Reverse slider technique using the Endurant stent graft for accurate proximal sealing in hostile neck endovascular aneurysm repair

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ABSTRACT

This report introduces the reverse slider technique to obtain proximal sealing effectively in endovascular aneurysm repair in short or angulated necks. It is the deployment process of the stent graft main body by repeatedly rotating and reversing the external slider with slight loosening of the suprarenal stent. This method helps obtain accurate placement of the proximal edge and effective sealing on the greater curvature side even in short and angulated necks. It is an effective method of extending the proximal sealing zone. It is gained by changing the deployment process with the Endurant stent graft (Medtronic, Santa Rosa, Calif) as an existing popular device. (J Vasc Surg Cases and Innovative Techniques 2019;5:332-7.)

Keywords: Endurant; Short neck; Angulated neck; Hostile neck; Reverse slider technique

One important factor that affects the outcomes of endovascular aneurysm repair (EVAR) is type IA endoleak. The Endurant stent graft system (Medtronic, Santa Rosa, Calif) can achieve favorable proximal sealing because of reduced incidence of type IA endoleak and migration.[1,2] However, it is not suitable in cases with short necks of <10 mm.[3] Furthermore, the incidence of type IA endoleak increases with additional factors outside instructions for use (IFU), such as angulated or reversed taper necks.[4] To avoid type IA endoleak, it is important to place the top edge of the graft fabric just below the renal artery accurately and to make the main body track in conformability with the angulated neck. Short and angulated necks tend to cause type IA endoleak because such requirements are difficult to meet. The reverse slider technique is introduced in this study. This technique can accurately place the top edge of the graft fabric and achieve effective proximal sealing in short or angulated necks. Institutional Review Board approval was not obtained for this study because there is no need to obtain it in our institution. All study participants provided informed consent for both the procedure and the study.

TECHNIQUE

The IFU of the Endurant stent graft system show that after the graft is deployed to the contralateral gate, the suprarenal stent is released. However, this general process has a risk of failure of proximal placement when the suprarenal stent is unfastened because the top edge of the graft fabric on one side is still away from the aortic wall under the captured suprarenal stent. Specifically, when the delivery system is not touching the lower renal artery, deployment should be done in the lower position to avoid covering the renal artery. This phenomenon reduces the proximal sealing zone. Therefore, to position the graft fabric edge close to the aortic wall and to gain maximum sealing zone, the top edge of the graft fabric should be expanded as much as possible before unfastening the suprarenal stent. The reverse slider technique makes this process possible by simply rotating the external slider in the reverse direction without unfastening the suprarenal stent; consequently, the top edge of the graft fabric can touch the aortic wall (Fig 1).

The reverse slider technique is performed as follows:

1. Deploy the first stent of the main body by rotating the external slider (larger main front deployment wheel).
2. Rotate the backend wheel slightly to loosen the captured suprarenal stent.
3. Slowly rotate the external slider 1½ to 2 times in reverse to raise the outer sheath until there is resistance and rotate the external slider in

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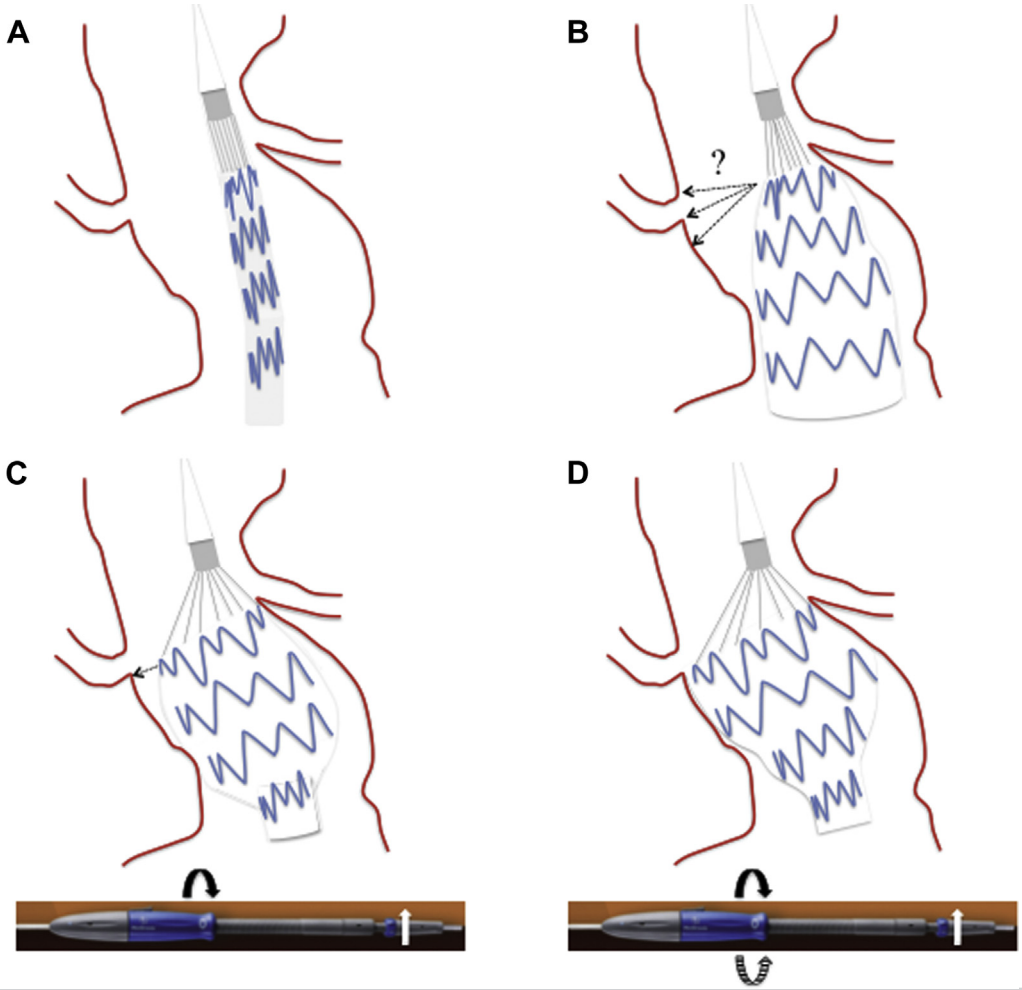

Fig 1. Movement of the proximal edge of the stent graft. **A,** If the delivery system touches only one side of the aortic wall in the proximal neck, the other side is kept away from the aortic wall. **B,** It is difficult to forecast the point at which to touch on the other side when deploying the main body without unfastening the suprarenal stent. **C,** When the main body and suprarenal stent are expanded slightly and alternately, the top edge of the graft fabric expands to fill the gap in the contralateral side of the aortic wall. **D,** Performing the reverse slider technique repeatedly will increasingly expand the top edge of the graft fabric. The top edge of the graft fabric on both sides can touch the aortic wall without unfastening the suprarenal stent. *Black dashed arrows,* Expected point at which to touch the aortic wall on the contralateral side; *black arrows,* external slider rotating in the right direction; *white arrows,* backend wheel rotating in the right direction; *black-and-white striped arrow,* external slider rotating in reverse.

counterclockwise direction to return the outer sheath to its natural position.

4. Deploy the main body until the second stent and repeat steps 2 and 3 until the edge of the stent graft expands, which is visible on the fluoroscope. By repeating these steps slowly, the top edge of the graft fabric expands increasingly. These steps help the graft fabric edge to come in contact with or to be positioned close to the aortic wall by deploying only two or three stents without unfastening the suprarenal stent.
5. Release the suprarenal stent.

In angulated neck anatomy, the delivery system does not run axially along the aorta and the graft does not land orthogonal to the axis of the aorta with the general deployment process. The biggest reason for this failure is that the delivery system touches the lesser curvature side in most angulated neck cases; therefore, the graft on the greater curvature side flops onto the inferior point as the suprarenal stent is released. To avoid this phenomenon, the suprarenal stent should be released after the graft on the greater curvature side touches or is positioned close to the aortic wall, based on the preceding descriptions. This seems to be the most effective way to overcome the weak point of the general deployment procedure in angulated cases, and the reverse slider technique enables the graft to land more orthogonal to the axis of the aorta compared with the general

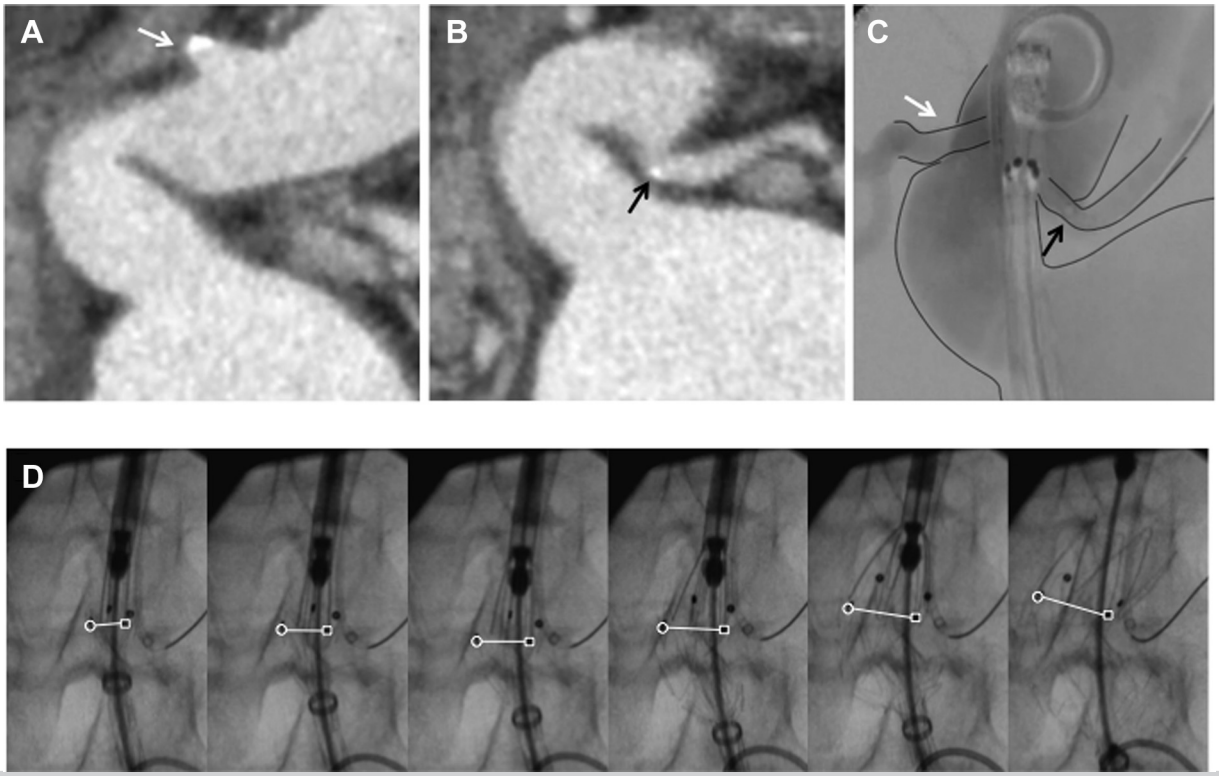

Fig 2. Deployment of the Endurant stent graft with the reverse slider technique in the angulated neck case (case 1). **A** and **B,** Preoperative three-dimensional computed tomography images show a severely angulated neck at 130 degrees with neck length of 25 mm. **C,** Angiography during the procedure. The Endurant delivery system runs on a shortcut. It touches the lower left renal artery in the lesser curvature side. **D,** A series of photographs until the suprarenal stent release. The top edge of the graft fabric on the greater curvature side is deployed and kept in the upper position. The *open circles* indicate the e mark stitched on the graft fabric edge. Each *open square* indicates the o mark stitched on the contralateral side of the e mark. As the top edge of the graft fabric expands, the e mark on the greater curvature side rises upward to a proximal position. The line between the e and o marks leans upward to the aortic axial. *White arrow,* right renal artery; *black arrow,* left renal artery.

procedure. In an angulated neck case (case 1; Fig 2, *A-C*), enough sealing in the proximal zone will not be obtained during general deployment. Placement of the top edge of the graft fabric below the renal artery on the lesser curvature side will lose the sealing zone in the greater curvature side because the graft fabric edge is generally unfolded vertically on the delivery system. This lower side of the graft fabric edge cannot rise to the same level as the higher side in such angulated anatomy. If it is placed in the upper position for sufficient sealing on the greater curvature side, the renal artery on the lesser curvature side might be covered. Even in such anatomy, the reverse slider technique can help the top edge of the graft fabric to come in contact with the aortic wall without unfastening the suprarenal stent. This process affects accurate placement without lowering the graft fabric edge on the greater curvature side. Consequently, the stent graft is placed almost axially along the aortic wall (case 1; Fig 2, *D*). This technique is useful for short and angulated necks, in which obtaining a sealing zone on the greater curvature side is more difficult. In short and angulated neck cases (case 2; Fig 3), the anatomy allows the delivery system to run only on the shortest route in angulation; hence, placing the graft axially is more challenging. In such situations, general deployment of the main body will fail to obtain proximal sealing on the greater curvature side (Fig 3). However, with this technique, the first and second stents can touch the aortic wall without unfastening the suprarenal stent. The greater curvature side can obtain a proximal sealing zone similar to that on the lesser curvature side. Furthermore, the third stent has not fully deployed yet. It means that the rest of the stents until the fifth stent can be deployed slowly with the push-up technique[5] (case 2; Fig 4; Video). It helps the deployment of the main body with conformability in high angulation.

DISCUSSION

The main purpose of the reverse slider technique is to expand the top edge of the graft fabric. It enables the top edge of the graft fabric to come in contact with or to be positioned close to the aortic wall by expanding

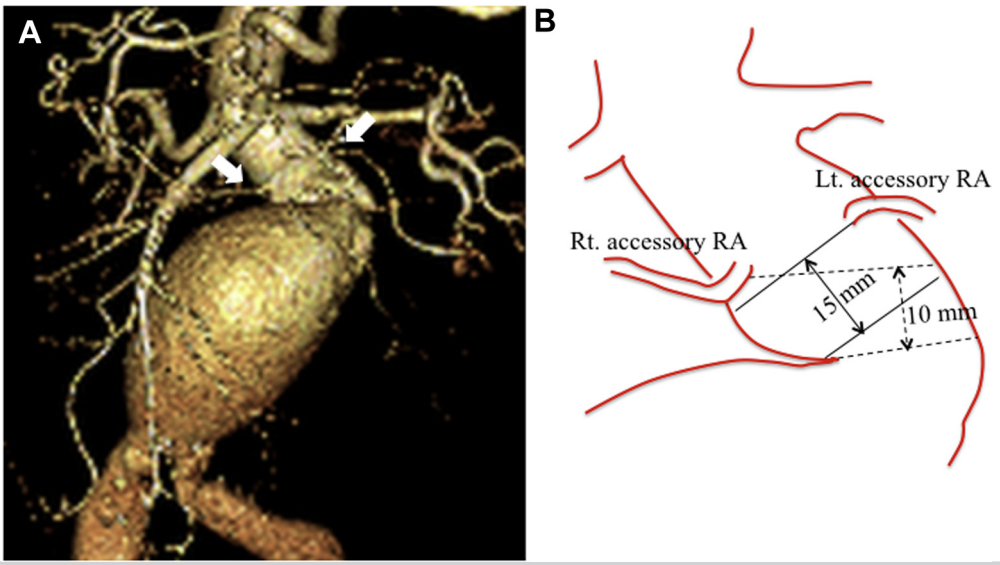

Fig 3. Short and angulated neck (case 2). An 86-year-old man with chronic kidney disease stage 3a. Preoperative three-dimensional computed tomography image **(A)** and planning schema **(B)** show short neck under accessory renal arteries (*arrows*) and severe angulation under the neck. *RA,* Renal artery.

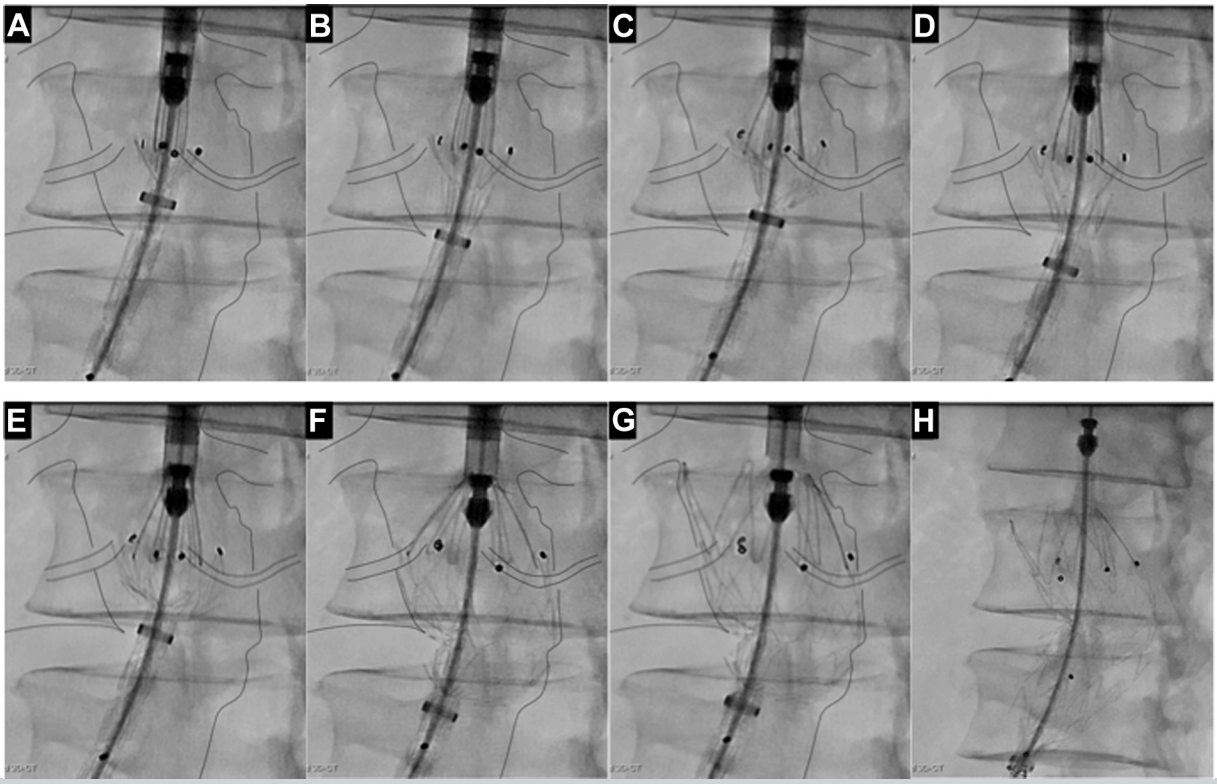

Fig 4. Deployment of the Endurant stent graft using the reverse slider technique (case 2). **A,** After deployment of the first stent, rotate the external slider in reverse, and the top edge of the graft fabric expands slightly. **B,** Deploy until the second stent, loosen the backend wheel slightly, and the graft fabric edge expands a little more. **C,** Rotate the external slider in reverse, and the top edge of the graft fabric expands more. **D,** Deploy until half of the third stent and loosen the backend wheel slightly. **E,** Rotate the external slider in reverse, and the top edge of the graft fabric expands more and touches the aortic wall upward on the greater curvature side. **F,** The first and second stents touch the aortic wall completely without unfastening the suprarenal stent. Therefore, the top edge of the graft fabric on the greater curvature side can be placed accurately in the upper position. **G,** Thereafter, release the suprarenal stent. **H,** Deploy the rest of the main body slowly using push-up technique so that it tracks with conformability.

Table. Overview of patient characteristics, anatomic characteristics, intraoperative variables, and outcomes

Variables	Hostile necks (n = 34)	Favorable necks (n = 28)
Age, years	76.8 ± 7.3	74.6 ± 11.3
Female	8 (24)	5 (18)
Maximal aneurysm diameter, mm	54.5 ± 14.0	50.3 ± 4.8
Proximal neck		
Diameter, mm	24.4 ± 4.1	23.3 ± 3.1
Length <10 mm	3 (9)	0 (0)
Length <15 mm	15 (44)	0 (0)
Angulation >60 degrees	12 (35)	0 (0)
Reverse taper	9 (27)	0 (0)
>50% calcification or thrombus	7 (21)	0 (0)
Operative time, minutes	164.9 ± 74.5	157.1 ± 71.6
Fluoroscopy time, minutes	55.4 ± 38.2	47.1 ± 30.3
Contrast material volume, mL	51.0 ± 31.7	44.5 ± 22.1
Type IA endoleak	0 (0)	0 (0)
Endograft migration	0 (0)	0 (0)
Sac regression, mm	6.0 ± 6.1	6.9 ± 6.4
Aneurysm-related reintervention	0 (0)	0 (0)
Follow-up period, months	8.7 ± 3.3	9.7 ± 3.6

Categorical variables are presented as number (%). Continuous variables are presented as mean ± standard deviation.

only two or three stents without unfastening the suprarenal stent. Therefore, placement of the top edge of the graft fabric can be adjusted accurately. This is effective in short neck cases requiring accurate placement on the proximal point. Moreover, without this technique, deployment in angulated neck cases will encounter difficulties because if there is a gap between the graft fabric edge and the aortic wall, the graft fabric edge on the greater curvature side would not rise axially when the suprarenal stent is unfastened. If the graft fabric edge can touch the aortic wall without unfastening the suprarenal stent, such falling motion does not happen. Furthermore, as another advantage, given that the rest of the main body is still in the delivery system, it will be deployed in conformity with the angulation using the push-up technique. Moreover, the technique is useful not only for hostile neck cases but also for favorable neck cases. The more accurately the top edge of the graft fabric is placed, the more effective proximal sealing can be obtained and type IA endoleak will be prevented.

Some points should be considered. The first point is device diameter selection. Although it is usually recommended to choose a 10% to 20% oversized device, it should actually be 20% to 30% or bigger. Bigger stent grafts appeared to make it easier to touch the aortic wall. Second, the reverse slider technique should be performed with sufficient time to deploy the main body. In our institution, it takes approximately 5 minutes from the start of the main body deployment until the contralateral gate is opened. The expanded first and second stents take enough blood flow in this duration and expand further. Third, the external slider should be rotated in reverse until there is light resistance, and it should not be rotated in reverse again. The outer sheath is lifted sufficiently by the reverse rotation without resistance. The graft fabric edge does not expand sufficiently if the loosening degree of the captured suprarenal stent is insufficient. To address this, to return the external slider to its natural antegrade position, the backend wheel should be rotated slightly to loosen the captured suprarenal stent. The most noteworthy point is that after reverse rotation of the external slider, it has to be rotated counterclockwise to return it to its natural position and then the next process can be performed. While the external slider is rotated in reverse, the outer sheath pushes the stent graft up in the proximal direction, which helps tracking with conformability on the angulated neck on fluoroscopy; however, this condition is at risk of migration to the proximal direction when the suprarenal stent is unfastened. In addition, the contrast media should be injected to identify the location of the lower renal artery and to verify the position before fully unfastening the suprarenal stent.

We have performed the reverse slider technique on 62 patients in succession, 34 cases with hostile necks as outside IFU and 28 cases with favorable necks. The Table presents the overview of patient characteristics, anatomic characteristics, intraoperative variables, and outcomes. In hostile neck cases, except severe chimney EVAR cases, 15 patients have <15-mm short neck, 3 have <10-mm short neck, 12 have >60-degree angulated neck, 9 have conical neck, and 7 have >50% calcification or thrombus. Six patients have both <15-mm short and angulated neck, and one patient has both <10-mm short and angulated neck. They were evaluated by computed tomography or duplex ultrasound ≥6 months after operation and did not show any type IA endoleak. The anatomic limitation of the standard EVAR using the reverse slider technique is thought to be neck length <10 mm and angulation. Only one patient with these conditions underwent standard EVAR with reverse slider technique and showed success. There was no other choice but this standard EVAR because the chimney EVAR had to be avoided for shaggy thoracic aorta. Other patients with such short and angulated neck underwent chimney EVAR. Calcification or thrombus in the neck is not thought to be a contraindication. There were no unexpected motions, such as unconscious release of the suprarenal stents, migration, distal atheroembolization, or stent graft infolding, in the presented technique. Moreover, follow-up computed tomography showed that the stent graft retained its original shape

in all cases. It allows the operator to perform the procedure very slowly and appears to be a safe technique, especially for operators who are familiar with the Endurant stent graft system, but long-term durability of grafts after this technique is unknown. As mentioned, much force is not required to rotate the external slider in reverse; hence, there are a few concerns about the durability of the grafts. However, long-term outcomes should be evaluated.

This novel technique can obtain proximal sealing especially in short and angulated neck cases in which proximal sealing is difficult. A slight modification to the process in the Endurant stent graft system is required. Overall, it is a useful and simple technique and may be performed by all operators.

CONCLUSIONS

The reverse slider technique using the Endurant stent graft system helps overcome the weaknesses of EVAR for patients with abdominal aortic aneurysm having a hostile neck. This technique is expected to achieve more effective proximal sealing. However, long-term follow-up is required.

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