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Mid-Term Outcomes of Stent Overlap in Long Total Occluded Lesions of Superficial Femoral Artery

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Background: Superficial femoral artery chronic total occlusion (SCTO) is a common type of peripheral arterial disease (PAD). Endovascular therapy is a treatment approach that has a poor long-term success rate in this group. The aim of this study was to compare the mid-term results of two different uses of nitinol stents in long SCTO lesions (>100 mm): the use of one long stent or two shorter stents.

Material/Methods: Of 154 patients who underwent percutaneous infrainguinal interventions from 2011 to 2014, a total of 170 CTO lesions were selected for this retrospective study analysis. The mean age of the study population was 63.4±10.4 years (range 29–89 years); 71.8% of the patients were male.

Results: Patients were divided into two groups according to the number of stents used. Patients treated with a single stent were placed into group A and patients treated with two stents were placed into group B. The stent fracture rate was significantly higher in group B compared to group A (29.2% *vs.* 42%). Type 1 and 2 fracture rates were higher in group A, but type 3 and 5 fracture rates were significantly higher in group B. The rate of stent restenosis was significantly higher in group B compared to group A (45.1% *vs.* 54.5%, p=0.05).

Conclusions: Mid-term patency rate was low in patients with long totally occluded superficial femoral artery (SFA) lesions. Using a long single stent had an acceptable mid-term patency rate compared to using a two stent strategy. Stent fracture seemed to be the main reason for in-stent restenosis in cases of multiple stenting. A long single stent strategy may be more appropriate and reasonable than a two stent strategy in the treatment of long SFA lesions.

MeSH Keywords: Femoral Artery • Peripheral Vascular Diseases • Stents

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Background

Peripheral arterial disease (PAD) incidence rate ranges between 12–20% in the 65 year old and older population [1] and this percentage increases with age. Superficial femoral artery chronic total occlusion (SCTO) is a common type of PAD [2]. Superficial femoral artery atherosclerosis is a diffuse disease characterized by the presence of moderate to severe calcification [3] that can adversely affect treatment response. Open surgical revascularization is accepted as an appropriate treatment [4], however, endovascular therapy (EVT) is more widely used and has lower mortality and morbidity rates compared to surgery. The rate of procedure success and the rate of limb-saving are similar, and if necessary, surgery can be a last resort [5–7]. EVT has a reported success rate of 95% in SCTO [8], however, the long-term patency rate falls below 50% depending on the structure and location of the vessels [9]. Vessels exposed to mechanical factors (external forces, compression, torsion, and elongation) [10] have an increased frequency of restenosis and stent fracture. Nitinol stents are designed to be more flexible and resistant to mechanical stress in order to provide long-term patency and to reduce stent fracture [10]. Stent fracture is still a serious problem despite improvement in the structure of the nitinol stent aimed to reduce fractures. It is unclear whether the reported low success rates, especially in earlier studies involving long lesions, was due to the use of multiple stents or long stents since the nitinol stents used in older studies were shorter. Additional effects of multiple stenting on stent fracture and restenosis is unknown. The aim of this study was to compare the mid-term patency results of the use of a single long nitinol stent to the use of two shorter nitinol stents to treat long SCTO lesions (>100 mm).

Material and Methods

Of 154 patients who underwent percutaneous infrainguinal interventions, a total of 170 CTO lesions were selected for the retrospective study analysis; 111 consecutive limbs from 97 patients with severe SCTO treated with EVT between July 2011 and June 2014 were included in this study. Patients with acute ischemia requiring urgent intervention and patients who had symptoms for the last three months were excluded. Informed consent was obtained from all patients and the ethics committee of the hospital approved this study.

Enrolment criteria

The criteria for enrolling patients in this study were as follows: (1) lifestyle-limiting claudication (for more than three months) or critical limb ischemia (CLI) defined as rest pain or tissue loss; (2) a long lesion with a total occlusion of >10 cm; (3) inoperable condition due to comorbid disease (i.e., severe heart failure, renal failure, chronic pulmonary disease such as chronic obstructive pulmonary disease), patients who might not survive major surgery, or patients who refused bypass surgery. The major exclusion criteria were: a target lesion that extended into the popliteal artery, and a previous implantation of a stent in the targeted superficial femoral artery (SFA). The degree of calcification was evaluated visually from angiographic views as we did not use intravascular ultrasound (IVUS) in our patient population. The patients were divided into two groups: group A was treated with a single long stent, and group B was treated with a double stent. Patients with incomplete recanalization and missing follow-up data were excluded from the study.

Treatment protocols

Once-daily dose of 325 mg aspirin, before and after the procedure, and 75 mg clopidogrel daily for 7 days before the procedure, 300 mg for 3 days before the procedure, or 600 mg within 24 hours before or immediately after the procedure, (aspirin 100 mg/day, clopidogrel 75 mg/day) were given to all the patients. Arterial access was gained through an ipsilateral or contralateral common femoral artery puncture. Contralateral puncture was applied in patients with ostial SFA occlusion. Intentional subintimal access was achieved using either a hydrophilic 0.035 inch wire or a 0.018 inch guidewire. Intravenous heparin (100 Ul/kg) was administered at the start of all the procedures. Primary angioplasty was performed with appropriately sized noncompliant balloons with inflation times ranging from 60–180 seconds after the SFA recanalization. We implanted a nitinol stent in accordance with the American College of Cardiology/American Heart Association guidelines [11] to patients who had a residual pressure gradient >10 mm Hg, residual stenosis >30%, and/or flow-limiting dissection after balloon therapy. The stents were self-expandable and had the diameter approximately 2-mm larger than the reference diameter. Selective stenting with self-expanding nitinol stents (the Protégé EverFlex Self-Expanding Peripheral Stent System, Plymouth, MN, USA) was performed. Overlapping segment was approximately 5–10 mm in patients treated with a double stent. Stent implantation was never performed in the middle or distal third of the popliteal artery.

Follow-up

All patients were discharged with oral antiplatelet therapy consisting of aspirin indefinitely, and clopidogrel 75 mg per day for at least one month after the procedure. Anticoagulant therapy was initiated in select patients. Clinical evaluations, such as symptom changes, ankle brachial index measurement, ultrasonographic evaluation of lesion patency, and stent fracture follow-up with x-ray were performed at baseline, 3, 6, 12, 18, and 24 months. Primary patency was defined as detection

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of peak systolic velocity ratio <2.4 on duplex ultrasound [12]. Angiography was performed in patients with peak velocity ratio above 2.4 on duplex ultrasound, no-flow in stent, or clinical suspicion of restenosis (decrement in the ankle-brachial index (ABI) or worsening symptoms reflected by changes in the Rutherford category). The in-lesion segment was defined as the in-stent segment plus 5 mm proximal and distal to the stent. A >50% stenosis on angiography was defined as in-stent restenosis. A stent fracture was defined as the complete/incomplete separation of the stent strut (>1 to 2 mm) identified by x-ray from four projections that lead to kink or misalignment along the axial length of the stent. Stent fracture classification published by Rocha-Singh et al. was used [13]. In summary, we classified stent fracture into the following five types: Type I, a single-tine strut fracture only; type II, multiple strut fractures at different sites; type III, stent fracture(s) with preserved alignment of the components; type IV, stent fracture(s) with malalignment of the components; type V, stent fracture(s) in a trans-axial spiral configuration. We performed an x-ray for four projections on every visit to evaluate the stent fracture. Overall primary patency, patency associated with and without stent fracture, patency according to the types of nitinol stents, and the morphology of the stent fracture were the outcomes of this study. Angiography was performed on the patients who had clinical and ultrasonographic findings supporting in-stent restenosis.

Statistical analysis

All statistical analyses were performed using SPSS (SPSS Inc., Chicago, IL, USA). Data were presented as mean ± standard deviation. We used unpaired *t*-test to compare the continuous variables between the groups, and chi-square test was used to compare ratios. The Kaplan-Meier method of survival analysis was used in order to determine primary patency, and primary patency was compared by log-rank testing. A p value <0.05 was accepted as statistically significant.

Results

Patient characteristics

From 2011 to 2014, 187 limbs from 169 patients were treated. The revascularization attempt failed in seven patients with SFA lesions. After excluding nine patients (10 SCTOs) who did not have follow-up data available (due to myocardial infarction, cerebral infarction, and infection), 154 patients (170 CTOs) were included in the study: the mean patient age 63.4±10.4 years (range 29–89 years); and 71.8% were males. Patient characteristics were consistent with the intended study population and are summarized in Table 1. The most common pre-existing risk factors were: smoking defined as current or recent smoking (less than one year since cessation), 89.4% (152 patients); hypertension, 80% (136 patients); hyperlipidemia, 64.1% (109 patients); and coronary artery disease, 61.1% (104 patients). Demographics, comorbid conditions, symptom status, and lesion morphology are listed in Tables 1 and 2. Medication, body mass index, and biochemical parameters were similar between the two groups. The average Rutherford classification score was 3.6±0.9 on admission; 35 patients (20.5%) had critical limb ischemia (CLI), and the average ABI was 0.41±0.14.

Procedural results

Our success rate was 96.3% for the totally occluded SFA process. Recanalization could not be achieved in seven of the 187 limbs. The mean lesion length was 154.5±35.9 mm. Severe calcification was observed in 38 patients (22.3%), and was significantly more common in group B than group A (31.8% *vs.* 12.2%). The average vessel diameter was 6.9±0.7 mm, and there was no difference between the two groups. Details of pre-procedural lesion characteristics are summarized in Table 2. Stent fracture rates after the follow-up are given Table 3. Fracture rate was significantly higher in group B (29.2% *vs.* 42%). Type 1 and 2 fracture was higher in group A, but type 3 and 5 fractures were significantly higher in group B (Table 3). There was a significant correlation between the presence of restenosis and stent fracture (70.4%, 43/61 patients). The effect of stent fracture morphology on restenosis was also evaluated. Restenosis occurred in almost all patients with type 5 fractures (92.8%, 13/14 patients). Although type 1 and 2 stent fractures (38%, 8/21 patients) revealed similar outcomes compared with those without stent fractures (38.5%, 42/109 patients), higher rates of restenosis were detected in patients with type 3 and 4 fractures (84.6%, 11/13 patients). Also, higher restenosis rates were seen in patients with multiple stent fractures (70%, 14/20 patients) (Table 3). Primary patency was 92%, 76%, 63%, and 50% at 6, 12, 18, and 24 months, respectively and fracture rate was 9.2%, 17.8%, 23.5%, and 35.8% at 6, 12, 18, and 24 months, respectively. The overall restenosis rate was 50% in the study population, although group B had a higher restenosis rate than group A (45.1% *vs.* 54.5% p=0.05) (Table 4). In all, 90 patients underwent coronary angiography, in which restenosis was determined according to duplex ultrasound. Restenosis was detected in 85 patients.

Discussion

During the follow-up period, the patency rate decreased in both groups and the restenosis rate was found to be 50% at two years. Restenosis was significantly associated with stent fracture. Also, risk of restenosis increased with increasing severity of fractures. Restenosis developed in almost all patients

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Table 1. Baseline demographic characteristics of patients.

	Overall (170 p)	Group A (82 p)	Group B (88 p)	P Value
Age	63.4±10.4	61.9±11.6	64.8±9.1	N
Men	71.8% (122)	73.2% (60)	70.5% (62)	N
Hypertansion	80% (136)	70% (64)	81.8% (72)	N
Hyperlipidemia	64.1% (109)	62.1% (51)	65.9% (58)	
Diabetes mellitus	48.2% (82)	51.2% (42)	45.4% (40)	N
Smoking (current)	89.4% (152)	90% (74)	88.6% (78)	N
Renal failure	17.6% (30)	14.6% (12)	20.5% (18)	N
Cerebrovascular disease	3.5% (6)	2.4% (2)	4.5% (4)	N
Coronary artery diseas	61.1% (104)	56.1 (46)	65.9% (58)	N

P – patients; N – non-significant.

Table 2. Lower limb and lesion characteristics.

	Overall	Group A	Group B	p Value
ABI	0.41±0.14	0.39±0.1	0.42±0.1	N
Rutherford classification	3.6±0.9	3.5±0.8	3.6±0.9	N
Critical limb ischemia	20.5% (35)	18.3% (15)	22.7% (20)	N
TASC II	2.6±0.5	2.4±0.5	2.8±0.4	N
Vessel diameter	6.9±0.7	6.8±0.8	7.0±0.7	N
Lesion lenght, mm	154.5±35.9	147±34.9	163.2±32.9	N
Lesion calcification				
Moderate/severe	22.3% (38)	12.2% (10)	31.8% (28)	0.05
Mild/none	77.7% (132)	87.8% (72)	68.2% (70)	N

Critical limb ischemia; Rutherford stages 4–6. N – non-significant.

Table 3. Stent fracture and restenosis rates in groups.

	Overall	Group A	Group B	P value
Fracture rate	35.8% (61)	29.2% (24)	42% (37)	0,001
Type 1/restenosis rate	8.9% (15)	11% (9)	6.8% (6)	0.005
Type 2/restenosis rate	3.5% (6)	4.9% (4)	2% (2)	N
Type 3/restenosis rate	7.6% (13)	3.6% (3)	11.3% (10)	0.001
Type 4/restenosis rate	7.6% (13)	6.1% (5)	9% (8)	N
Type 5/restenosis rate	8.2% (14)	3.6% (3)	12.5% (11)	<0.001
Multi fracture/restenosis rate	11.1% (19)	8.5% (7)	13.6% (12)	0.002

N – non-significant.

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Table 4. Adverse event rates at 24 months.

	Overall	Group A	Group B	p value
Restenosis	50% (85p)	45.1% (37p)	54.5% (48)	0.05
Amputation	7% (12p)	7% (6p)	7% (6p)	N
Changes in ABI	0.36±0.28	0.42±0.25	0.29±0.29	0.05

P – patients; N – non-significant; ABI – ankle-brachial index.

with stent distortion (type V stent fracture). In addition, stent fracture and restenosis was significantly more common in the group treated with multiple stents. Demographic features and lesion length were similar between the groups. However, heavily calcified lesions were higher in group B.

SCTO lesions are a common type of PAD and are difficult to treat. EVT has three basic problems in the treatment of totally occluded lesions: (1) challenges in wire passage, (2) entry into the lumen, and (3) ensuring long-term patency. The technical success rate for EVT for stenotic and occlusive lesions in SCTO lesions has been shown to reach over 95% [14], and this ratio was 96.3% in our study. However, long-term patency is a major problem in lesions which have severe calcification [14,15]. In addition, atherosclerotic tissue with intense calcification induces a strong inflammatory response [15]. Similarly, in our study, severe calcification was observed in 22.8% of lesions. However, SFA is uniquely one of the longest and most dynamically active vessels [16]. SFA demonstrates bending, elongation, kinking movement other than the flexion and compressed due to muscle mass surrounding it. These movements increase the risk of in-stent restenosis by activating smooth muscle cell proliferation and inflammation [16–18]. Neointimal hyperplasia that evolves due to repetitive biomechanical forces is highly effective in the development of stent restenosis of SFA [16–18]. Moreover, this movement causes stent fracture. All these factors reduce the long-term success of EVT in SFA stenting. Although, intermediate-term restenosis rates are variable, it is usually nearly 50% [19–21], as observed in our results.

Stent fracture is considered an important obstacle to ensure long-term patency in SFA lesions. Also, stent fracture is one of the main reasons for lower success rates of balloon-expandable endovascular stents compared to balloon angioplasty alone [22]. Although fracture rates were lower with first generation nitinol stents, patency rates remained low in the long-term. The second-generation stent designs have tried to reduce the fracture rate. However, new generation nitinol stents degrades over time despite their elasticity. In addition, fractures have been observed in stents implanted for relatively immobile abdominal and thoracic aorta due to device fatigue [23]. Second-generation flexible nitinol stents were used in our study and the stent fracture rate was 35.8%. The stent fracture rate varied in other trials (2–53%) [24–26]. Variability of stent fracture rates may be related to stented segment length, stent design, stent location, and process technique. Increasing the stent length outside the size of the SFA is also a reason for stent fracture [26]. The mean lesion length in our study was 154.5±35.9 mm, and it was quite long compared to other studies. This may be a reason for our higher fracture rate.

Restenosis rate was 70.4% in patients with stent fractures. Restenosis rate increased with the severity of the fracture and restenosis reached 92.8% with type V fractures. According to several recent studies, stent fractures are associated with stent restenosis or reocclusions in about two-thirds of the cases. Particularly when stent fractures were categorized as type V, restenosis was observed in almost all cases [27]. As a result, preventing distortion of the stents seems to be an important step in the development of stent restenosis.

When the two groups were compared, fracture and restenosis rates were significantly higher in the group treated with two stents (Table 4) and may be related to higher fracture rates in this group (Table 3). In addition, multiple fractures were also higher in this group apart from severe stent fracture (type IV and V). Although mild (type I and II) stent fractures may be a benign condition in some patients, severe (type IV and V) stent fractures are associated with stent restenosis or reocclusion in the majority of the cases [28]. Our study also showed the similar results. While mild stent fracture (type I and II) was higher in patients treated with a single stent, severe fracture (type III–V) was higher in patients treated with two stents, with 78.5% of type V stent fractures occurring in this group. All of these factors may have contributed to higher restenosis rates. However, overlapping between stents may be the main reason for higher fracture and distortion in patients treated with two stents. In general, multiple stents are required to cover the lesion segment, and they should overlap by a minimum of 5–10 mm (5–20 mm). Although, this approach is applied in all vessels, it may not be suitable for SFA. Overlapping critically increases the axial stiffness of the stented segment [27]. Circular flexion between the hip and knee causes axial compression because of the anatomical position of the SFA. SFA is located in adductor canal and stents are exposed to axial and bending

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stress during the exercise and eventually stent distortion and fracture occur [29,30]. Overlapping reduces the flexibility of stents (special mechanical influences) and the physical stress response that leads to stent distortion and multiple fractures.

Conclusions

As a result, despite the quite higher success rate in long totally occluded SFA lesions, mid-term patency rate was still low. However, a long single stent had an acceptable patency rate at mid-term compared to a two stent strategy. Overlapping and stent fracture seemed to be the basic reason for restenosis in the multiple stent procedure. Perhaps, using long single stent in SFA lesions may be more appropriate to avoid fracture and distortion. If a multiple stent strategy has to be selected, stents could be implanted sequentially without overlapping.

Conflicts of interest

None.

References:

1. Ostchega Y, Paulose-Ram R, Dillon CF et al: Prevalence of peripheral arterial disease and risk factors in persons aged 60 and older: Data from the National Health and Nutrition Examination Survey 1999–2004. J Am Geriatr Soc, 2007; 55: 583–89
2. White C: Clinical practice. Intermittent claudication. N Engl J Med, 2007; 356: 1241–50
3. Yahagi K, Otsuka F, Sakakura K et al: Pathophysiology of superficial femoral artery in-stent restenosis. J Cardiovasc Surg (Torino), 2014; 55: 307–23
4. Gallagher KA, Meltzer AJ, Ravin RA et al: Endovascular management as first therapy for chronic total occlusion of the lower extremity arteries: Comparison of balloon angioplasty, stenting, and directional atherectomy. J Endovasc Ther, 2011; 18(5): 624–37
5. Jacobs DL, Cox DE, Motaganahalli R: Crossing chronic total occlusions of the iliac and femoral-popliteal vessels and the use of true lumen reentry devices. Perspect Vasc Surg Endovasc Ther, 2006; 18: 31–37
6. London NJ, Srinivasan R, Naylor AR et al: Subintimal angioplasty of femoropopliteal artery occlusions: the long-term results. Eur J Vasc Surg, 1994; 8: 148–55
7. Laxdal E, Jenssen GL, Pedersen G, Aune S: Subintimal angioplasty as a treatment of femoropopliteal artery occlusions. Eur J Vasc Endovasc Surg, 2003; 25: 578–82
8. Schlager O, Petra D, Schila S et al: Long-segment SFA stenting the dark sides:In-stent restenosis, clinical deterioration, and stent fractures. J Endovasc Ther, 2005; 12: 676–84
9. Schillinger M, Sabeti S, Dick P et al: Sustained benefit at 2 years of primary femoropopliteal stenting compared with balloon angioplasty with optional stenting. Circulation, 2007; 115: 2745–49
10. Schillinger M, Minar E: Past, present and future of femoropopliteal stenting. J Endovasc Ther, 2009; 16: 147–52
11. Gerhard-Herman MD, Gornik HL, Barrett C et al: 2016 AHA/ACC guideline on the management of patients with lower extremity peripheral artery disease: A report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. J Am Coll Cardiol, 2016 [Epub ahead of print]
12. Ranke C, Creutzig A, Alexander K: Duplex scanning of peripheral arteries: Correlation of the peak velocity ratio with angiographic diameter reduction. Ultrasound Med Biol, 1992; 18: 433–40
13. Rocha-Singh KJ, Jaff MR, Crabtree TR et al: Performance goals and endpoint assessments for clinical trials of femoropopliteal bare nitinol stents in patients with symptomatic peripheral arterial disease. Catheter Cardiovasc Interv, 2007; 69: 910–19
14. Duda SH, Bosiers M, Lammer J et al: Drug-eluting and bare nitinol stents for the treatment of atherosclerotic lesions in the superficial femoral artery: Long-term results from the SIROCCO trial. J Endovasc Ther, 2006; 13: 701–10
15. Yahagi K, Otsuka F, Sakakura K et al: Pathophysiology of superficial femoral artery in-stent restenosis. J Cardiovasc Surg, 2014; 55: 307–23
16. Dubé H, Clifford AG, Barry CM et al: Comparison of the vascular responses to balloon-expandable stenting in the coronary and peripheral circulations: Long-term results in an animal model using the TriMaxx stent. J Vasc Surg, 2007; 45: 821–27
17. Barth KH, Virmani R, Froelich J et al: Paired comparison of vascular wall reactions to Palmaz stents, Strecker tantalum stents, and Wallstents in canine iliac and femoral arteries. Circulation, 1996; 93: 2161–69
18. Smouse HB, Nikanorov A, LaFlash D: Biomechanical forces in the femoropopliteal arterial segment. Endovasc Today, 2005; 60–66
19. Gray BH, Sullivan TM, Childs MB et al: High incidence of restenosis/reocclusion of intravascular stents in the percutaneous treatment of long-segment superficial femoral artery disease after suboptimal angioplasty. J Vasc Surg, 1997; 25: 74–83
20. Schillinger M, Sabeti S, Loewe C et al: Balloon angioplasty versus implantation of nitinol stents in the superficial femoral artery. N Engl J Med, 2006; 354: 1879–88
21. Van der Zaag ES, Legemate DA, Prins MH et al: Angioplasty or bypass for superficial femoral artery disease? A randomised controlled trial. Eur J Vasc Endovasc Surg, 2004; 28: 132–37
22. Rosenfield K, Schainfeld R, Pieczek A et al: Restenosis of endovascular stents from stent compression. J Am Coll Cardiol, 1997; 29: 328–38
23. Jacobs TS, Won J, Gravereaux EC et al: Mechanical failure of prosthetic human implants: A 10-year experience with aortic stent graft devices. J Vasc Surg, 2003; 37: 16–26
24. Schlager O, Petra D, Schila S et al: Long-segment SFA stenting – the dark sides: In-stent restenosis, clinical deterioration, and stent fractures. J Endovasc Ther, 2005; 12: 676–84
25. Scheinert D, Scheinert S, Sax J et al: Prevalence and clinical impact of stent fractures after femoropopliteal stenting. J Am Coll Cardiol, 2005; 45: 312–15
26. Duda SH, Pusich B, Richter G et al: Sirolimus-eluting stents for the treatment of obstructive superficial femoral artery disease: Six-month results. Circulation, 2002; 106: 1505–9
27. Schillinger M, Sabeti S, Loewe C et al: Balloon angioplasty versus implantation of nitinol stents in the superficial femoral artery. N Engl J Med, 2006; 354: 1879–88
28. Iida O, Nanto S, Uematsu M et al: Influence of stent fracture on the long-term patency in the femoro-popliteal artery: experience of 4 years. JACC Cardiovasc Interv, 2009; 2: 665–71
29. Dubé H, Clifford AG, Barry CM et al: Comparison of the vascular responses to balloon-expandable stenting in the coronary and peripheral circulations: Long-term results in an animal model using the TriMaxx stent. J Vasc Surg, 2007; 45: 821–27
30. Barth KH, Virmani R, Froelich J et al: Paired comparison of vascular wall reactions to Palmaz stents, Strecker tantalum stents, and Wallstents in canine iliac and femoral arteries. Circulation, 1996; 93: 2161–69

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