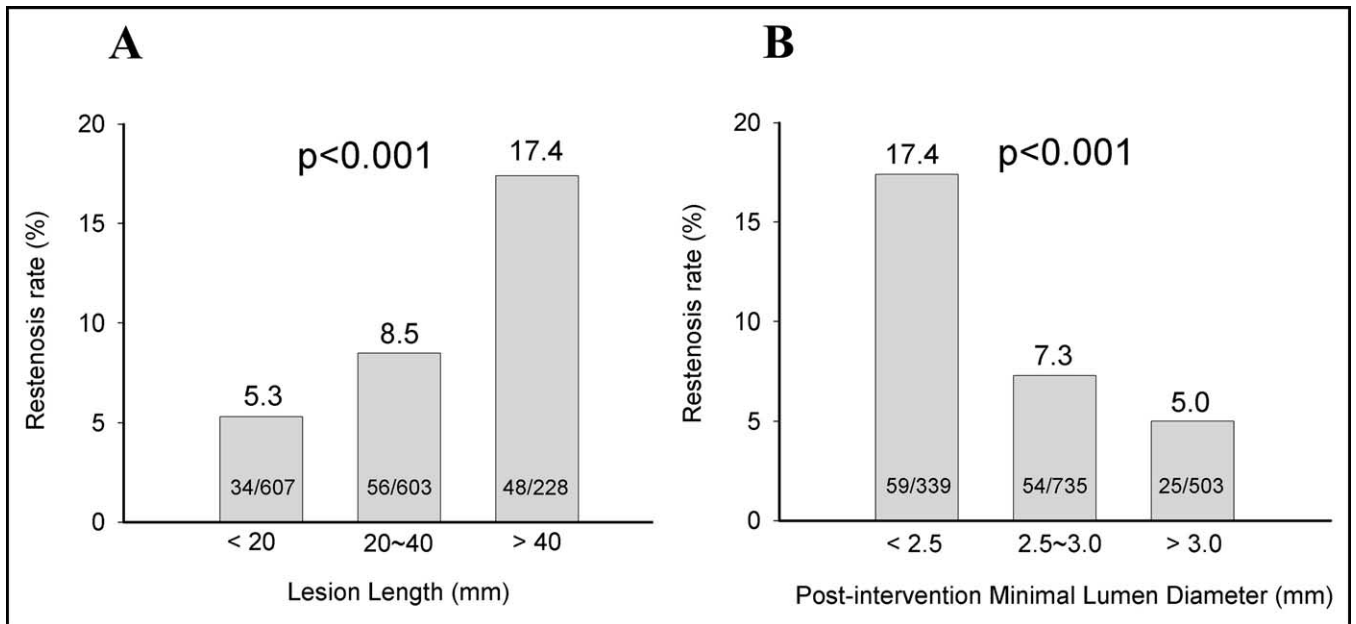
Figure 2. Effects of *(A)* lesion length (p <0.001) and *(B)* postintervention minimal lumen diameter (p <0.001) on restenosis rate.

ical variables. Continuous variables were compared by unpaired Student's *t* test and categorical variables by the chi-square test. Regression analysis was performed on all variables to identify the determinants of restenosis; variables that were significant on univariate analysis were entered into the multivariate analysis to determine their independent relation to restenosis. Statistical significance was defined as a 2-sided p value of <0.05.

## Results

We were able to perform angiographic follow-up on 1,228 (1,577 lesions) of the 1,743 (2,221 lesions) eligible patients who constituted the study population (follow-up rate 70.5%). The groups with and without follow-up angiography did not differ significantly with regard to clinical, lesion, or procedural characteristics (data not shown). However, the 515 patients without follow-up angiography were older, had a higher percentage of women, and had a lower ejection fraction than the 1,228 patients in whom follow-up angiography was performed.

**Restenosis patterns:** Restenosis was angiographically documented in 125 patients with 138 lesions (8.8%, in-stent 7.5%, in-segment 8.8%). Target lesion revascularization was required in 70 patients with 82 lesions (5.7%). Focal restenosis occurred in 85 (62%), diffuse in 29 (21%), diffuse proliferative in 11 (8%), and total restenosis in 13 (9%) patients (Figure 1). The nonfocal restenosis group had a higher incidence of complex lesions (93% vs 81%, respectively, p = 0.036), lower incidence of the use of intravascular ultrasonography (59% vs 76%, p = 0.029), higher incidence of the use of Taxus stents (62% vs 39%, p = 0.007), and smaller postintervention minimal lumen diam-

eter (2.46 ± 0.41 vs 2.68 ± 0.50, p = 0.006) compared with the focal restenosis group.

**Univariate predictors:** The baseline clinical characteristics were similar in the group in whom restenosis was documented and the group without restenosis (Table 1). Diabetes was also not a significant predictor of restenosis. When we compared the angiographic and procedural data (Table 2), the restenosis group had longer lesion and stent lengths, a smaller postintervention minimal lumen diameter, a smaller reference artery size, and more complex lesions than did the group with no restenosis. A significant correlation was found between the restenosis rate and lesion length, and a significant inverse correlation was found between the restenosis rate and postintervention minimal lumen diameter (Figure 2). Restenosis was more common in patients treated with Taxus stents than in those treated with Cypher stents (19.9% vs 5.8%, respectively; p <0.001). Late loss was also significantly higher in the Taxus stent group than in the Cypher stent group (0.70 ± 0.68 mm vs 0.28 ± 0.57 mm, respectively, p <0.001; Figure 3). No significant differences were found between the 2 DES groups in the baseline characteristics, except for age, lesion location, maximal inflation pressure, stents per lesion, and postintervention minimal lumen diameter (Table 3).

The univariate predictors of restenosis included complex lesions, lesion length, total stent length, number of stents per lesion, use of Taxus stents, reference vessel diameter, preintervention minimal lumen diameter, preintervention diameter stenosis, postintervention minimal lumen diameter, and acute gain (Table 4).

**Multivariate analysis:** On multivariate analysis, however, the use of Taxus stents, postintervention minimal lumen diameter, and lesion length were significant indepen-
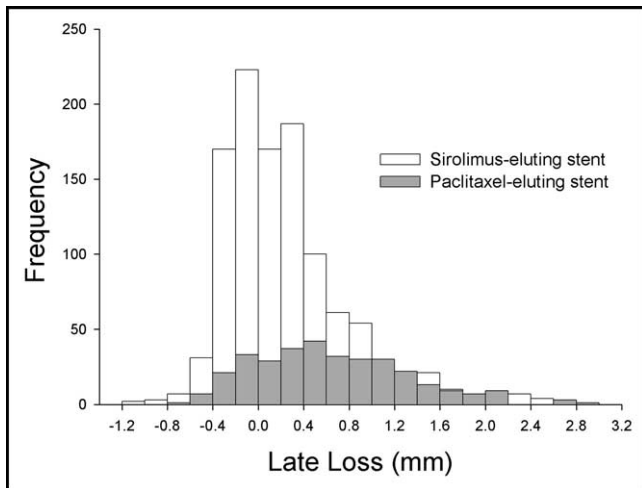
Figure 3. Frequency distribution of late loss values for Cypher and Taxus stents.

Table 3
Cypher stent versus Taxus stent

| Characteristic | Cypher (n = 1,374) | Taxus (n = 421) | p Value |
|---|---|---|---|
| No. of coronary lesions | 1,788 | 517 | |
| Age (yrs) | 60.3 ± 10.5 | 61.7 ± 10.5 | 0.016 |
| Men | 978 (71.2%) | 299 (70.0%) | 0.950 |
| Current smoker | 417 (30.8%) | 134 (33.8%) | 0.245 |
| Diabetes mellitus | 377 (27.8%) | 120 (28.5%) | 0.779 |
| Hypercholesterolemia (≥200 mg/dl) | 186 (22.8%) | 55 (22.6%) | 0.951 |
| Hypertension | 706 (52.1%) | 230 (54.6%) | 0.357 |
| Clinical presentation | | | 0.316 |
| Stable angina pectoris | 729 (53.1%) | 205 (48.9%) | |
| Unstable angina pectoris | 482 (35.1%) | 162 (38.7%) | |
| Acute myocardial infarction | 162 (11.8%) | 52 (12.4%) | |
| Previous myocardial infarction | 127 (9.3%) | 43 (10.2%) | 0.554 |
| Previous percutaneous intervention | 302 (22.0%) | 85 (20.2%) | 0.435 |
| Lesion characteristics | | | |
| Target coronary vessel | | | <0.001 |
| Left anterior descending | 892 (50.2%) | 235 (45.5%) | |
| Left circumflex artery | 274 (15.4%) | 91 (17.6%) | |
| Right coronary artery | 431 (24.3%) | 181 (35.0%) | |
| Left main | 175 (9.9%) | 0 (0%) | |
| Saphenous vein graft | 2 (0.1%) | 6 (1.2%) | |
| Internal mammary artery | 2 (0.1%) | 4 (0.7%) | |
| Type B2/C lesions | 1,245 (74.5%) | 377 (73.1%) | 0.512 |
| Chronic total occlusion | 107 (6.0%) | 20 (3.9%) | 0.62 |
| Ostial lesion | 192 (10.7%) | 24 (4.7%) | <0.001 |
| Bifurcation | 339 (19.0%) | 59 (11.4%) | <0.001 |
| In-stent restenosis | 167 (9.4%) | 21 (4.1%) | <0.001 |
| Procedural characteristics | | | |
| Maximal inflation pressure (atm) | 16.62 ± 3.49 | 13.78 ± 3.90 | <0.001 |
| Stents per lesion | 1.39 ± 0.66 | 1.33 ± 0.58 | 0.047 |
| Stent length per lesion (mm) | 32.44 ± 18.00 | 31.65 ± 16.55 | 0.348 |
| Quantitative coronary angiography | | | |
| Lesion length (mm) | 25.20 ± 14.47 | 25.78 ± 13.32 | 0.432 |
| Reference vessel diameter (mm) | 2.91 ± 0.50 | 2.88 ± 0.49 | 0.220 |
| Preintervention | | | |
| Minimal lumen diameter (mm) | 0.94 ± 0.59 | 0.92 ± 0.49 | 0.474 |
| Diameter stenosis (%) | 67.66 ± 18.16 | 67.78 ± 15.81 | 0.880 |
| Postintervention | | | |
| Minimal lumen diameter (mm) | 2.83 ± 0.48 | 2.78 ± 0.46 | 0.037 |
| Diameter stenosis (%) | 1.76 ± 13.20 | 2.20 ± 13.86 | 0.517 |
| Acute gain (mm) | 1.89 ± 0.59 | 1.86 ± 0.56 | 0.327 |

dent predictors of restenosis. Of these, the postintervention minimal lumen diameter was a major predictor of restenosis after DES implantation, in that the predicted risk of restenosis decreased 68% for every 1-mm increase in postintervention minimal lumen diameter. In patients treated with Cypher stents, the lesion length (odds ratio [OR] 1.025, 95% confidence interval [CI] 1.005 to 1.046, p = 0.014) and postintervention minimal lumen diameter (OR 0.215, 95% CI 0.098 to 0.472, p <0.001) were significant predictors of restenosis. In patients implanted with Taxus stents, the lesion length (OR 1.022, 95% CI 1.001 to 1.043, p = 0.036) and postintervention minimal lumen diameter (OR 0.213, 95% CI 0.104 to 0.437, p <0.001) were also significant predictors of restenosis.

## Discussion

We have demonstrated that the rate of restenosis after DES implantation in routine clinical practice is similar to the restenosis rate reported in clinical trials. Our results have also indicated that sirolimus-eluting stents may be superior to paclitaxel-eluting stents for the treatment of unselected lesions and that the postintervention final lumen size is a major determinant of restenosis even in patients implanted with DESs. These results suggest that routine DES implantation is highly effective in routine clinical practice, providing a rationale for its use.

Restenosis has been the major limiting factor in coronary angioplasty. Many studies that sought to define factors predictive of restenosis have shown that the postintervention final lumen diameter is the most powerful predictor of restenosis after bare metal stenting.[10–12] In patients implanted with bare metal stents, an increased restenotic risk has been associated with smaller stent area. With DES, however, the relation between the postintervention final lumen size and restenosis in unselected patients has not been well defined. We have shown

that, in patients receiving DES implants, the postintervention final lumen size continues to be the most important determinant of restenosis, suggesting that a larger stent area contributes to a decreased rate of restenosis, even in patients implanted with DESs.[13,14] Lesion length and stent length also correlated weakly with restenosis, but stent length was not an independent predictor of restenosis. These results indicate that, for DESs, stent length has less influence on restenosis than it does with bare metal stents, supporting the current strategy of complete lesion coverage. Coronary artery disease is more

Table 4
Predictors of angiographic restenosis by logistic regression analysis

| Variable | Univariate Analysis | | | Multivariate Analysis | | |
|---|---|---|---|---|---|---|
| | OR | 95% CI | p Value | OR | 95% CI | p Value |
| Use of Taxus stent | 4.064 | 2.837–5.814 | <0.001 | 4.367 | 2.899–6.579 | <0.001 |
| Postintervention minimal lumen diameter | 0.294 | 0.197–0.441 | <0.001 | 0.319 | 0.202–0.503 | <0.001 |
| Lesion length | 1.026 | 1.015–1.038 | <0.001 | 1.023 | 1.010–1.035 | <0.001 |
| Total stent length | 1.025 | 1.014–1.032 | <0.001 | | | |
| Stent length >40 mm | 2.431 | 1.698–3.482 | <0.001 | | | |
| Stent per lesion | 1.190 | 1.039–1.364 | 0.012 | | | |
| Reference artery diameter | 0.442 | 0.297–0.658 | <0.001 | | | |
| Reference artery diameter <2.5 mm | 1.884 | 1.258–2.821 | 0.002 | | | |
| Preintervention minimal lumen diameter | 0.594 | 0.427–0.825 | 0.002 | | | |
| Preintervention diameter stenosis | 1.011 | 1.001–1.021 | 0.038 | | | |
| Acute gain | 0.702 | 0.513–0.961 | 0.027 | | | |
| Type B2/C lesions | 2.774 | 1.624–4.739 | <0.001 | | | |

aggressive in diabetic than in nondiabetic patients, and coronary revascularization procedures are associated with less favorable outcomes in diabetic patients. In randomized trials, sirolimus- and paclitaxel-eluting stents were shown to demonstrate durable clinical and angiographic benefits for diabetic patients, but it was unclear whether diabetes increased the risk of restenosis after DES implantation.[2,3,6] Our results have demonstrated that diabetes is not a predictor of restenosis after DES implantation, indicating that DESs significantly improve on the major limitations of bare metal stenting in diabetic patients. In-stent restenosis, which is secondary to neointimal hyperplasia, presents in different patterns. Focal in-stent restenosis was the most favorable pattern with respect to late outcome after repeat intervention.[9] Our study has shown that, similar to previous results with DESs,[2,3] in-stent restenosis occurred mostly as a focal pattern.

After sirolimus- and paclitaxel-eluting stents became commercially available, unrestricted use of DESs has occurred in clinical practice. Three, recent, separate head-to-head comparison trials of Cypher and Taxus stents have tended to favor the use of Cypher stents. In the Intracoronary Stenting or Angioplasty for Restenosis Reduction–Drug-Eluting Stents for In-Stent Restenosis (ISAR-DESIRE) trial, the 2 DES types were superior to balloon angioplasty, but the sirolimus-eluting Cypher stent demonstrated a higher potential benefit than did the paclitaxel-eluting Taxus stent.[15] The in-segment late lumen loss was 0.32 mm with the Cypher stents and 0.55 mm with the Taxus stents (p = 0.02); the target vessel revascularization rate also differed significantly (8% vs 19%, respectively, p = 0.02). In a head-to-head, multicenter, randomized study of these sirolimus- and paclitaxel-eluting stents, the binary restenosis rates at 8 months follow-up did not differ significantly (9.6% vs 11.1%, respectively, p = 0.31).[16] In a single-center comparison trial, however, when compared with the Taxus stent, the Cypher stent was associated with a reduction in late loss and lower angiographic restenosis (6.7% vs 11.9%, p = 0.02) and target lesion revascularization (4.8% vs 8.3%, p = 0.025) rates.[17] In our study, the use

of the Taxus stent was related to an increase in late loss and a higher risk of restenosis compared with the Cypher stent. Taken together, these results suggest that the 2 stent types are very effective, but the Cypher stent has a somewhat higher benefit in terms of the restenosis rate.

Our study had several potential limitations. First, the choice of the DES was left to the physician, leading to possible selection bias. Second, our study was limited by incomplete angiographic follow-up, thus possibly leading to a potential error for the restenosis rate.

1. Morice MC, Serruys PW, Sousa JE, Fajadet J, Hayashi EB, Perin M, Colombo A, Schuler G, Barragan P, Guagliumi G, Molnàr F, Falotico R, for the RAVEL Study Group. A randomized comparison of a sirolimus-eluting stent with a standard stent for coronary revascularization. *N Engl J Med* 2002;346:1773–1780.

2. Moses JW, Leon MB, Popma JJ, Fitzgerald PJ, Holmes DR, O'Shaughnessy C, Caputo RP, Kereiakes DJ, Williams DO, Teirstein PS, Jaeger JL, Kuntz RE, for the SIRIUS Investigators. Sirolimus-eluting stents versus standard stents in patients with stenosis in a native coronary artery. *N Engl J Med* 2003;349:1315–1323.

3. Colombo A, Drzewiecki J, Banning A, Grube E, Hauptmann K, Silber S, Dudek D, Fort S, Schiele F, Zmudka K, Guagliumi G, Russell ME, for the TAXUS II Study Group. Randomized study to assess the effectiveness of slow- and moderate-release polymer-based paclitaxel-eluting stents for coronary artery lesions. *Circulation* 2003;108:788–794.

4. Halkin A, Stone GW. Polymer-based paclitaxel-eluting stents in percutaneous coronary intervention: a review of the TAXUS trials. *J Interv Cardiol* 2004;17:271–282.

5. Costa MA, Simon DI. Molecular basis of restenosis and drug-eluting stents. *Circulation* 2005;111:2257–2273.

6. Finn AV, Palacios IF, Kastrati A, Gold HK. Drug-eluting stents for diabetes mellitus: a rush to judgment? *J Am Coll Cardiol* 2005;45:479–483.

7. Lemos PA, Hoye A, Goedhart D, Arampatzis CA, Saia F, van der Giessen WJ, McFadden E, Sianos G, Smits PC, Hofma SH, et al. Clinical, angiographic, and procedural predictors of angiographic restenosis after sirolimus-eluting stent implantation in complex patients: an evaluation from the Rapamycin-Eluting Stent Evaluated at Rotterdam Cardiology Hospital (RESEARCH) study. *Circulation* 2004;109:1366–1370.

8. Zahn R, Hamm CW, Schneider S, Zeymer U, Nienaber CA, Richardt G, Kelm M, Levenson B, Bonzel T, Tebbe U, Sabin G, Senges J, for the German Cypher Registry. Incidence and predictors of target vessel

revascularization and clinical event rates of the sirolimus-eluting coronary stent (Results from the Prospective Multicenter German Cypher Stent Registry). *Am J Cardiol* 2005:95:1302–1308.

9. Mehran R, Dangas G, Abizaid AS, Mintz GS, Lansky AJ, Satler LF, Pichard AD, Kent KM, Stone GW, Leon MB. Angiographic patterns of in-stent restenosis: classification and implications for long-term outcome. *Circulation* 1999;100:1872–1878.

10. Hoffmann R, Mintz GS, Mehran R, Pichard AD, Kent KM, Satler LF, Popma JJ, Hongsheng W, Leon MB. Intravascular ultrasound predictors of angiographic restenosis in lesions treated with Palmaz-Schatz stents. *J Am Coll Cardiol* 1998;31:43–49.

11. Kastrati A, Schomig A, Elezi S, Schühlen H, Dirschinger J, Hadamitzky M, Wehinger A, Hausleiter J, Walter H, Neumann FJ. Predictive factors of restenosis after coronary stent placement. *J Am Coll Cardiol* 1997;30:1428–1436.

12. Hoffmann R, Mintz GS, Pichard AD, Kent KM, Satler LF, Leon MB. Intimal hyperplasia thickness at follow-up is independent of stent size: a serial intravascular ultrasound study. *Am J Cardiol* 1998;82:1168–1172.

13. Fujii K, Mintz GS, Kobayashi Y, Carlier SG, Takebayashi H, Yasuda T, Moussa I, Dangas G, Mehran R, Lansky AJ, et al. Contribution of stent underexpansion to recurrence after sirolimus-eluting stent implantation for in-stent restenosis. *Circulation* 2004;109:1085–1088.

14. Mauri L, Orav EJ, O'Malley AJ, Moses JW, Leon MB, Holmes DR, Teirstein PS, Schofer J, Breithardt G, Cutlip DE, et al. Relationship of late loss in lumen diameter to coronary restenosis in sirolimus-eluting stents. *Circulation* 2005;111:321–327.

15. Kastrati A, Mehilli J, von Beckerath N, Dibra A, Hausleiter J, Pache J, Schühlen H, Schmitt C, Dirschinger J, Schömig A, for the ISAR-DESIRE Study Investigators. Sirolimus-eluting stent or paclitaxel-eluting stent vs balloon angioplasty for prevention of recurrences in patients with coronary in-stent restenosis: a randomized controlled trial. *JAMA* 2005;293:165–171.

16. Morice M-C. REALITY results presented at the ACC 2005.

17. Windecker S, Remondino A, Eberli FR, Jüni P, Räber L, Wenaweser P, Togni M, Billinger M, Tüller D, Seiler C, et al. Sirolimus-eluting and paclitaxel-eluting stents for coronary revascularization. *N Engl J Med* 2005;353:653–662.