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EXPEDITED PUBLICATION

Prospective, Randomized, Multicenter Evaluation of a Polyethylene Terephthalate Micronet Mesh–Covered Stent (MGuard) in ST-Segment Elevation Myocardial Infarction

The MASTER Trial

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Objectives This study sought to evaluate the potential utility of a novel polyethylene terephthalate micronet mesh–covered stent (MGuard) in patients with acute ST-segment elevation myocardial infarction (STEMI) undergoing percutaneous coronary intervention (PCI).

Background Suboptimal myocardial reperfusion after PCI in STEMI is common and results in increased infarct size and mortality. The MGuard is a novel thin-strut metal stent with a polyethylene terephthalate micronet covering designed to trap and exclude thrombus and friable atheromatous debris to prevent distal embolization.

Methods A total of 433 patients with STEMI presenting within 12 h of symptom onset undergoing PCI were randomized at 50 sites in 9 countries to the MGuard (n = 217) or commercially available bare metal or drug-eluting stents (n = 216). The primary endpoint was the rate of complete (≥70%) ST-segment resolution measured 60 to 90 min post-procedure.

Results Baseline characteristics were well matched between the groups. The primary endpoint of post-procedure complete ST-segment resolution was significantly improved in patients randomized to the MGuard stent compared with control patients (57.8% vs. 44.7%; difference: 13.2%; 95% confidence interval: 3.1% to 23.3%; p = 0.008). By core laboratory analysis, the MGuard stent compared with control stents also resulted in superior rates of Thrombolysis In Myocardial Infarction 3 flow (91.7% vs. 82.9%, p = 0.006) with comparable rates of myocardial blush grade 2 or 3 (83.9% vs. 84.7%, p = 0.81). Mortality (0% vs. 1.9%, p = 0.06) and major adverse cardiac events (1.8% vs. 2.3%, p = 0.75) at 30 days were not significantly different between patients randomized to the MGuard stent and control stent, respectively.

Conclusions Among patients with acute STEMI undergoing emergent PCI, the MGuard micronet mesh–covered stent compared with conventional metal stents resulted in superior rates of epicardial coronary flow and complete ST-segment resolution. A larger randomized trial is warranted to determine whether these benefits result in reduced infarct size and/or improved clinical outcomes. (Safety and Efficacy Study of MGuard Stent After a Heart Attack [MASTER]; NCT01368471) (J Am Coll Cardiol 2012;60:1975–84) © 2012 by the American College of Cardiology Foundation

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Abbreviations and Acronyms

BMS = bare-metal stent(s)
CMRI = cardiac magnetic resonance imaging
DES = drug-eluting stent(s)
ECG = electrocardiogram
IPTE = intraprocedural thrombotic event
MVO = microvascular obstruction
PCI = percutaneous coronary intervention
PET = polyethylene terephthalate
STEMI = ST-segment elevation myocardial infarction
STR = ST-segment resolution
SVG = saphenous vein graft
TIMI = Thrombolysis In Myocardial Infarction
TLR = target lesion revascularization
TVR = target vessel revascularization

Emergent percutaneous coronary intervention (PCI) is the optimal reperfusion modality in patients with acute ST-segment elevation myocardial infarction (STEMI) and has contributed to improved survival in patients with cardiovascular disease (1,2). However, although PCI frequently restores normal epicardial coronary flow in patients with STEMI, myocardial perfusion is often suboptimal, which results in increased infarct size and mortality (3–5). Although numerous mechanisms may underlie the etiology of microcirculatory dysfunction in STEMI, PCI-induced distal embolization of thrombus and/or friable atheromatous debris is believed to be ubiquitous and has been shown to contribute to impaired myocardial perfusion and adverse clinical outcomes (6–8). To date, efforts to improve myocardial reperfusion success after PCI in STEMI with a variety of thrombectomy and embolic protection devices and intracoronary administration of glycoprotein IIb/IIIa inhibitors have yielded conflicting results (9–12). Moreover, although a small randomized trial suggested that myocardial salvage after failed thrombolytic therapy might be improved with stenting compared with balloon angioplasty (13), in large trials, the routine implantation of metal stents during primary PCI has not been shown to enhance epicardial or myocardial reperfusion, decrease distal embolization, or improve left ventricular function (14–16).

The MGuard (InspireMD, Tel Aviv, Israel) is a novel bare-metal stent (BMS) with a polyethylene terephthalate (PET) micronet mesh covering designed to trap and exclude embolism-prone material before distal embolization (17). Case reports in patients with STEMI undergoing primary PCI have demonstrated the capability of the MGuard stent to capture thrombus and atheroma behind its net, thereby preventing embolization (18). Use of the MGuard in thrombotic lesions in native coronary arteries and saphenous vein grafts (SVGs) has been reported in 4 uncontrolled single- and multicenter studies, each demonstrating high rates of procedural success with low rates of distal embolization (19–22). We therefore performed a prospective, multicenter, randomized, controlled trial to evaluate whether the MGuard stent improves myocardial reperfusion in patients with STEMI undergoing PCI.

Methods

Patients. Patients 18 years of age and older presenting with symptoms consistent with STEMI lasting ≤12 h in duration, with ≥2 mm of ST-segment elevation in ≥2 contiguous leads, intended for PCI were eligible for enrollment. The principal clinical exclusion criteria were left bundle branch block, paced rhythm, or other electrocardiographic abnormality interfering with assessment of ST-segment resolution (STR); PCI performed within 6 months or previous coronary artery bypass graft surgery at anytime; bleeding diathesis or indication for long-term warfarin anticoagulation; allergy or contraindication to antiplatelet agents, anticoagulant therapy, metal stent or mesh material, and/or iodinated contrast that cannot be adequately premedicated; known renal insufficiency (serum creatinine >2.0 mg/dl) or on dialysis; left ventricular ejection fraction ≤20%, cardiogenic shock, or cardiopulmonary resuscitation; and comorbid conditions that may cause noncompliance with the protocol or are associated with a life expectancy <1 year.

Angiographic eligibility required planned PCI of a single de novo lesion ≤33 mm in length and reference vessel diameter (RVD) ≥3.0 to ≤4.0 mm by visual estimation, capable of being covered by a single study stent. Patients were not eligible if a ≥50% left main stenosis was present; if the target lesion was ostial in location or involved a bifurcation with a ≥2.0-mm side branch; if the target vessel or lesion was excessively tortuous or angulated or had moderate to heavy calcification; if a >50% stenosis proximal or distal to the target lesion was present; or if any previous stent was identified proximal to or within 10 mm distal to the target lesion. In the case of an occluded infarct vessel, angiographic eligibility was assessed only after restoration of Thrombolysis In Myocardial Infarction (TIMI) flow grade ≥2 by a guidewire, manual aspiration, or balloon angioplasty.

Study design and protocol procedures. The protocol was approved by the ethics committee at each participating center, and informed written consent was obtained in all clinically eligible patients. Before cardiac catheterization, consented patients were administered aspirin 300 to 325 mg chewed or 250 to 500 mg intravenously and either 600 mg clopidogrel, 60 mg prasugrel, or 180 mg ticagrelor. Emergent left ventriculography and 3-vessel coronary arteriography were then performed. If all angiographic eligibility criteria were met, the patient was then randomized 1:1 to either the MGuard stent or, per operator discretion, any commercially available BMS or drug-eluting stent (DES), the latter collectively comprising the control group (as differences in

fees from St. Jude Medical. All other authors have reported that they have no relationships relevant to the contents of this paper to disclose. A complete list of the study organization and participating sites and investigators from the MASTER (Safety and Efficacy Study of MGuard Stent After a Heart Attack) trial is provided in the Online Appendix.

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the acute rates of TIMI flow, myocardial blush grade or STR have not been reported as a function of stent type) (22). Randomization in alternating block sizes of 6 was performed by opening sealed envelopes, stratified by infarct vessel (left anterior descending vs. other) and the intended use versus nonuse of thrombus aspiration (per operator discretion).

Procedural anticoagulation consisted of unfractionated heparin plus intravenous glycoprotein IIb/IIIa inhibition or bivalirudin monotherapy. Procedural use of low molecular weight heparin, fondaparinux, and intracoronary glycoprotein IIb/IIIa inhibition was not permitted. The decision to perform manual thrombus aspiration and/or pre-dilate before stenting was left to operator discretion, but if required, a 1.5- or 2.0-mm balloon diameter was suggested to minimize the risk of embolization before stenting. Larger balloons could be used if stent passage was unsuccessful. Rheolytic thrombectomy was not permitted other than for major procedural complications. The need for further balloon dilation after stent implantation was left to operator discretion, with the goal of achieving as close to a 0% visual residual stenosis as possible. Only the single culprit lesion was treated during the index procedure; staged PCI in a noninfarct vessel was permitted ≥72 h post-procedure.

A 12-lead electrocardiogram (ECG) was obtained 60 to 90 min post-procedure. All patients were treated with aspirin (75 to 162 mg/day) indefinitely and an adenosine diphosphate receptor antagonist for 1 year. High-dose statins, beta-blockers, and angiotensin-converting enzyme inhibitors or receptor blockers were also prescribed in the absence of contraindications. Clinical follow-up was performed at 30 days, 6 months, and 12 months. To assess late vascular responses, angiographic follow-up at 13 months was performed in 50 consecutive MGuard patients at 17 participating centers. A subset of 60 consecutive randomized patients at 7 participating centers also underwent cardiac magnetic resonance imaging (CMRI) at 3 to 5 days post-PCI for assessment of infarct size and microvascular obstruction (MVO). The present study is reported after completion of the 30-day follow-up period in all patients.

The local principal investigator and research coordinators were aware of the study assignments. The patients, core laboratory technicians, clinical event adjudication committee, executive committee, and sponsor were blinded to the randomized treatment. Independent study monitors reviewed all source documents on-site for accuracy and completeness.

Device description. The MGuard consists of a balloon-expandable BMS platform with a PET micronet sleeve coating (fiber width, 20 μm; aperture size, 150 ×180 μm) attached to its outer surface (Fig. 1) (17–22). The micronet holes are expandable, so side branches may still be accessed through the mesh. The first-generation stent had a 316L stainless steel frame (strut thickness, 100 μm), whereas the current MGuard Prime platform is composed of cobalt chromium (strut thickness, 80 μm). The micronet mesh is the same in both stents, although the range of available diameters and lengths varies slightly. The MGuard Prime stent became available late during the study recruitment period.

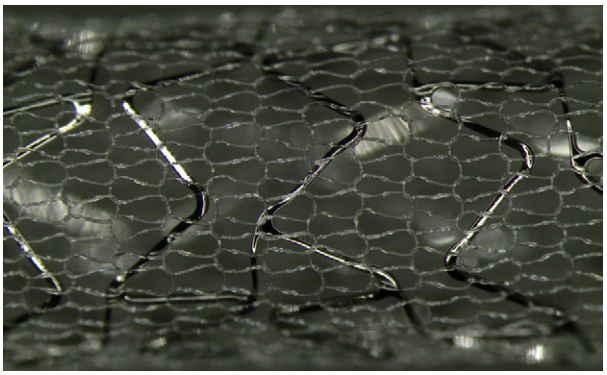

Figure 1 The MGuard Stent

The MGuard stent has a 316L stainless steel frame with 100-μm strut thickness. It is manufactured in diameters ranging from 2.0 to 4.0 mm and in lengths ranging from 11 to 39 mm. The crossing profile ranges from 1.0 to 1.3 mm. The MGuard Prime stent is similar in configuration, but has a L605 cobalt chromium alloy frame with 80-μm strut thickness and slightly lower crossing profile. It is manufactured in diameters ranging from 2.5 to 4.0 mm and in lengths ranging from 13 to 38 mm. The polyethylene terephthalate micronet is identical on both stents and has a fiber width of 20 μm and an expanded aperture size of 150 × 180 μm. Both stents are compatible with 0.014-inch guidewires and 6-French guiding catheters.

Endpoints and definitions. The primary endpoint was the rate of complete STR, defined as ≥70% reduction in the summed 12-lead extent of ST-segment elevation from the baseline to the post-procedure ECG, as determined by a blinded, independent electrocardiographic core laboratory. As a secondary analysis, the rate of STR was also determined in the lead with the greatest baseline degree of ST-segment elevation. The statistical analysis plan prespecified that the primary analysis population would consist of all patents with at least 1 mm of baseline ST-segment elevation in at least 2 contiguous leads (as assessed by the core laboratory) with a qualifying paired ECG obtained within 120 min post-procedure. Secondary endpoints consisted of acute device, lesion, and angiographic success rates, post-procedural TIMI flow, corrected TIMI frame count, myocardial blush grade, and intraprocedural thrombotic events (IPTEs), defined as the development of new or increasing thrombus, abrupt vessel closure, no reflow, slow reflow, distal embolization, side branch closure, or intraprocedural stent thrombosis at any time during the procedure and were determined by independent angiographic core laboratories, as previously described (23,24). Major adverse cardiovascular and cerebral events (the composite of all-cause death, reinfarction, stroke or ischemia-driven target lesion revascularization [TLR]), major adverse cardiovascular events (the composite of cardiac death, reinfarction, or ischemia-driven TLR); stroke, stent thrombosis (Academic

Table 1 Baseline Characteristics of the Randomized Groups

	MGuard Stent (n = 217)	Control Stent (n = 216)
Age, yrs	60.0 (52.0–68.0)	58.0 (51.0–67.0)
Male	163 (75.1)	166 (76.9)
Hypertension	91/215 (42.3)	100/211 (47.4)
Hyperlipidemia	58/212 (27.4)	57/210 (27.1)
Diabetes mellitus	26 (12.0)	39 (18.1)
Current cigarette smoking	120 (55.3)	101 (46.8)
Previous myocardial infarction	8 (3.7)	19 (8.8)
Previous percutaneous coronary intervention	8 (3.7)	12 (5.6)
Body mass index, kg/m^2	26.6 (24.5–30.2)	26.7 (24.8–30.2)
Symptom to hospital arrival, min	150.5 (95.5–246.0)	175.0 (92.0–320.0)
Hospital arrival to first device, min	45.0 (33.0–72.0)	45.0 (31.5–72.0)
Symptom onset to first device, min	206.5 (155.5–307.5)	240.0 (140.0–383.0)
Infarct artery lesion location*		
Left anterior descending coronary artery	87 (40.1)	87 (40.3)
Left circumflex coronary artery	20 (9.2)	17 (7.9)
Right coronary artery	110 (50.7)	112 (51.9)
Baseline TIMI flow grade*		
0/1	143/215 (66.5)	159/215 (74.0)
2	39/215 (18.1)	29/215 (13.5)
3	33/215 (15.3)	27/215 (12.6)
Baseline reference vessel diameter, mm*	3.15 (2.87–3.38)	3.06 (2.87–3.40)
Baseline minimal luminal diameter, mm*	0.00 (0.00–0.45)	0.00 (0.00–0.34)
Baseline diameter stenosis, %*	100.0 (85.2–100.0)	100.0 (88.3–100.0)

Values are median (interquartile range) or n (%). *Assessed by core laboratory quantitative coronary angiography.
TIMI = Thrombolysis In Myocardial Infarction.

Research Consortium definition), and major bleeding (TIMI definition) were adjudicated by an independent clinical events committee blinded to treatment assignment. Absolute and relative (percentage of total left ventricular mass) infarct size and MVO at 3 to 5 days post-procedure were determined at an independent CMRI core laboratory using previously described methodology (12).

Power and statistical analysis. With 412 assessable patients, the trial had 80% power to demonstrate a 21.7% relative improvement in the frequency of complete STR from 60% to 73% with a 2-sided $\alpha = 0.05$. Assuming a 95% rate of assessable paired ECGs, enrollment was planned for 432 patients.

All analyses were performed by intention to treat. Missing data were not replaced. Categorical outcomes were compared by the chi-square or Fisher exact test. Continuous variables are presented as median with interquartile range and were compared by the Wilcoxon rank sum test. All statistical tests were 2 sided. A p value <0.05 was considered significant for all analyses. Subgroup analysis with interaction testing by logistic regression was prespecified to examine the consistency of treatment effect for the primary endpoint, according to age, sex, diabetes, infarct artery, baseline TIMI flow, and time from symptom onset to PCI. All statistical analyses were performed using SAS version 9.2 (SAS Institute Inc., Cary, North Carolina).

Results

Patients and procedures. Between July 22, 2011 and May 29, 2012, 433 patients with STEMI were enrolled and randomized at 50 sites in 9 countries to the MGuard stent (n = 217) or a control stent (n = 216). Baseline clinical and angiographic features were well matched between the 2 groups (Tables 1 and 2). The median age was 59 years, and 24% of patients were female. The infarct vessel was the left anterior descending coronary artery in 40.2% of patients, the right coronary artery in 51.3%, and the left circumflex coronary artery in 8.3%; a single lesion was treated in all patients. Aspiration was performed in approximately two thirds of patients in each group, and pre-dilation before stent implantation was performed in ~50% of patients, with a median 2.0-mm diameter balloon. Use of antiplatelet agents, anticoagulants, and other study procedures were also similar between the 2 groups.

Device performance. The MGuard stent was unable to reach or cross the lesion in 9 of 217 patients (4.1%), including 9 of 191 (4.7%) and 0 of 26 (0%) patients in whom the original MGuard and MGuard Prime devices were used, respectively. There were 2 cases of MGuard stent dislodgment, both occurring during attempted withdrawal of the device after unsuccessful vessel passage. In 1 patient, the stent embolized peripherally without clinical sequelae; balloon angioplasty of the infarct lesion was performed without stent implantation. In the second case, the stent

Table 2 Procedural Details and Medications

	MGuard Stent (n = 217)	Control Stent (n = 216)	p Value
Antiplatelet agents, periprocedural			
Aspirin	214 (98.6)	214 (99.1)	1.0
ADP antagonists	207 (95.4)	207 (95.8)	0.82
Clopidogrel	151/207 (72.9)	145/207 (70.0)	0.51
Ticlopidine	1/207 (0.5)	0/207 (0.0)	1.0
Prasugrel	45/207 (21.7)	43/207 (20.8)	0.81
Ticagrelor	10/207 (4.8)	19/207 (9.2)	0.08
Anticoagulation, periprocedural			
Unfractionated heparin	210 (96.8)	208 (96.3)	0.79
Glycoprotein IIb/IIIa inhibitor	180 (82.9)	180 (83.3)	0.92
Bivalirudin	24 (11.1)	27 (12.5)	0.64
Aspiration performed	143 (65.9)	145 (67.1)	0.79
Balloon pre-dilation performed	109 (50.2)	97 (44.9)	0.27
Direct stenting	26 (12.0)	23 (10.6)	0.66
≥1 stent implanted	216 (99.5)	216 (100.0)	1.0
≥2 stents implanted	28 (12.9)	23 (10.6)	0.47
Stent type			
MGuard	208/216 (96.3)	1 (0.5)	<0.0001
Bare-metal stent	3/216 (1.4)	129 (59.7)	<0.0001
Drug-eluting stent	5/216 (2.3)	86 (39.8)	<0.0001
Total stent length, mm	19.0 (15.0–24.0)	20.0 (15.0–24.0)	0.64
Post-stent dilation performed	79 (36.4)	66 (30.6)	0.20
Maximal device size, mm	3.5 (3.0–3.5)	3.5 (3.0–.5)	0.78
Maximal dilation pressure, atm	16 (14–18)	16 (14–18)	0.02*
Discharge medications			
Aspirin	217 (100.0)	214/215 (99.5)	0.50
ADP antagonists	217 (100.0)	214/215 (99.5)	0.50
Beta-blockers	194 (89.4)	197/215 (91.6)	0.43
ACE inhibitors	189 (87.1)	182/215 (84.7)	0.47
Angiotensin-receptor blockers	16 (7.4)	15/215 (7.0)	0.87
Statins	214 (98.6)	208/215 (96.7)	0.22

Values are n (%), n/N (%), or median (interquartile range). *Marginally higher in the MGuard group.
ACE = angiotensin-converting enzyme; ADP = adenosine diphosphate.

dislodged in the proximal vessel where it was implanted. The infarct lesion in the distal vessel was then crossed and successfully treated with a commercially available BMS. There were no device failures in the control group.

Angiographic measures. As seen in Table 3, device success was lower with the MGuard stent compared with the control stents, although lesion success was similar. TIMI-3 flow was restored more frequently in patients randomized to the MGuard stent compared with the control stents, however, and as a result, angiographic success rates were higher in the MGuard group (91.7% vs. 82.4%, p = 0.004). There were no statistically significant post-PCI differences between the stent groups in corrected TIMI frame count, myocardial blush grade, or the occurrence of IPTE.

Primary endpoint: ST-segment resolution. Qualifying baseline and post-procedure ECGs were available for 412 and 410 of the 433 randomized patients (95.2% and 94.7%, respectively). As shown in Table 4, the primary endpoint of complete STR summed across the 12-lead ECG was achieved in a significantly greater percentage of patients randomized to the MGuard stent than to the control stents (57.8% vs. 44.7%; difference, 13.2%; 95% confidence interval: 3.1 to 23.3; p = 0.008). The secondary endpoint of complete STR in the lead with the greatest ST-segment elevation was also greater with the MGuard stent. The greater rate of complete STR with the MGuard stent compared with the control stents was consistent across numerous subgroups (Fig. 2).

Clinical outcomes and cardiac magnetic resonance imaging. Clinical follow-up at 30 days was complete in 431 of 433 patients (99.5%); follow-up was not available for 2 control patients. Adverse clinical events were infrequent in both groups at 30 days (Table 5). Pooled across stent type, mortality at 30 days occurred in 0 of 211 patients with complete (≥70%) STR and in 4 of 198 patients with partial or absent (<70%) STR (0% vs. 2.0%, p = 0.05), and a nonsignificant trend toward lower mortality was present in the MGuard arm (0% vs. 1.9%, p = 0.06). Reinfarction and stent thrombosis each occurred in 3 MGuard patients and 2 control stent patients (1.4% vs. 0.9%, p = 1.0). Ischemia-driven TVR occurred in 6 MGuard patients and 1 control stent patient (2.8% vs. 0.5%, p = 0.12). Among 59 patients

Table 3 Angiographic Measures Post-PCI

	MGuard Stent (n = 217)	Control Stent (n = 216)	p Value
Device success*	208 (95.9)	214 (99.1)	0.03
Lesion success†	217 (100.0)	215 (99.5)	0.50
Angiographic success‡	199 (91.7)	178 (82.4)	0.004
Reference vessel diameter, mm§	3.20 (2.90–3.46)	3.16 (2.91–3.46)	0.99
Minimal luminal diameter, mm§			
In-stent	2.99 (2.73–3.25)	2.99 (2.69–3.31)	0.91
In-lesion	2.64 (2.40–2.96)	2.64 (2.36–2.95)	0.82
Diameter stenosis, %§			
In-stent	6.9 (4.2–10.5)	6.4 (3.9–10.3)	0.56
In-lesion	15.3 (9.6–21.2)	15.4 (10.8–21.2)	0.66
TIMI flow grade§			
0/1	4 (1.8)	12 (5.6)	0.01
2	14 (6.5)	25 (11.6)	0.06
3	199 (91.7)	179 (82.9)	0.006
Corrected TIMI frame count§	17.0 (12.0–23.0)	18.0 (13.0–22.0)	0.23
Myocardial blush grade§			
0/1	35 (16.1)	32 (14.8)	0.71
2	21 (9.7)	28/215 (13.0)	0.27
3	161 (74.2)	155/215 (72.1)	0.62
2/3	182 (83.9)	183 (84.7)	0.81
IPTE§	47 (21.7)	48/215 (22.3)	0.87

Values are n (%) or median (interquartile range). *Device success = attainment of <50% final residual stenosis of the target lesion using only the randomized stent. †Lesion success = attainment of <50% final residual stenosis of the target lesion using any percutaneous method. ‡Angiographic success = attainment of <50% final residual stenosis of the target lesion and final TIMI flow grade 3. §Assessed by core laboratory quantitative coronary angiography.

IPTE = intraprocedural thrombotic event; TIMI = Thrombolysis In Myocardial Infarction.

in whom CMRI was completed, there were no significant differences in infarct size or MVO between the 2 groups (Table 6).

Discussion

In the present prospective, multicenter, single-blind, randomized, controlled trial, the MGuard PET micronet mesh–covered stent compared with the use of standard metal stents in patients with acute STEMI undergoing emergent PCI resulted in significantly higher rates of TIMI flow grade 3, acute angiographic success, and complete STR, the latter representing the powered primary endpoint of the study. The greater rate of complete STR achieved with the MGuard stent was consistent among numerous important subgroups, including infarct vessel, lesion length, reference vessel diameter, and use of aspiration. In previous STEMI studies, restoration of TIMI-3 flow and complete STR after PCI have been strongly associated with subse-

Table 4 Core Laboratory Electrocardiographic Results

	MGuard Stent (n = 204)	Control Stent (n = 208)	p Value
Baseline ECG, total ST-segment elevation, mm	10.00 (6.55–15.00)	9.65 (6.15–15.00)	0.64
Baseline ECG, worst lead ST-segment elevation, mm	3.35 (2.20–5.00)	3.20 (2.20–4.50)	0.74
Post-procedure to second ECG, min	70.5 (63.5–81.0)	72.0 (63.0–80.0)	0.71
ST-segment resolution, sum of all leads	n = 204	n = 206*	
Complete (≥70%)	118 (57.8)	92 (44.7)	0.008
Partial (>30% to <70%)	52 (25.5)	79 (38.3)	0.005
Absent (≤30%)	34 (16.7)	35 (17.0)	0.95
Median (IQR), % (range)	75.4 (45.3–90.8)	64.5 (39.3–88.6)	0.07
ST-segment resolution, worst lead			
Complete (≥70%)	136 (66.7)	118 (57.3)	0.05
Partial (>30% to <70%)	44 (21.6)	64 (31.1)	0.03
Absent (≤30%)	24 (11.8)	24 (11.7)	0.97
Median (IQR), %	84.8 (62.5–100.0)	76.2 (50.0–100.0)	0.01

Values are median (interquartile range) or n (%). *Two control patients with qualifying baseline ECGs did not have interpretable follow-up ECGs; in 1 patient left bundle branch block developed, whereas in the second patient, a single lead was absent.

ECG = electrocardiogram; IQR = interquartile range.

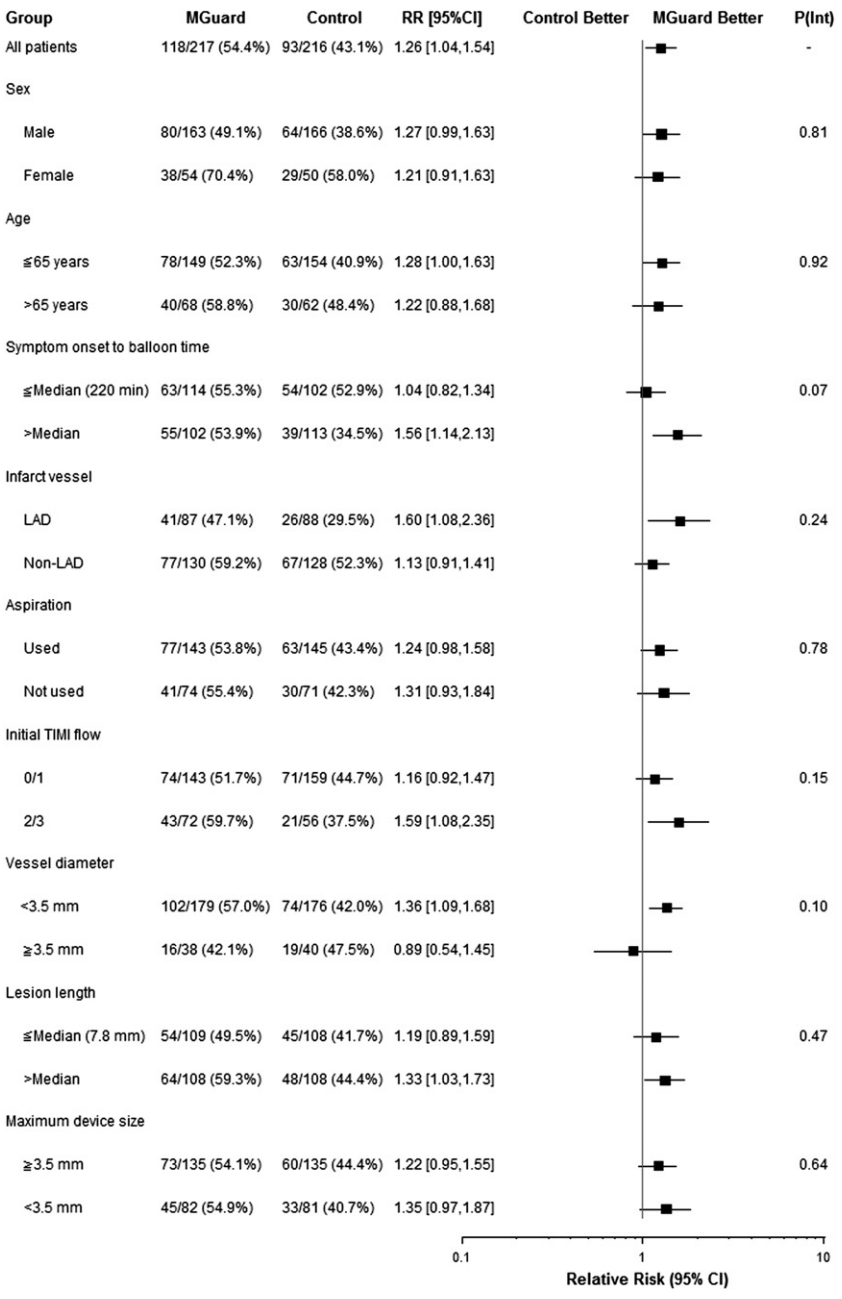

Figure 2 **Subgroup Analysis for the Primary Endpoint of Complete ST-Segment Resolution**

Subgroup analysis comparing patients randomized to the MGuard stent versus a control stent for the primary endpoint of complete ST-segment resolution, displayed as the relative risk between groups **(black boxes)** with 95% confidence intervals (CI) **(horizontal limit lines)**. The probability for interaction [P(Int)] represents the likelihood for interaction between the variable and the relative treatment effect. CMRI = cardiac magnetic resonance imaging; IPTE = intraprocedural thrombotic events; LAD = left anterior descending; MBG = myocardial blush grade; MVO = microvascular obstruction; PET = polyethylene terephthalate; PTFE = polytetrafluoroethylene; RVD = reference vessel diameter; STR = ST-segment resolution; SVG = saphenous vein graft; TIMI = Thrombolysis In Myocardial Infarction.

quent early and late survival (25–27). Concordantly, mortality at 30 days in the present trial was significantly greater in patients not achieving complete STR, resulting in a strong trend toward reduced cardiac and all-cause mortality in patients treated with the MGuard stent compared with a control stent.

Although not directly evaluated in the present study, the higher rate of reperfusion success with the MGuard stent is likely due to its design, affording trapping and exclusion of thrombus and friable atheromatous debris before embolization to the distal microvasculature (17,18). Consistent with this hypothesis, although the exploratory CMRI study was

Table 5 Clinical Events at 30-Day Follow-Up

	MGuard Stent (n = 217)	Control Stent (n = 214)	p Value
MACCE	5 (2.3)	5 (2.3)	1.00
MACE	4 (1.8)	5 (2.3)	0.75
All-cause mortality	0 (0.0)	4 (1.9)*	0.06
Reinfarction	3 (1.4)	2 (0.9)	1.00
Q-wave	3 (1.4)	1 (0.5)	0.62
Non–Q-wave	0 (0.0)	1 (0.5)	0.50
TLR, ischemia-driven	4 (1.8)	1 (0.5)	0.37
TVR, ischemia-driven	6 (2.8)	1 (0.5)	0.12
Stent thrombosis, definite or probable	3 (1.4)	2 (0.9)	1.00
Acute (≤24 h)	1 (0.5)	0 (0.0)	1.00
Subacute (24 h–30 days)	2 (0.9)	2 (0.9)	1.00
Definite	3 (1.4)	1 (0.5)	0.62
Acute (≤24 h)	1 (0.5)	0 (0.0)	1.00
Subacute (24 h–30 days)	2 (0.9)	1 (0.5)	1.00
Probable	0 (0.0)	1 (0.5)	0.50
Acute (≤24 h)	0 (0.0)	0 (0.0)	—
Subacute (24 h–30 days)	0 (0.0)	1 (0.5)	0.50
Stroke	1 (0.5)	0 (0.0)	1.00
TIMI bleeding	4 (1.8)	4 (1.9)	1.00
Major	3 (1.4)	2 (0.9)	1.00
Minor	1 (0.5)	2 (0.9)	0.62

Values are n (%). *All deaths were cardiac.

MACCE = major adverse cardiovascular or cerebral events; MACE = major adverse cardiac events; TIMI = Thrombolysis In Myocardial Infarction; TLR = target lesion revascularization; TVR = target vessel revascularization.

underpowered to demonstrate significant intergroup differences, the numerically lower rates of MVO seen in the MGuard stent group suggests that early microcirculatory function may be improved compared with a control stent (28,29). Similarly, infarct size was numerically smaller and global wall motion and left ventricular ejection fraction were directionally improved at 3 to 5 days post-PCI, although these results should be interpreted cautiously given the modest substudy size. Conversely, no differences between the stent types were seen in the rates of myocardial blush, macroemboli, or IPTE, indices that have also been correlated with outcomes after PCI in STEMI and acute coronary syndromes (8,23,24). Although it is possible that these measures are less sensitive or prognostic than STR (or assess different mechanisms of reperfusion success), a larger randomized trial is warranted to definitively demonstrate whether the MGuard stent reduces infarct size and/or improves clinical outcomes compared with standard metal stents.

Stent grafts were unsuccessful in previous studies in preventing distal embolization during PCI of diseased SVGs and were associated with high rates of restenosis and reocclusion (30–33). However, these devices were covered with a single or dual layer of tightly woven polytetrafluoroethylene and were thus incapable of trapping friable material without extruding it downstream ("toothpaste" effect). In contrast, the MGuard stent is constructed with a loosely interlaced PET micronet mesh that by optical coherence tomography has been shown to trap and exclude thrombus before distal embolization (18). Thus, the results with these 2 devices would be expected to be quite different. Moreover, PCI in STEMI (as tested in the present trial) and SVGs are not comparable, although preliminary results with the MGuard stent in SVGs have been favorable (19,20).

The MGuard stent was unable to reach or cross the infarct lesion in 9 of 217 patients (4.1%). Stent embolization occurred in 2 of these patients, without adverse clinical sequelae. The MGuard stent has a higher profile and is less flexible than a standard stent, and retention of the current device may not be as robust. Manual thrombus aspiration and/or pre-dilation with a small balloon angioplasty catheter were performed in most patients in the current study. Lesion pre-dilation with a balloon sized 1:1 to the reference vessel before MGuard stent passage may improve device deliverability, but may also reduce the extent to which embolization can be prevented. Of note, there were no device failures in the present study among the 26 patients in whom the lower profile and more flexible MGuard Prime device was used, and additional device iterations are under way to further improve acute performance.

Long-term follow-up is ongoing at the time of this report and is essential to examine the late results with the MGuard stent after primary PCI in STEMI. In the largest study before the MASTER (Safety and Efficacy Study of MGuard Stent After a Heart Attack) trial, none of 60 patients required ischemia-driven TLR within 6 months after MGuard stent implantation in STEMI (21). This small study notwithstanding, as the MGuard stent lacks an

Table 6 Cardiac Magnetic Resonance Imaging Substudy Results at Days 3 to 5

	MGuard Stent (n = 30)	Control Stent (n = 29)	p Value
Total LV myocardial mass, g	141 (117–163)	147 (118–174)	0.41
Infarct mass, g	17.1 (10.0–30.0)	22.3 (15.7–30.1)	0.27
Infarct mass, % of total LV mass	13.3 (7.9–25.0)	16.6 (10.0–22.6)	0.48
Total microvascular obstruction, g	0.3 (0.0–1.6)	1.0 (0.2–2.8)	0.14
Microvascular obstruction, % of total LV mass	0.4 (0.0–1.4)	0.8 (0.2–1.9)	0.39
Total abnormal wall motion score	22.5 (20.0–26.0)	25.0 (21.0–27.0)	0.48
LV ejection fraction, %	48.3 (44.5–52.3)	47.3 (42.0–54.5)	0.79

Values are median (interquartile range).

LV = left ventricular.

antiproliferative agent, it is not expected to match a DES in protection from restenosis. However, the absolute clinical benefit of DES compared with BMS in preventing ischemia-driven TLR in STEMI is modest (34) and must be weighed against the potential utility of the MGuard stent in reducing infarct size, heart failure events, and mortality. Both BMS and DES are currently used in a substantial proportion of patients undergoing primary PCI in STEMI, with DES use reserved at most centers for lesions at high risk of restenosis. However, these longer and more complex lesions may possess greater potential for embolization and thus theoretically may benefit most by use of the MGuard stent. Moreover, stent thrombosis is common in STEMI with both BMS and DES (35,36), and although no significant differences in the rates of thrombotic events between the MGuard and conventional stents at 30 days were observed, the present study was underpowered in this regard. These considerations reinforce the need for a larger randomized trial comparing the MGuard stent with both BMS and DES across the range of lesions encountered among patients with STEMI, with long-term follow-up to fully characterize the competing risks and benefits of these devices.

Study limitations. The MASTER trial was underpowered to draw definitive conclusions regarding infarct size and clinical events, and all subgroup analyses should be considered hypothesis-generating. Longer-term clinical and angiographic follow-up is ongoing to characterize the late vascular responses of the MGuard stent. More experience with the MGuard Prime device in STEMI is required. The discordance in findings between TIMI flow, STR, blush, and IPTE has been noted. Finally, although events were assessed and adjudicated by independent blinded core laboratories and clinical events committees, the operators and research coordinators were not blinded to stent assignment, and thus some degree of bias cannot be excluded. The directional concordance of most of the outcome measures, including TIMI flows and frame counts, STR, MVO, infarct size, and mortality provides consistency and validity to the results.

Conclusions

Among patients with acute STEMI undergoing emergent PCI enrolled in the present multicenter, randomized, controlled trial, the MGuard micronet mesh–covered stent compared with conventional metal stents resulted in superior rates of epicardial coronary flow and complete STR.

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Key Words: embolic protection ■ myocardial infarction ■ reperfusion.

APPENDIX

For a complete list of the study organization and participating sites and investigators from the MASTER trial, please see the online version of this article.