Comparison of serial optical coherence tomography imaging following aggressive stent expansion technique: Insight from the MECHANISM study

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Abstract

Purpose: To compare early vascular healing following cobalt-chromium everolimus-eluting stent (CoCr-EES) implantation between groups with or without aggressive stent expansion in patients treated by CoCr-EES for stable coronary artery disease (CAD).

Methods: Seventy-one stable CAD lesions underwent CoCr-EES implantation and analysis of serial optical coherence tomography (OCT) images obtained post-procedure and at early-term (1- or 3-month) follow-up. The endpoints of this study were neointimal thickness at the time of 1- or 3-month OCT and presence and healing of stent edge dissection. Aggressive stent expansion was defined as a lesion complying with ILUMIEN III sizing protocol; that is, external elastic lamina (EEL) diameter minus maximum balloon diameter ≤0.25 mm.

Results: Comparing groups with and without aggressive stent expansion, median neointimal thickness at 1 and 3 months after CoCr-EES implantation was similar (1 month: 0.031 mm vs. 0.041 mm, respectively, p = 0.27; 3 months: 0.036 mm vs. 0.040 mm, respectively, p = 0.84). Regarding stent edge findings, the presence of any stent edge dissection immediately after percutaneous coronary intervention was also similar between the groups (25% vs. 15%, respectively; p = 0.30) and most stent edge dissections resolved completely within 3 months, regardless of location or dissection severity. After 1 year, no clinically driven target lesion revascularization or stent thrombosis was observed in either cohort.

Conclusion: Even after aggressive stent expansion, early neointimal proliferation appeared modest with CoCr-EES implantation, and most stent edge dissections had resolved by 3 months. These findings may support the feasibility of EEL-based sizing by pre-stenting OCT.

Keywords: coronary artery disease, drug-eluting stent, optical coherence tomography, percutaneous coronary intervention

Introduction

At the time of coronary stent implantation, the physician sometimes performs aggressive expansion to avoid stent under-expansion, which is related to worse clinical outcomes that include in-stent restenosis, target lesion revascularization, and/or stent thrombosis [1, 2]. Importantly, because overstretch and mechanical injury to the coronary artery lead to vessel healing of mechanical and traumatic damage caused by stent implantation [3], the possibility of aggressive expansion causing excessive in-stent neointimal proliferation and stent edge dissection must be considered. Indeed, in the era of bare metal stents (BMSs), an observational study using intravascular ultrasound (IVUS) reported that aggressive stent expansion was related to more neointimal proliferation than seen with non-aggressive stent expansion [4]. However, the impact of aggressive stent expansion on vascular healing has not been clarified since the establishment of second-generation drug-eluting stents (DESs).

Optical coherence tomography (OCT) provides high-resolution images for assessing coronary artery and neointimal tissue, and along with IVUS is a useful modality for obtaining accurate vessel or lumen diameters for coronary stent sizing and for assessing optimal stent expansion [5-7]. The ILUMIEN III study recently established the safety and procedural benefits of aggressive stent expansion based on OCT measurement using external elastic lamina (EEL) diameters [5]. However, vascular healing following EEL-based sizing for stent implantation has not yet been demonstrated. We hypothesized that excessive neointimal hyperplasia induced by aggressive stent expansion is less common when implanted second-generation DES, which presents less neointimal proliferation than BMS. In order to assess this hypothesis, we compared serial OCT images following cobalt-chromium everolimus-eluting stent (CoCr-EES) implantation between groups with and without aggressive stent expansion.

Materials and methods

MECHANISM-elective study

The MECHANISM-elective (Multicenter Comparison of Early and Late Vascular Responses to Everolimus-Eluting Cobalt-CHromium Stent and Platelet AggregatioN Studies In patients with Stable Angina Managed as Elective cases) is a multicenter, prospective study regarding the evaluation of early vascular healing (Clinicaltrials.gov ID: NCT02014818, UMINID: UMIN000012616). Serial OCT images for patients with stable coronary artery disease (CAD) were obtained immediately after percutaneous coronary intervention (PCI) and at 1- and 12-month follow-ups (1-month follow-up cohort; n = 50) or 3-

and 12-month follow-ups (3-month follow-up cohort, n = 50). All procedural strategies and endpoints associated with OCT findings depended on the discretion of the operator. Informed consent was obtained from each patient after admission and this study protocol was performed in accordance with the Declaration of Helsinki. This study has been approved by institutional ethics committee.

The main results of the MECHANISM-elective study have been reported in detail [8]. Briefly, the uncovered strut rate and the incidences of intra-stent thrombus and irregular protrusion were dramatically improved in the early (1- and 3-month) follow-up period, and good early and mid-term vascular healing was obtained by implanting CoCr-EESs in stable CAD patients.

Definition of aggressive stent expansion

In this sub-study, we performed post-hoc analyses between the group with and without aggressive stent expansion. Because procedural protocols for stenting were not arranged in advance, stent sizing and expansion were performed according to the decision of each physician using pre- and post-stent OCT images, and heterogeneous procedural data to determine the efficacy of aggressive expansion were included in this study. On this basis, we sought to evaluate the impact of aggressive stent expansion on excessive in-stent tissue proliferation and the presence of stent edge dissection. In the present study, we consider that EEL-based sizing, which was nearly equal to vessel diameter, was more aggressive than lumen-based sizing. Based on this, aggressive stent expansion was defined as occurring in any lesion with EEL diameter minus maximum balloon diameter ≤0.25 mm according to the pre-stenting OCT assessment, indicating compliance with the ILUMIEN III sizing protocol (Fig. 1) [5]. When post-dilatation was performed using a larger balloon, the largest balloon diameter was used in this calculation.

Endpoints of the present study

The primary endpoint of this sub-study was neointimal thickness after CoCr-EES implantation at early-term. The secondary endpoint was the presence of stent edge dissection at early-term, which was defined by the OCT measurement criteria of ILUMIEN III [5]. Notably, major dissection was defined as that ≥60 degrees of the circumference of the vessel at the site of dissection, and/or ≥3 mm in length. All other dissections were defined as minor. In terms of the assessment of lesion morphology from pre-stenting and post-PCI OCT, previously reported methods were used to evaluate calcification, lipid-rich

plaque, thin-cap fibroatheroma thrombus, and irregular protrusion [9-13]. In the image analysis, independent reviewers from the Iwate Core-Analysis Laboratory (ICAL) assessed all OCT images using ILUMIEN proprietary software (ILUMIEN or ILUMIEN OPTIS; Abbott Vascular, Santa Clara, CA). All OCT images were analyzed at 1-mm intervals throughout the stented segment. The thickness of neointimal tissue at early follow-up was measured from the center reflection of the stent strut to the vessel–lumen border for each stent strut. Struts were recorded as uncovered if any part was visibly exposed in the lumen, or covered if a layer of tissue covered all reflecting surfaces.

Statistical analysis

All data are presented as the median (1st quartile–3rd quartile) or as the number (percentage). Statistical comparisons of differences in categorical data between groups were performed using the chi-square contingency test. In addition, comparisons of medians between groups were performed using the Mann–Whitney U test. Differences showing values of $p < 0.05$ were considered significant, and all statistical analyses were performed with SPSS for Windows version 21.0 (SPSS, Chicago, IL).

Results

Baseline patient, angiographic, and procedural characteristics

Of the 100 cases enrolled in the MECHANISM-elective study, the EEL border could not be visualized or measured in 13 patients (13.0%) who had mild atherosclerotic lesion at distal edge, and the pre-stenting OCT images were of insufficient quality due to poor blood cell removal in 16 patients (16.0%). After excluding these cases from analysis, 71 lesions in 71 patients with visible EEL were finally analyzed. When classified according to the criteria for aggressive stent expansion, 24 of the 71 lesions (34%) were classified as aggressive stent expansion (Group A), and the remaining 47 lesions (66%) were classified as without aggressive stent expansion (Group B).

Overall, median age was 74 years and 70% of patients were male (Table 1). In comparisons between Groups A and B, characteristics appeared similar except for the prevalence of diabetes mellitus (42% vs. 68%, respectively; $p = 0.03$). In terms of the angiographic findings, reference vessel diameter was smaller in Group A than in Group B (2.27 vs. 2.55 mm, respectively; $p = 0.005$). In terms of PCI procedure (Table 2), selected stent diameter was significantly smaller in Group A than in Group B (2.62 vs. 3.00 mm, respectively; $p = 0.01$). The frequency of distal optimization by non-compliant balloon was

higher in Group A than in Group B (33% vs. 11%, respectively; p = 0.02). Regarding the post-PCI angiographic characteristics, maximum balloon diameter/reference diameter ratio was higher in Group A than in Group B (1.32 vs. 1.20, respectively; p = 0.02).

Pre-stenting and post-PCI OCT assessment

In pre-stenting OCT assessment, mean reference lumen area was smaller in Group A than in Group B (4.40 mm^2 vs. 6.15 mm^2, respectively; p = 0.02) (Table 3). Although calcification potentially relates to under-expansion, no difference in frequency of >180° of calcification was identified between the groups. In post-PCI OCT assessment (Table 4), stent expansion was comparable and acceptable in both groups (0.92 vs. 0.90, respectively; p = 0.48), although vessel size was different in each group. Regarding stent edge findings, both groups had similar presence of any stent edge dissection (25% vs. 15%, respectively; p = 0.30) and major stent edge dissection (13% vs. 4%, respectively; p = 0.20) at either the proximal or distal edge (Fig. 2). In addition, similar qualitative findings, including in-stent thrombus, number of tissue prolapses, number of stent malappositions, and presence of irregular protrusion, were observed in the two groups. In this cohort, aggressive stent expansion was performed for a target vessel diameter ≤3.0 mm (Fig. 3).

Follow-up OCT assessment and clinical outcomes

Neointimal thickness at 1 and 3 months after CoCr-EES implantation (primary endpoint) was 0.040 mm (0.025–0.047 mm) and 0.038 mm (0.029–0.055 mm), respectively. These values had no relationship with difference in vessel–balloon diameter or distal reference lumen diameter (Fig. 4). Comparing groups with and without aggressive stent expansion, median neointimal thickness at 1 and 3 months after CoCr-EES implantation was similar (1 month: 0.031 mm vs. 0.041 mm, respectively, p = 0.27; 3 months: 0.036 mm vs. 0.040 mm, respectively, p = 0.84). Most dissections had completely resolved at 1 or 3 months (Fig. 5). Moreover, all stent edge dissections were resolved at the 12-month follow-up (Fig. 6). No instances of cardiac death, clinically driven target lesion revascularization, or stent thrombosis were identified in either group during 1 year of clinical follow-up, whereas one case of any acute myocardial infarction was recorded in each group (4.2% vs. 2.1%, p = 0.62).

Discussion

In this sub-analysis of the MECHANISM-elective study, we used serial OCT images to retrospectively examine the impact of aggressive stent expansion on early vascular healing after CoCr-EES implantation. The main findings of the present study are as follows: 1) No relationship between aggressiveness of stent expansion and early vascular healing was evident at the 1- or 3-month follow-ups. 2) Distal and proximal edge dissections after stenting were not increased by aggressive stent expansion, and most dissections had resolved completely within 3 months. Even though the operator made an effort to avoid stent under-expansion when the target vessel was small, aggressive stent expansion might have a small impact on excessive proliferation of in-stent neointima and the incidence of stent edge dissections when a CoCr-EES is implanted.

The main reason why the present study did not show excessive neointimal proliferation when a CoCr-EES was implanted with aggressive expansion is that CoCr-EESs offer excellent performance in terms of vascular healing compared with BMSs or first-generation DESs. Basically, late lumen loss at follow-up 6-8 months after CoCr-EES implantation is markedly thinner than that observed after BMS implantation [14, 15]. In addition, according to recent OCT studies that used images from follow-up after 6-7 months, mean neointimal thickness after CoCr-EES implantation was thinner (0.08–0.09 mm) [16-18] compared with that after BMS implantation (0.29 mm) reported in a much earlier IVUS study [4]. Modest neointimal hyperplasia following CoCr-EES implantation may thus obscure excessive vascular healing when aggressive stent expansion is performed. Another reason for the lower impact of aggressive stent expansion on early vascular healing might be that lesions showing geographic mismatch were excluded from analyses. Lesions with edge disease were excluded as the EEL borders were not visible. This may have resulted in all analyzed stents being located in less atherosclerotic segments, which were most likely to show a plaque burden <50%. Considering that plaque burden >55% or lipid-rich plaque at a post-stenting reference segment has been correlated with stent edge restenosis [19, 20], the findings of the present study suggest that optimal stent landing also reduces injury to the atherosclerotic segment by aggressive stent expansion.

At post-procedure, the presence of any and distal stent edge dissection after aggressive stent expansion was 25% and 8%, respectively. As previous large-scale OCT studies have shown similar incidences of stent edge dissection (any: 29%–33%, distal: 6%–16%) [5, 13, 21-23], the results of the present OCT study suggest that aggressive stent expansion based on EEL-based sizing has a little impact on stent edge dissection for mild to moderately calcified lesions. However, those incidences in

group B were 15% and 6%, which were numerically less frequent than those in group A. Even though there were no statistical difference in the incidences of stent edge dissection between both groups, aggressive stent expansion may be related with stent edge dissection. On the other hand, the present study also demonstrated that most stent edge dissections had resolved within 3 months after stenting without ischemic events. Although resolution of stent edge dissections at 8–12 months has been reported [22, 24, 25], none has been demonstrated within 3 months. Based on our results and the evidence that adverse clinical events rarely occur after the first 3 months in patients with suboptimal OCT criteria, including stent edge dissection [23], it appears that minor stent edge dissection (as detected by post-procedure OCT imaging) may be mostly resolved at around 3 months after PCI.

To determine vessel size, we retrospectively applied EEL-based sizing following the ILUMIEN III sizing protocol. However, the optimal method for stent sizing has yet to be established, at least in terms of EEL-based or lumen-based sizing [7]. Even though OCT can determine stent size in fine detail, the EEL border at the distal reference segment could not be determined in 29% of our cohort and in 23% of the ILUMIEN III cohort [5, 7]. In addition, when the operator cannot avoid lipid-rich plaque for the distal landing due to a diffuse or long lesion, aggressive expansion may be unsuitable because the incidence of stent edge dissection is increased by lipid-rich plaque [21]. Considering these exceptions, further investigations may be needed to establish optimal stent sizing based on OCT measurements.

The present study demonstrated good clinical outcomes from treatment with CoCr-EES and the results appear quite reasonable with respect to those of previous trials [26-28]. Focusing on the clinical outcomes of aggressive stent expansion, Kitahata et al. have already reported the feasibility of aggressive expansion of DES in terms of 1-year clinical outcomes, including target lesion revascularization and stent thrombosis [29]. However, in that study, 90% of DESs were first-generation stents, and stent size was determined on the basis of angiography. Thus, for second-generation DESs, the present study is the first to report the efficacy of aggressive stent sizing as determined by OCT imaging, even though the clinical data remain limited. Although it is difficult to obtain large stent area in small vessels, there was a tendency to perform aggressive expansion for small vessel lesions in this study. Even in the aggressive expansion group, many problems such as remaining edge dissection and excessive neointimal hyperplasia did not occur at early term follow-up. From the results of this study, it is considered that the safety of aggressive expansion of EEL base was shown even in small vessels when edge disease was avoided.

Limitations

The present study has several limitations. First, the sample size was too small to reveal the impact of aggressive stent expansion on clinical outcomes such as including cardiac death, revascularization and stent thrombosis. Second, because of the small-sized observational nature of the study and selection bias (i.e. diabetic patients were less frequently performed aggressive expansion), it was difficult to eliminate differences in patient background from the analyses. Third, the lesions with geographic mismatch, which mostly had edge disease were excluded from each analysis. Real-world data indicate that even for DESs implanted under IVUS guidance, one-sixth of stents were placed at a diseased reference segment that had a moderate amount of plaque [30]. Therefore, we did not assess the impact of aggressive expansion on early vascular healing in lesions with distal edge disease. Fourth, because we only used CoCr-EES, it remains unclear whether our results represent common phenomena among current-generation DES. Fifth, the frequency of severe calcification was relatively low in the present study. Accordingly, the results of the present study cannot be applied to heavily calcified lesions that carry a high risk of stent under-expansion, for which rotational or orbital atherectomy is recommended.

Conclusion

Excellent vessel healing was observed as early as 1 or 3 months after CoCr-EES implantation regardless of the aggressiveness of stent expansion. These findings suggest that EEL-based OCT sizing may be feasible in the treatment of small-sized vessels.

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Compliance with ethical standards

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Figure Captions

Fig. 1 Definitions of aggressive and non-aggressive stent expansion. White arrows: EEL diameters. Yellow arrows: lumen diameters. Dotted line: EEL border. Group A = aggressive expansion group; Group B = non-aggressive expansion group

Fig. 2 Frequency of post-procedure stent edge dissection in lesions with and without aggressive stent expansion. Group A = aggressive expansion group; Group B = non-aggressive expansion group. Left panel: distal stent edge dissection; right panel: proximal stent edge dissection. Black bar: major stent edge dissection; white bar: minor stent edge dissection

Fig. 3 Relationship between aggressiveness of stent expansion and vessel diameter. Black circles: 1-month follow-up cohort; white circles: 3-month follow-up cohort. Difference in vessel–balloon diameter = distal EEL diameter – maximum balloon diameter. EEL = external elastic lamina

Fig. 4 Relationship of neointimal thickness with aggressiveness of stent expansion and distal reference lumen diameter. A: Relationship between aggressiveness of stent expansion and neointimal thickness at 1-, 3-, and 12-month follow-ups. B: Relationship between distal reference lumen diameter and neointimal thickness at 1-, 3-, and 12-month follow-ups. Difference in vessel–balloon diameter = distal EEL diameter – maximum balloon diameter. EEL = external elastic lamina

Fig. 5 Representative OCT images of stent edge dissection at post-procedure and at the 1- or 3-month follow-ups. Left panel: Post-procedure OCT images; right panel: follow-up OCT images

Fig. 6 Frequency of stent edge dissection at post-procedure and at 1-, 3-, and 12-month follow-ups. Black bar: major stent edge dissection; white bar: minor stent edge dissection

Table 1. Baseline patient and angiographic characteristics

	Group A (n = 24)	Group B (n = 47)	p-value
Age, y	74 (69–77)	73 (62–78)	0.64
Male sex	15 (63)	35 (75)	0.30
Diabetes mellitus	10 (42)	32 (68)	0.03
Hypertension	19 (79)	43 (92)	0.14
Hyperlipidemia	22 (92)	38 (81)	0.23
Current smoker	9 (38)	19 (40)	0.81
Prior PCI	10 (42)	16 (34)	0.53
Prior CABG	0	0	N/A
Prior myocardial infarction	6 (25)	11 (23)	0.88
Target vessels			0.50
LAD	10 (42)	23 (49)	
LCX	7 (29)	8 (17)	
RCA	7 (29)	16 (34)	
Minimum lumen diameter, mm	0.82 (0.64–0.97)	0.90 (0.70–1.08)	0.24
Reference diameter, mm	2.27 (2.04–2.57)	2.55 (2.32–2.85)	0.005
%Diameter stenosis	65.1 (60.2–74.6)	65.5 (55.7–72.3)	0.61
Lesion length, mm	15.3 (9.4–22.5)	15.5 (11.1–21.1)	0.69
AHA type B2/C lesion	19 (79)	41 (87)	0.37
Bifurcation	9 (38)	19 (40)	0.81

Data are presented as the median (1st quartile–3rd quartile), or as the n (%).

AHA = American Heart Association, CABG = coronary artery bypass grafting, N/A = not applicable, LAD = left anterior descending artery, LCX = left circumflex artery, PCI = percutaneous coronary intervention, RCA = right coronary artery

Table 2. Procedural characteristics and post-procedural angiographic findings

	Group A (n = 24)	Group B (n = 47)	p-value
Procedural characteristic			
Selected stent diameter, mm	2.62 (2.50–3.00)	3.00 (2.75–3.25)	0.01
Total stent length, mm	20.3 (14.9–28.0)	20.2 (14.7–26.7)	0.66
Maximum balloon diameter, mm	3.00 (2.56–3.44)	3.00 (3.00–3.50)	0.28
Maximum balloon pressure, atm	15.0 (12.5–19.5)	14.0 (14.0 –18.0)	0.72
Distal optimization	8 (33)	5 (11)	0.02
Proximal optimization	14 (58)	28 (60)	0.92
Angiographic characteristic			
Reference diameter, mm	2.73 (2.36–2.99)	2.78 (2.43–3.05)	0.52
B/A ratio	1.32 (1.18–1.43)	1.20 (1.13–1.27)	0.02
%Diameter stenosis	11.3 (7.2–16.3)	10.6 (7.3–14.2)	0.50
Stent length, mm	20.3 (14.8–26.9)	20.3 (14.8–27.0)	0.82
Final TIMI flow grade 3	24 (100)	46 (98)	0.47
dissection	1 (4)	0 (0)	0.16

Data are presented as median (1st quartile–3rd quartile), or n (%)

B/A ratio = maximum balloon diameter/reference diameter ratio

EEL = external elastic lamina, NC = non-compliant, TIMI = Thrombolysis In Myocardial Infarction

Table 3. Pre-stenting OCT assessment

	Group A (n = 24)	Group B (n = 47)	p-value
Lesion length, mm	24.0 (18.6–32.6)	22.4 (15.4–28.8)	0.23
Minimum LA, mm^2	1.15 (0.95–1.59)	1.39 (1.07–2.00)	0.12
Mean reference LA, mm^2	4.40 (3.50–5.96)	6.15 (5.01–6.94)	0.02
Calcification (>180°)	5 (21)	12 (26)	0.66
Thin-cap fibroatheroma	4 (17)	8 (17)	0.97
Thrombus	5 (21)	17 (36)	0.19

Data are presented as median (1st quartile–3rd quartile), or n (%)

EEL = external elastic lamina, LA = lumen area

Table 4. Post-PCI OCT assessment

	Group A (n = 24)	Group B (n = 47)	p-value
Quantitative assessment			
Lesion length, mm	24.0 (18.4–31.8)	20.4 (15.4–29.3)	0.30
Mean reference LA, mm^2	4.50 (3.58–6.16)	6.04 (5.21–6.98)	0.004
Distal reference diameter, mm	2.11 (1.89–2.50)	2.63 (2.33–3.03)	<0.001
Minimum distal EEL diameter, mm	2.71 (2.25–3.19)	3.78 (3.43–4.06)	<0.001
MSA, mm^2	4.31 (3.21–5.34)	5.59 (4.36–6.35)	0.008
MSA >4.5 mm^2	10 (42)	34 (72)	0.012
Stent expansion (MSA/mean reference LA)	0.92 (0.79–1.13)	0.90 (0.80–0.98)	0.48
Qualitative assessment			
Presence of any stent edge dissection	6 (25)	7(15)	0.30
Presence of stent distal edge dissection	2 (8)	3 (6)	0.76
Presence of stent proximal edge dissection	5 (21)	5 (11)	0.24
Presence of major stent edge dissection	3 (13)	2 (4)	0.20
Presence of in-stent thrombus	16 (67)	36 (77)	0.37
Number of tissue prolapses (≥250 μm)	1 (0–2)	1 (0–2)	0.58
Number of stent malappositions	5 (3–7)	4 (2–6)	0.18
Presence of irregular protrusion (≥100 μm)	3 (13)	13 (28)	0.15

Data are presented as the median (1st quartile–3rd quartile), or as the n (%)

EEL = external elastic lamina, LA = lumen area, MSA = minimum stent area

Figure 1

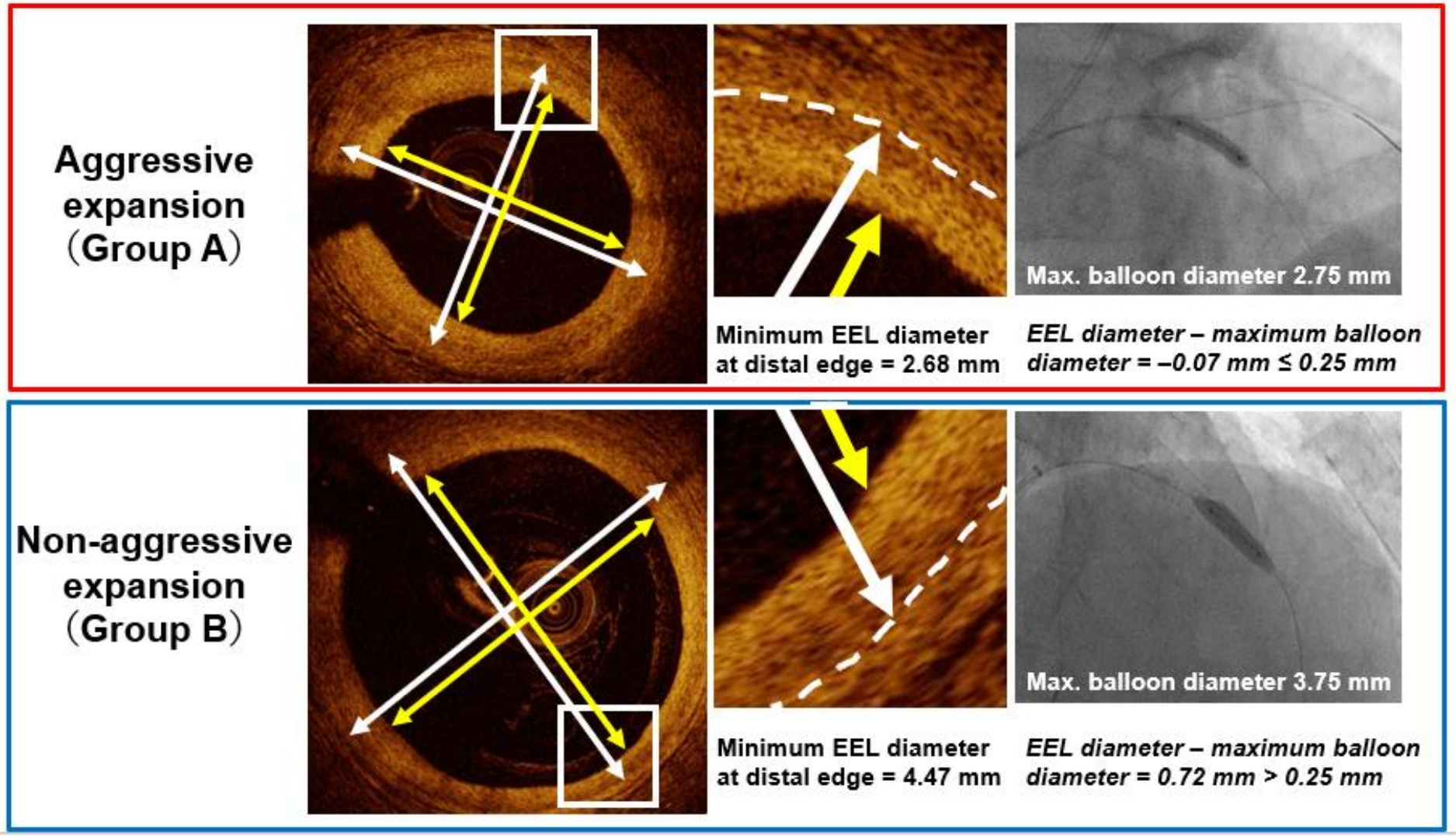

Aggressive expansion (Group A)
Minimum EEL diameter at distal edge = 2.68 mm
EEL diameter – maximum balloon diameter = –0.07 mm ≤ 0.25 mm
Max. balloon diameter 2.75 mm
Non-aggressive expansion (Group B)
Minimum EEL diameter at distal edge = 4.47 mm
EEL diameter – maximum balloon diameter = 0.72 mm > 0.25 mm
Max. balloon diameter 3.75 mm

Figure 2

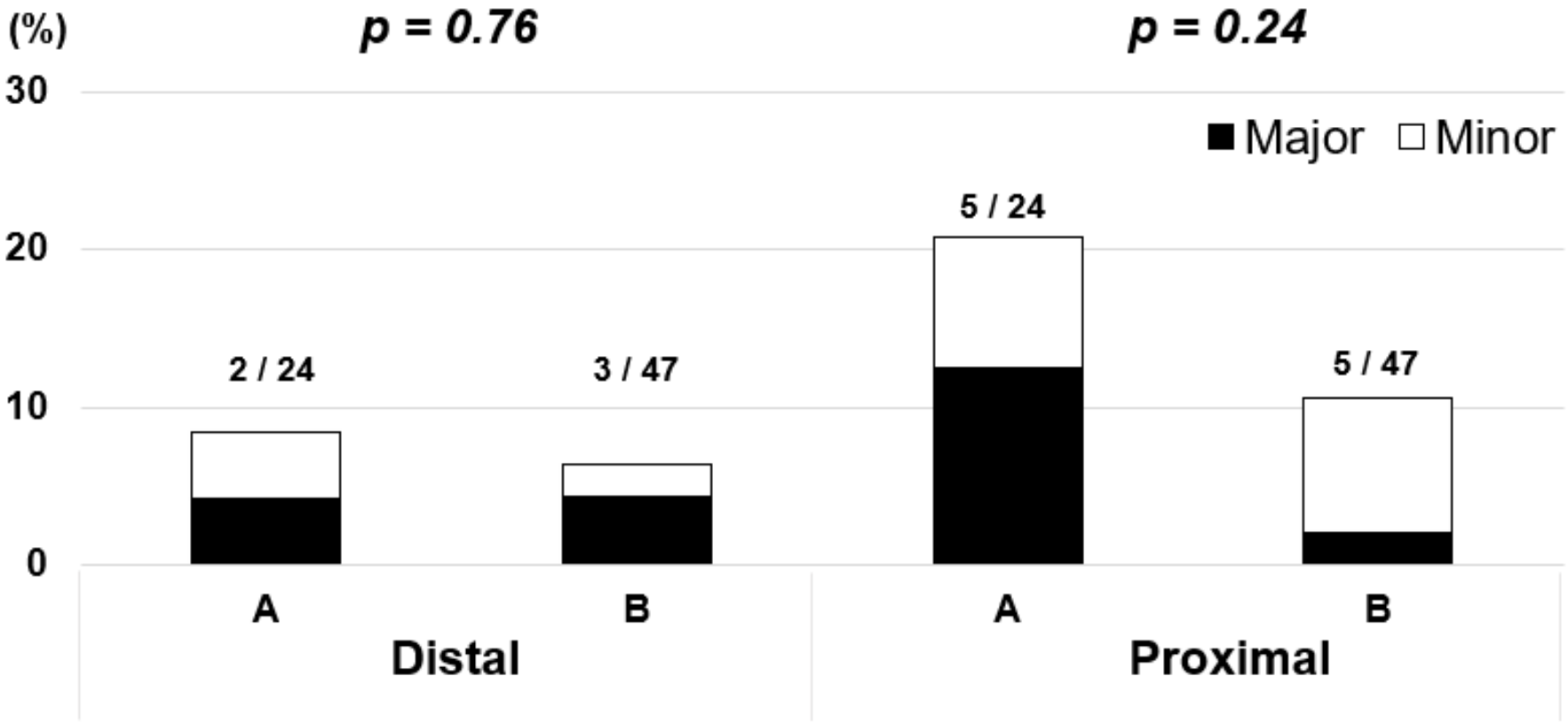

(%)
p = 0.76
p = 0.24
30
20
10
0
Major
Minor
2 / 24
3 / 47
5 / 24
5 / 47
A
B
A
B
Distal
Proximal

Figure 3

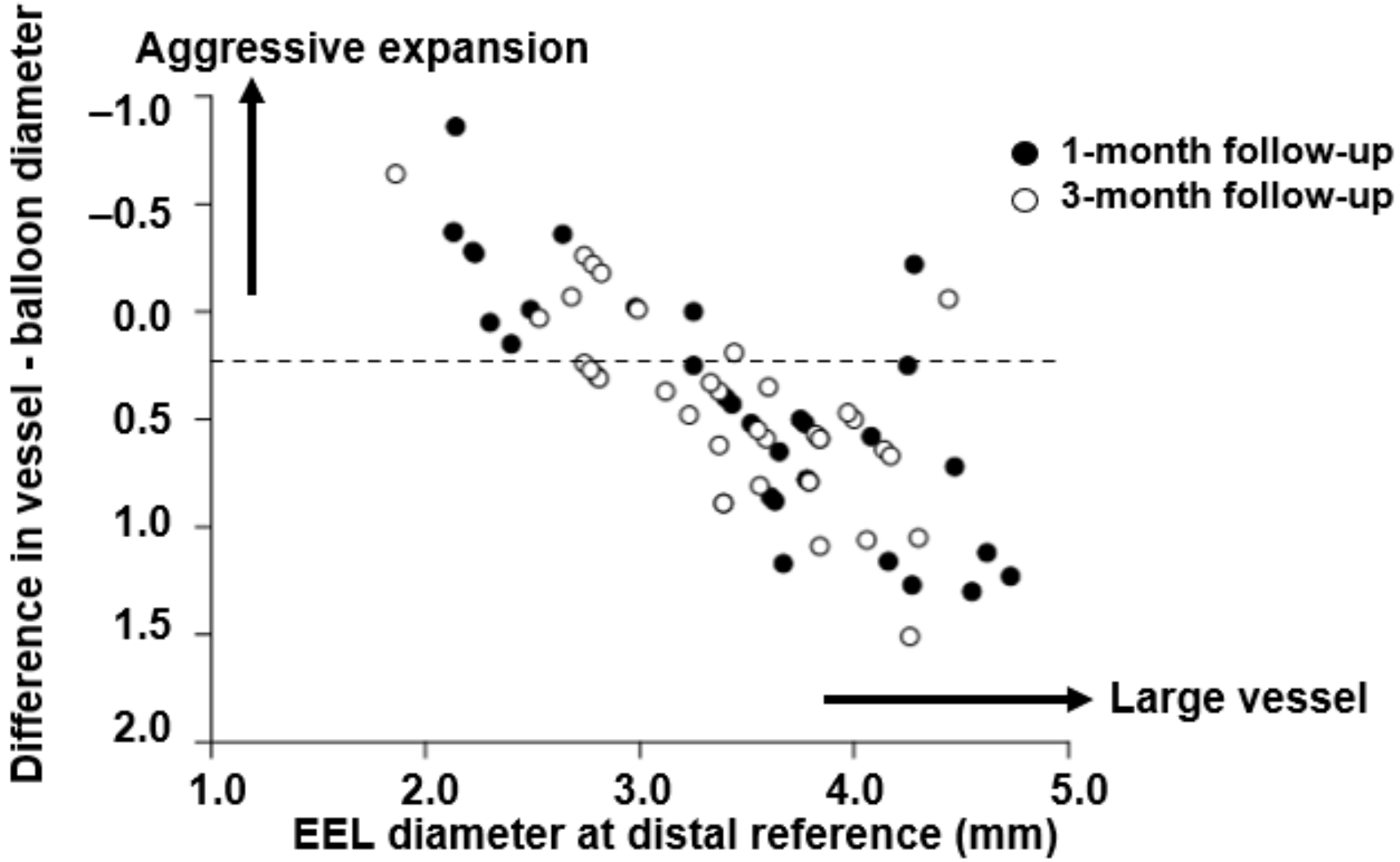

Aggressive expansion
Difference in vessel - balloon diameter
–1.0
–0.5
0.0
0.5
1.0
1.5
2.0
1-month follow-up
3-month follow-up
Large vessel
1.0
2.0
3.0
4.0
5.0
EEL diameter at distal reference (mm)

Figure 4

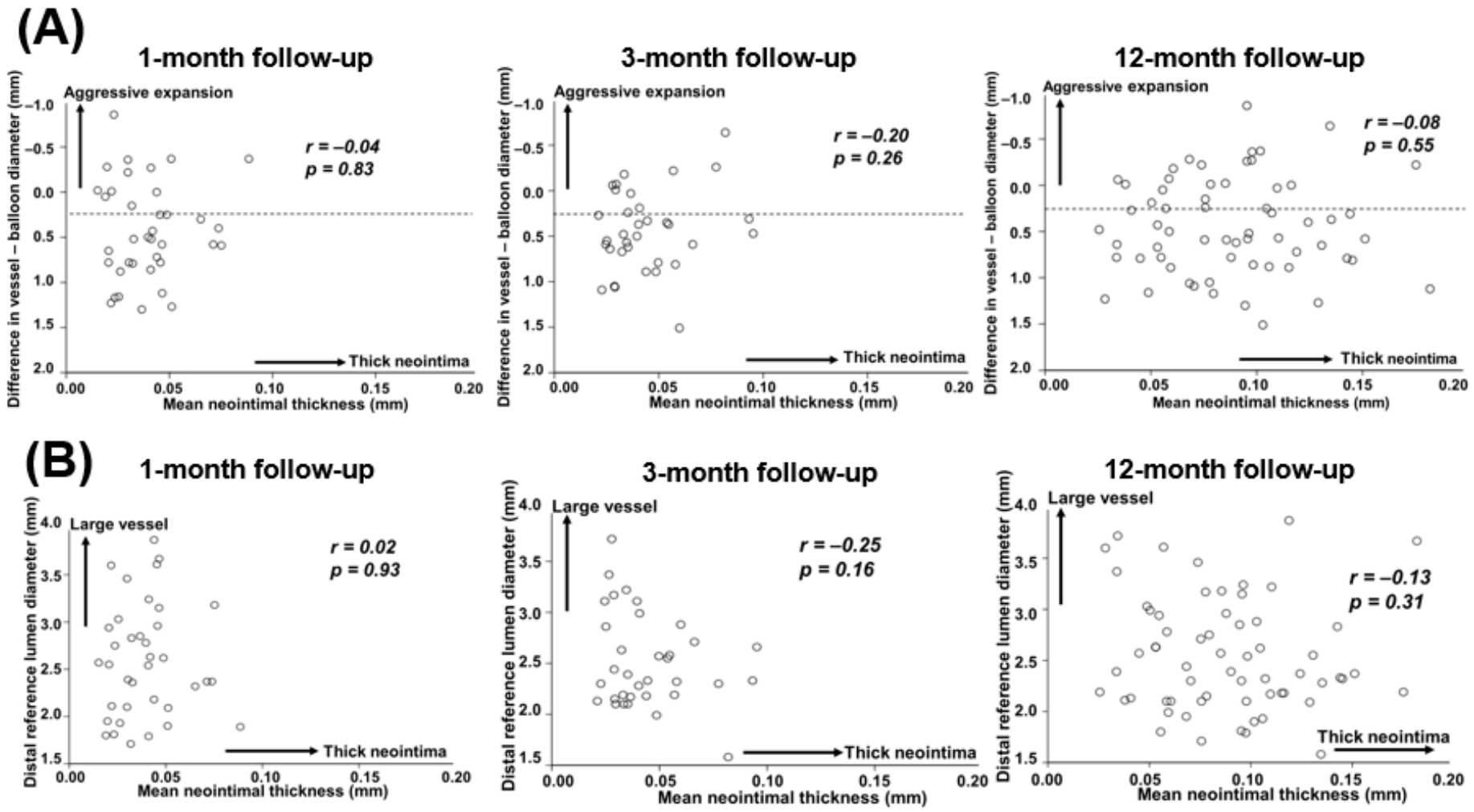

(A)
1-month follow-up
3-month follow-up
12-month follow-up
Aggressive expansion
Thick neointima
Difference in vessel – balloon diameter (mm)
Mean neointimal thickness (mm)
r = –0.04
p = 0.83
r = –0.20
p = 0.26
r = –0.08
p = 0.55
(B)
1-month follow-up
3-month follow-up
12-month follow-up
Large vessel
Thick neointima
Distal reference lumen diameter (mm)
Mean neointimal thickness (mm)
r = 0.02
p = 0.93
r = –0.25
p = 0.16
r = –0.13
p = 0.31

Figure 5

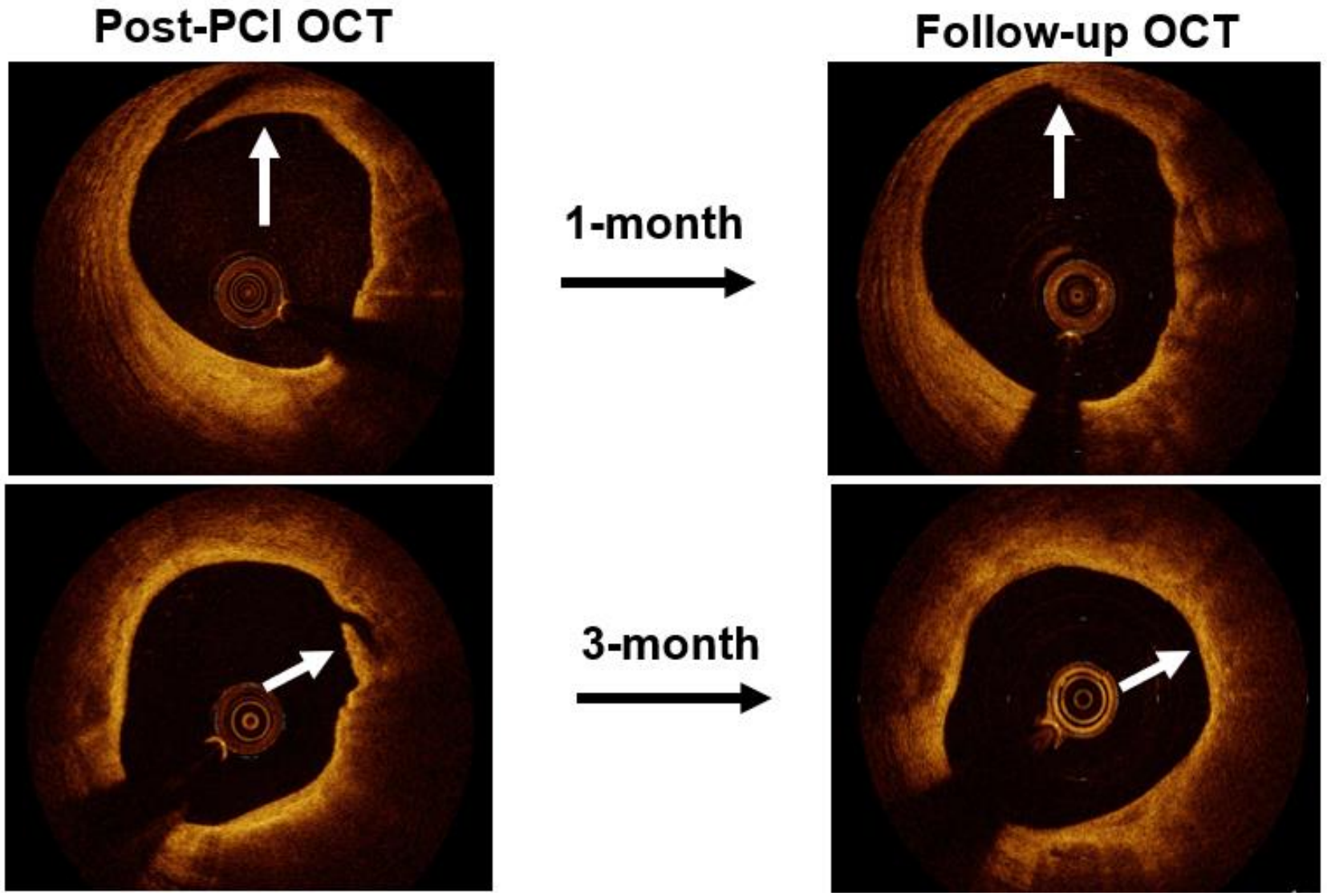
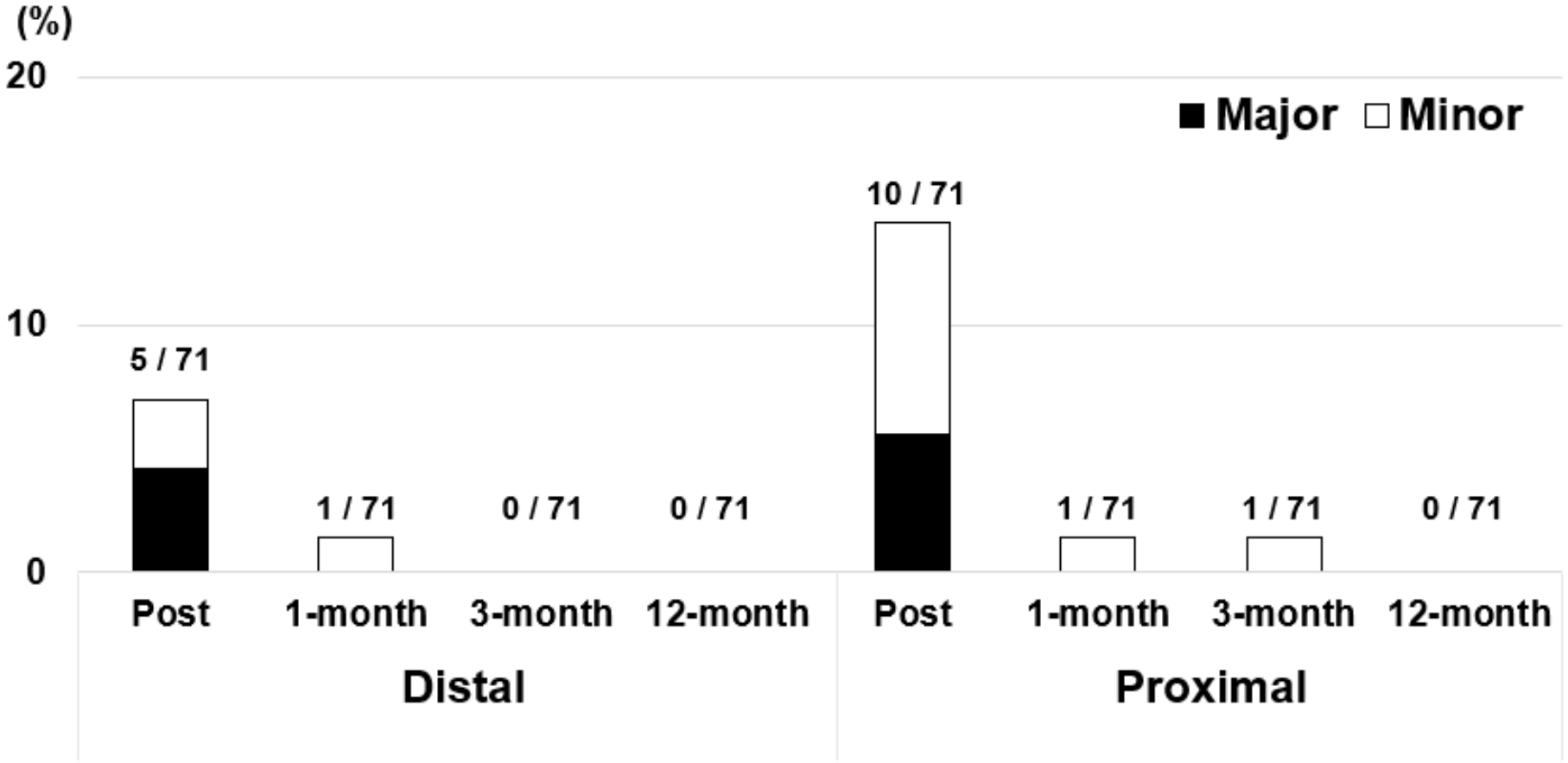


Figure 6


(%)
20
10
0
Major
Minor
5 / 71
1 / 71
0 / 71
0 / 71
10 / 71
1 / 71
1 / 71
0 / 71
Post
1-month
3-month
12-month
Post
1-month
3-month
12-month
Distal
Proximal