

Enhanced Safety During Carotid Artery Stenting

Utilization of Integrated Embolic Protection for Additional Protection During Carotid Stenting

with Ralf Langhoff, MD; Joachim Schofer, MD; Dierk Scheinert, MD; Horst Sievert, MD; Thomas Zeller, MD

**THE PALADIN[®] CAROTID POST-DILATION BALLOON SYSTEM WITH
INTEGRATED EMBOLIC PROTECTION**

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Over the past two decades, carotid artery stenting (CAS) has become a valuable alternative approach to carotid endarterectomy (CEA) for the treatment of carotid disease. In most cases, embolic protection devices are utilized to capture particles released in the vasculature for the protection from stroke. Once the guidewire has been placed, various technologies can be used to collect debris during the stenting procedure. Although these devices have improved procedural safety, there remains a risk of stroke especially during the post-dilation of the stent when showers of small debris particles can be released.

The traditional approach of embolic protection during CAS involves using a guidewire-based filter placed distally to the lesion location in order to collect freed particles during the procedure. While these distal protection filters are effective at collecting particles downstream from the treated area, they remain in place during the entire procedure and thus require a large filter mesh pore size to maintain good perfusion. Consequently, these filters may allow smaller sized particles to pass through. Proximal protection devices have been developed to address this issue, however, these devices tend to be more complicated to use and may require a longer learning curve.

The Paladin® Carotid Post-Dilation Balloon System

The Paladin Carotid Post-Dilation Balloon System with Integrated Embolic Protection (Contego Medical, LLC, Raleigh, NC) offers a simple and effective approach. The Paladin System (Figure 1) is designed to provide additional protection during stenting for carotid revascularization. This is the first system in which the distal filter is on the same platform as the angioplasty balloon.

PALADIN CAROTID POST-DILATION BALLOON SYSTEM

Key Features:

- 40µm filter mesh pore size for capturing both macro- and microemboli
- Low distal-end profile design for a low crossing profile
- Minimal landing zone due to fixed 4 mm balloon-filter transition
- Able to accommodate variable vessel diameters up to 7 mm
- Easy single-step deployment
- Enhanced radiopacity
- No recovery sheath

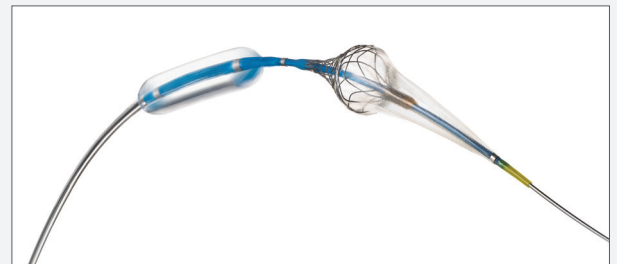


Figure 1. Paladin System

Once the stent has been deployed in the vessel, the Paladin System is used for post-dilation while simultaneously providing secondary embolic protection to capture smaller debris showers released during this portion of the stenting procedure.

The performance of the Paladin System was evaluated in a prospective, multicenter, non-randomized, single-arm post-market study of 106 patients at five high volume, high quality centers in Germany.

A formal presentation of the complete results will be the subject of a separate publication. This paper presents several relevant case studies that highlight the versatility of the Paladin System in a variety of settings.

All patients provided informed consent and were followed through 30 days to determine acute device clinical performance and 30-day safety. Routine standard of care remained unchanged except the inclusion of the Paladin System for post-dilation of the stent. The Paladin System can be used with all approved stents and protection devices and 0.014” wires.

CASE STUDIES

1. Treatment of a Symptomatic Patient Using the Paladin System with FilterWire EZ™ Embolic Protection System (Boston Scientific) and the Roadsaver® Carotid Artery Stent (Terumo) in Berlin, Germany

A 71-year old male presented to Sankt Gertrauden Krankenhaus with a symptomatic right internal carotid artery in the right internal carotid artery (RICA) stenosis reporting symptoms of an ipsilateral TIA. The patient's only significant medical history was hyperlipidemia treated with statin therapy. Preliminary neurological examination was normal, and the baseline NIHSS was 0/42. The patient underwent computed tomography angiography (CTA) which revealed an 80% lesion in the RICA of approximately 15 mm in length.

The patient was scheduled for carotid intervention, and a FilterWire was placed distal to the lesion in the RICA. Pre-dilation of the lesion was not performed. The lesion was successfully treated with an 8 mm x 25 mm Roadsaver stent. Post-dilation of the stent was subsequently performed using a 5.0 x 20 mm Paladin System. The patient did not experience any neurological adverse events during the procedure and stenosis of the lesion was reduced to 20%. Following the procedure, the Paladin and FilterWire filters were collected and preserved in 10% formalin. Embolic particle count and size in each filter was analyzed and reported. The distal filter (FilterWire) contained 1,171 particles and the proximal filter (Paladin) contained 2,834 particles. At discharge, the neurological examination was unremarkable and the NIHSS remained 0/42. The patient returned to the clinic for routine follow up 35 days post-intervention and reported no adverse events.

In this case of a patient with a symptomatic RICA stenosis, more embolic particles were captured in the Paladin filter (n=2,834) as compared to the mean number of embolic particles captured in 20 asymptomatic patients (n=1,288), Figure 2(a). These results are consistent with a known higher risk of embolization during post-dilation of symptomatic lesions as compared to asymptomatic lesions¹.

A further analysis of the 2,834 particles captured revealed that 2,476 (87%) particles were between 40 to 100 microns, 297 (11%) particles were between 101 to 200 microns, and 61 (2%) particles were between 201 and 400 microns. Results are shown in Figure 2(b). While this patient was treated with a mesh-covered stent, this did not appear to significantly reduce the number of embolic particles captured in the Paladin filter during post-dilation.

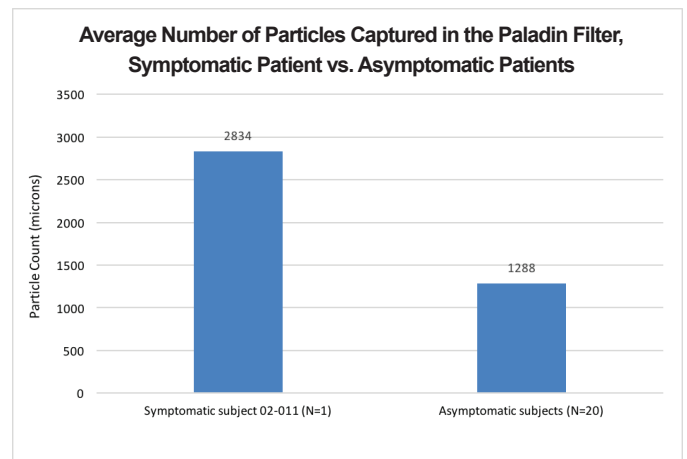


FIGURE 2(a). Average number of particles captured in the Paladin Filter, Symptomatic Patient vs. Asymptomatic Patients.

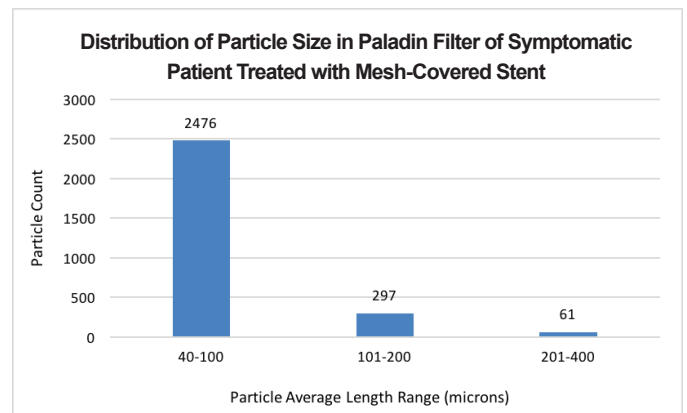


FIGURE 2(b). Distribution of particle size in Paladin Filter in Symptomatic Patient treated with mesh-covered stent.

¹Gray, W. A., et al. (2007), The CAPTURE registry: Predictors of outcomes in carotid artery stenting with embolic protection for high surgical risk patients in the early post-approval setting. Cath. Cardiovasc. Intervent., 70: 1025–1033. doi:10.1002/ccd.21359

2. Treatment of Previously Symptomatic Patient using Paladin System with Emboshield® NAV6 and XACT® Carotid Stent (Abbott Vascular) in Hamburg, Germany

A 61-year-old female presented to the Hamburg University Cardiovascular Center with a history of percutaneous transluminal angioplasty (PTA) and stenting of the left internal carotid artery (LICA) 5 years prior. The patient subsequently experienced motor aphasia which quickly resolved, however, diffusion-weighted magnetic resonance imaging (DW-MRI) revealed a new ischemic/embolic event.

The patient returned with an asymptomatic carotid artery stenosis of the RICA 5 years later. The patient had a medical history of type II diabetes, peripheral vascular disease, previous PCI and CABG, hyperlipidemia and hypertension.

Angiography revealed a target lesion stenosis of approximately 90% with lesion length of 15 mm and a reference vessel diameter of 5.0 mm. A primary distal protection device, Emboshield NAV6, was placed in the pre-petrous segment of the RICA. The RICA lesion was direct-stented with a 5 mm x 15 mm XACT carotid stent. A 5.0 mm x 20 mm Paladin System was then used to successfully post-dilate the stented lesion. Residual stenosis of the lesion was 20%.

The patient underwent DW-MRI scans prior to the procedure and within 24 hours post-procedure to assess for the presence of new ischemic lesions. The pre-procedure DW-MRI was unremarkable, with no cerebral ischemia as shown in Figure 3(a). Post-procedure DW-MRI revealed no new lesions, as seen in Figure 3(b). The patient reported no major adverse events through the 30-day follow-up.

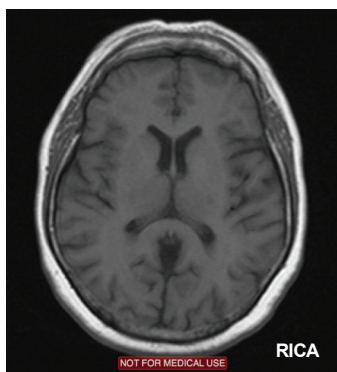


FIGURE 3(a). Pre-procedure DW-MRI performed pre-intervention indicated no ischemic neurological lesions.

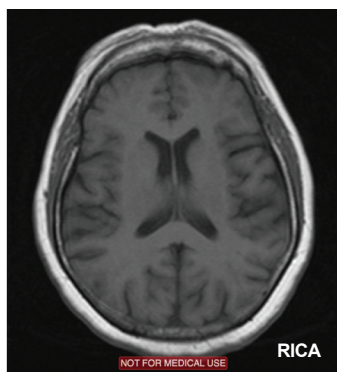


FIGURE 3(b). Post-procedure DW-MRI 24-hours post-intervention indicates no change from baseline; no new ischemia compared to pre-procedure.

3. Paladin System Use with Mo.MA® Ultra Proximal Cerebral Protection Device (Medtronic) and the Roadsaver Carotid Artery Stent in Leipzig, Germany with Histological Evaluation of Filter Contents

An 80-year-old male presented to the Leipzig Heart Center with asymptomatic carotid artery stenosis of the RICA. The patient had a medical history of previous tobacco use, hyperlipidemia treated with statins, hypertension, valvular disease and renal insufficiency. The patient also had a previous percutaneous carotid intervention of the left carotid artery.

Angiography revealed a target lesion stenosis of approximately 90% with a target lesion length of 17 mm and a reference vessel diameter of 6.0 mm. The Mo.MA proximal cerebral protection device was used and pre-dilation of the lesion was performed. The lesion was treated with a 7 mm x 25 mm Roadsaver stent. Post-dilation of the stent was performed using a 5.0 mm x 20 mm Paladin System. Residual stenosis of the lesion was 0%. No major or device-related adverse events were reported through 30-day follow-up.

Following the procedure, the Paladin filter was removed from the catheter, placed into formalin and evaluated by a histology core laboratory to identify particulate debris collected (Figure 4). In total, 2,789 particles were collected in the Paladin filter, ranging in size from 40 µm to >200 µm. The largest particle detected in the Paladin filter was 374 microns in size.

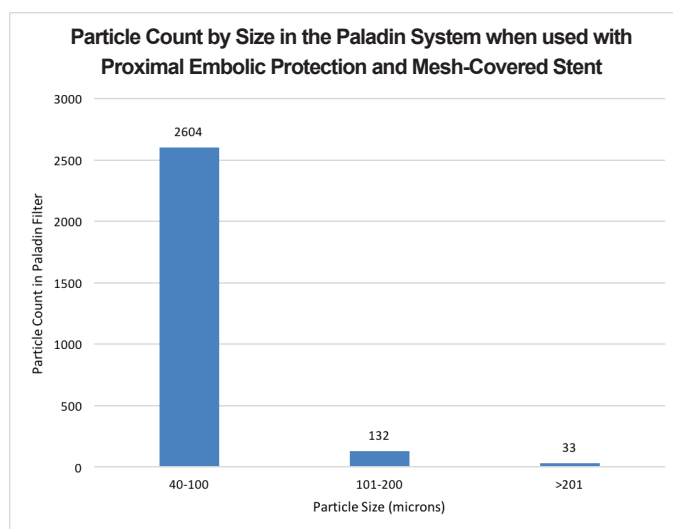


Figure 4. Particles captured in the Paladin filter by size and count following the use of proximal embolic protection and a mesh-covered stent.

4. Staged Bilateral Intervention using FilterWire EZ Embolic Protection System and the Roadsaver Carotid Artery Stent in Berlin, Germany

An 81-year-old male presented to the Sankt Gertrauden Krankenhaus with asymptomatic bilateral carotid artery stenosis. The patient had a medical history of previous smoker, hyperlipidemia treated with statins, hypertension, renal insufficiency and a previous bilateral CEA.

Diagnostic angiography revealed a stenosis of approximately 70% in the RICA and 70% in the LICA (Figure 5a). Visual estimation indicated a length of 20 mm and a reference vessel diameter of 5.0 mm of both target lesions. The patient first underwent intervention of the LICA, and a FilterWire EZ System was chosen as the primary distal protection device. The lesion was treated with a 9 mm x 30 mm Roadsaver stent and post-dilation was successfully performed using a 5.0 mm x 20 mm Paladin System, reducing the stenosis to 10% (Figure 5b).

The patient returned for a staged intervention to the RICA following the 30-day follow-up period. A FilterWire EZ System was again chosen as the primary distal protection device. The lesion was treated with a 9 mm x 30 mm Roadsaver stent and post-dilation was successfully performed using a 5.0 mm x 20 mm Paladin System. Residual stenosis of the lesion was 20% (Figure 5c). No major or device-related adverse events were reported through the 30-day follow-up period.

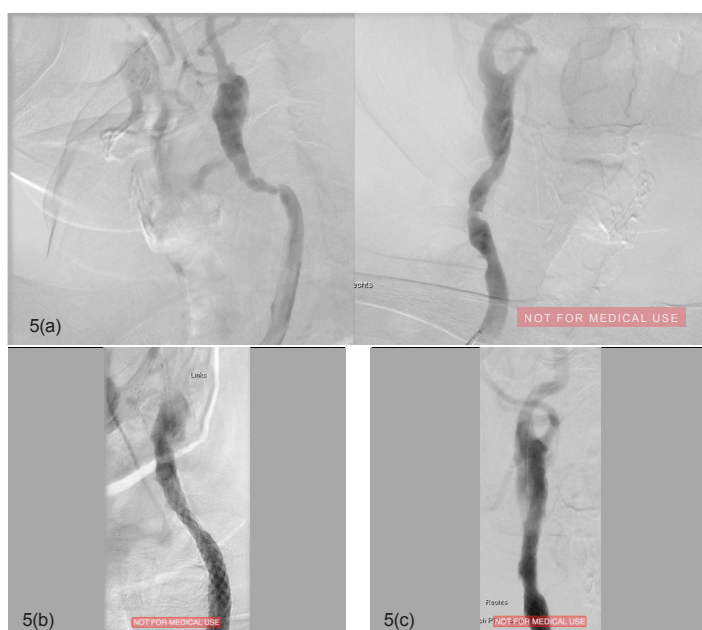


FIGURE 5. (a) Pre-procedure angiography indicative of 70% bilateral carotid artery stenosis. (b) Final angiography following intervention of RICA, with residual stenosis of 10%, and (c) staged intervention of LICA after 30 days, with a residual stenosis of 20%.

5. Paladin System Use with SpiderFX[™] Embolic Protection Device (Medtronic) and PRECISE[®] PRO Rx[®] Carotid Stent (Cordis) in Bad Krozingen, Germany

A 67-year-old female presented to the Universitaets-Herzzentrum Freiburg – Bad Krozingen with an asymptomatic stenosis of the LICA.

The patient had a medical history of current tobacco use, hypertension, peripheral vascular disease, valvular disease, and a previous right CEA. Angiography revealed a target lesion stenosis of approximately 80% with a length of 12 mm and a reference vessel diameter of 6.0 mm.

The patient underwent the carotid intervention of the LICA. A SpiderFX Embolic Protection Device was used for primary protection. Pre-dilation of the lesion not was performed prior to stent placement and the LICA lesion was successfully treated with an 8 mm x 30 mm PRECISE stent. Post-dilation of the stent was performed using a 5.0 mm x 20 mm Paladin System. Residual stenosis of the lesion was 20%. No adverse events were reported during the procedure through 30-day follow-up.

6. Use with Emboshield NAV6 Embolic Protection System and XACT Carotid Stent with the Paladin System in Frankfurt, Germany

A 67-year-old male presented to the Cardiovascular Center in Frankfurt with symptomatic LICA stenosis.

The patient had a medical history of hyperlipidemia treated with statins, hypertension, a previous posterior stroke and an abnormal ECG. Diagnostic angiography revealed a target lesion stenosis in the LICA of approximately 76% with a target lesion length of 15 mm and reference vessel diameter of 4.0 mm.

An Emboshield NAV6 Protection System was deployed for primary distal protection. Pre-dilation of the lesion was performed with a 2.5 mm x 20 mm balloon prior to stent placement. The lesion was then treated with an 8 mm x 30 mm XACT stent and post-dilation was performed using a 5.0 mm x 20 mm Paladin System. Residual stenosis of the lesion was 0%. No major or device-related adverse events were reported through 30-day follow-up.

FILTER PARTICLE CONTENT ANALYSIS

A quantitative particle analysis was conducted on the Paladin System filter used for post-dilation of carotid artery stents in a subset of patients[‡]. All interventions were performed using a primary EPD. Paladin filters and primary EPD filters were removed from the catheter, placed into formalin and evaluated by a histology core laboratory (Imaging and Analysis, LLC, Saint Paul, MN).

The preserved Paladin System and primary EPD underwent hematoxylin and eosin (H&E) stained microscopic evaluations to identify particulate debris collected (Figure 6). Filter particle count results are shown in Figure 7.

Microscopic debris was present in 100% of filters. The majority of particles (>85%) captured in the Paladin filter were 100 µm or less in size. The mean number of particles between 40 – 100 microns collected in the Paladin filter was 1,167 compared to a mean of 700 collected in the primary EPD, suggesting that the small-pore Paladin filter collects the smaller particles that could pass through the primary EPD, and may provide additional patient safety.

Available distal filter based embolic protection devices feature pore sizes of more than 100 microns, and thus are unlikely to capture a majority of embolic particles released during the post-dilation phase of carotid artery stenting. The small-pore filter on the Paladin System collects particles that could pass through the primary filter, thus providing additional patient safety during CAS during the time of highest risk of microembolization.

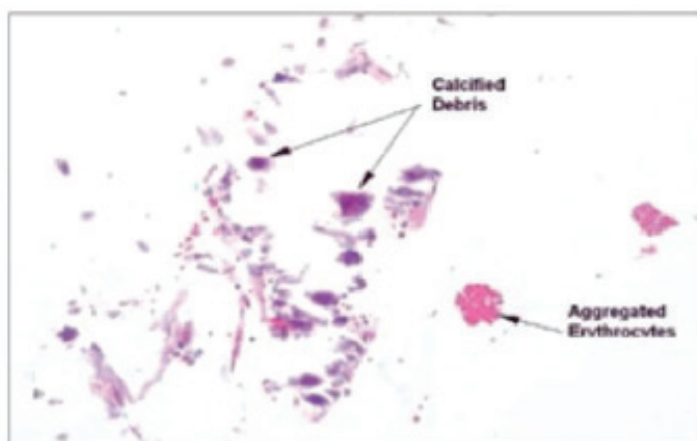


FIGURE 6. H&E stained microscopic filter particles retrieved from the Paladin filter.

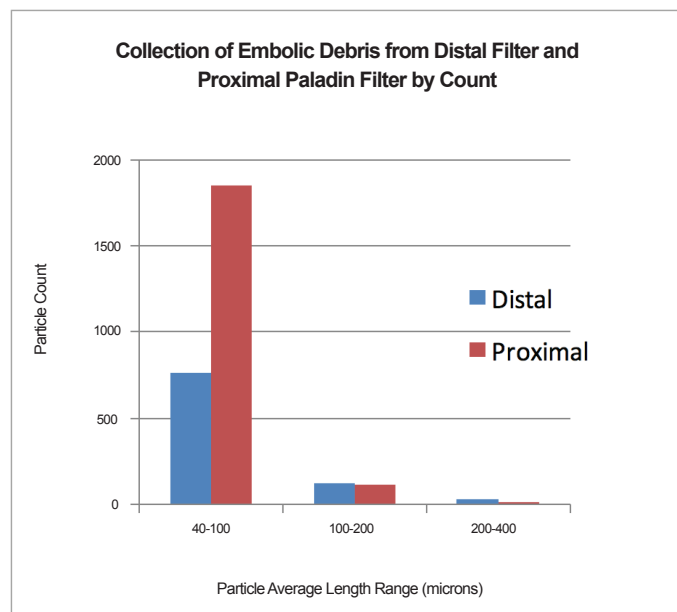


FIGURE 7. Particles captured by size and count following use of the Paladin System (proximal) with traditional wire-based EPD (distal)[‡].

CONCLUSION

Carotid stenting, while a widely used option for carotid stenosis treatment, continues to present clinical challenges. All major studies have shown that while the risk of death and major stroke is comparable between CEA and CAS, the risk of minor stroke remains higher during CAS. This may be due to small particle embolization, which is highest during post-dilation of the stent.

The Paladin Carotid Post-Dilation System with Integrated Embolic Protection is easy to use and features a unique filter with the ability to customize the opening diameter to the patient's anatomy, thus maximizing wall apposition. This feature, along with the 40 µm pore size, is designed for maximal capture efficiency during the critical post-dilation step and, together may decrease the incidence of new lesions as seen on DW-MRI post CAS.

Histopathological analysis of the Paladin filter demonstrates that greater than 85% of particles captured are less than 100 microns in size. The pore size cannot be made smaller in filter-based primary EPDs due to the risk of thrombosis during long deployment times spanning the entire case. The Paladin System filter can safely feature smaller pore sizes as the filter is deployed for a minimal time and only during the riskiest post-dilation phase of the procedure.

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Thomas Zeller, MD; Universitaets-Herzzentrum Freiburg, Bad Krozingen, Germany.

Core lab analysis conducted by: Jerry Sedgewick, Imaging and Analysis, LLC, Saint Paul, MN

‡ Test data on file at Contego Medical, LLC.

Results from case studies are not necessarily predictive of results in other cases. Results in other cases may vary. See "Instructions for Use" for complete procedure requirements. Patents pending.

The Paladin System is CE Marked and available for sale in select European markets.

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For more information on the Paladin Carotid Post-Dilation Balloon System with Integrated Embolic Protection, please contact:

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