Balloon Remodeling

Prem S. Rangi

Abstract

There has been a progressive incremental paradigm shift for treating intracranial aneurysms, both ruptured and unruptured, via endovascular techniques. The appeal of endovascular techniques for patients is in its minimally invasive approach and reduced recovery periods. Several trials have shown efficacy of endovascular treatment against traditional neurosurgical techniques for both ruptured and elective cases. The major challenge for endovascular management of intracranial aneurysms is twofold, endovascular results need to be durable and endovascular techniques need to able to manage complex aneurysms, including large, wide necked, and branches arising from the aneurysm sac. The treatment of complex aneurysms has been advanced by utilization of hypercompliant microballoons, particularly in acutely ruptured aneurysms, where the permanent deployment of a device, such as a stent, as an adjuvant device is prohibited, largely due to increased complications.

Keywords

Complex aneurysms • Remodeling • Hypercompliant microballoons • Acutely ruptured aneurysms • Complex aneurysms • Coil assistance • Stent assistance • Intra-procedural rupture

P.S. Rangi, MB, ChB
Department of Radiology, The Royal Free Hospital, London, UK
e-mail: prem.rangi@nhs.net

K. Murphy, F. Robertson (eds.), *Interventional Neuroradiology,*
Techniques in Interventional Radiology*,*
DOI 10.1007/978-1-4471-4582-0_5,

Indications

- Balloon remodeling technique or balloon-assisted coiling (BAC) first described in 1997 by Jacques Moret.
- Since its inception, its initial remit has been surpassed, allowing the treatment of an increasing complexity of aneurysm morphologies.
- The indications for using microballoons for remodeling are
  1. Broad-necked sidewall aneurysms
  2. Small aneurysms with branches arising from the sac
  3. Broad aneurysms with one or two branches arising at the neck or sac (typically MCA bifurcation, basilar tip) (Fig. 1)
- Additional adjuvant uses of microballoons include
  1. Rescue treatment of prolapsed coils
  2. Treating local thrombus formation

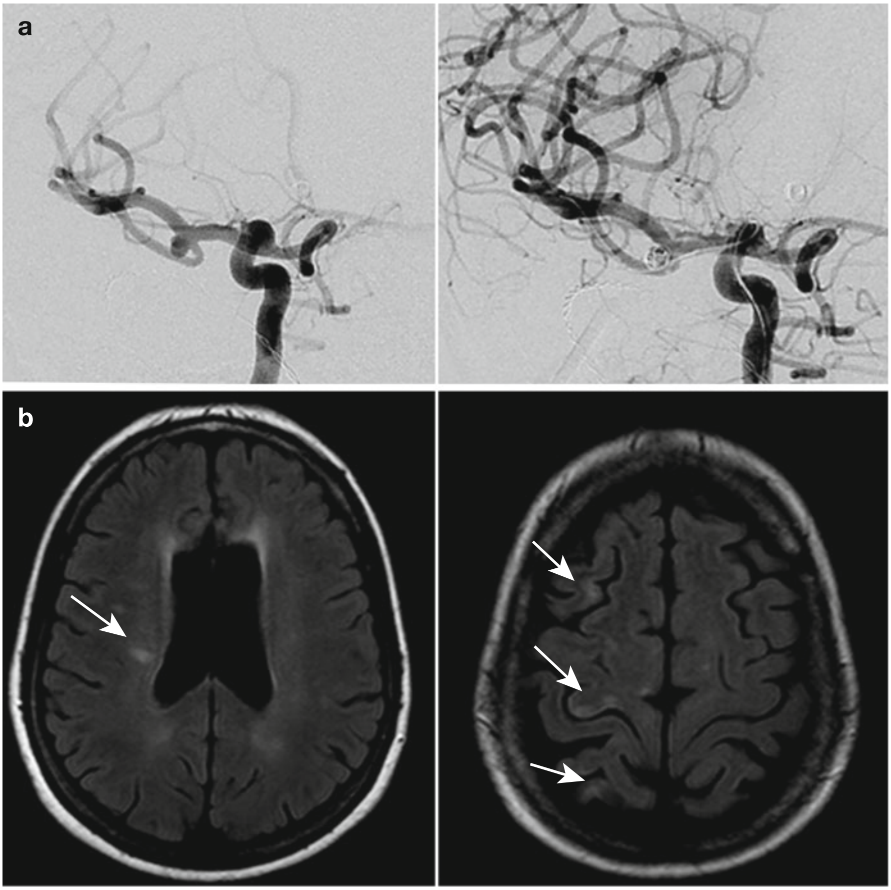

Fig. 1 Watershed ischemia post-balloon remodeling of right MCA aneurysm. (**a**) Pre- and post-angiograms using remodeling technique. MRI study post-embolization of right MCA aneurysm using remodeling technique. (**b**) FLAIR; (**b**) DWI; (**c**) ADC; (**d**) Maps show area of deep (*left*) and superficial (*right*) MCA watershed ischemia – *white arrows* show infarction

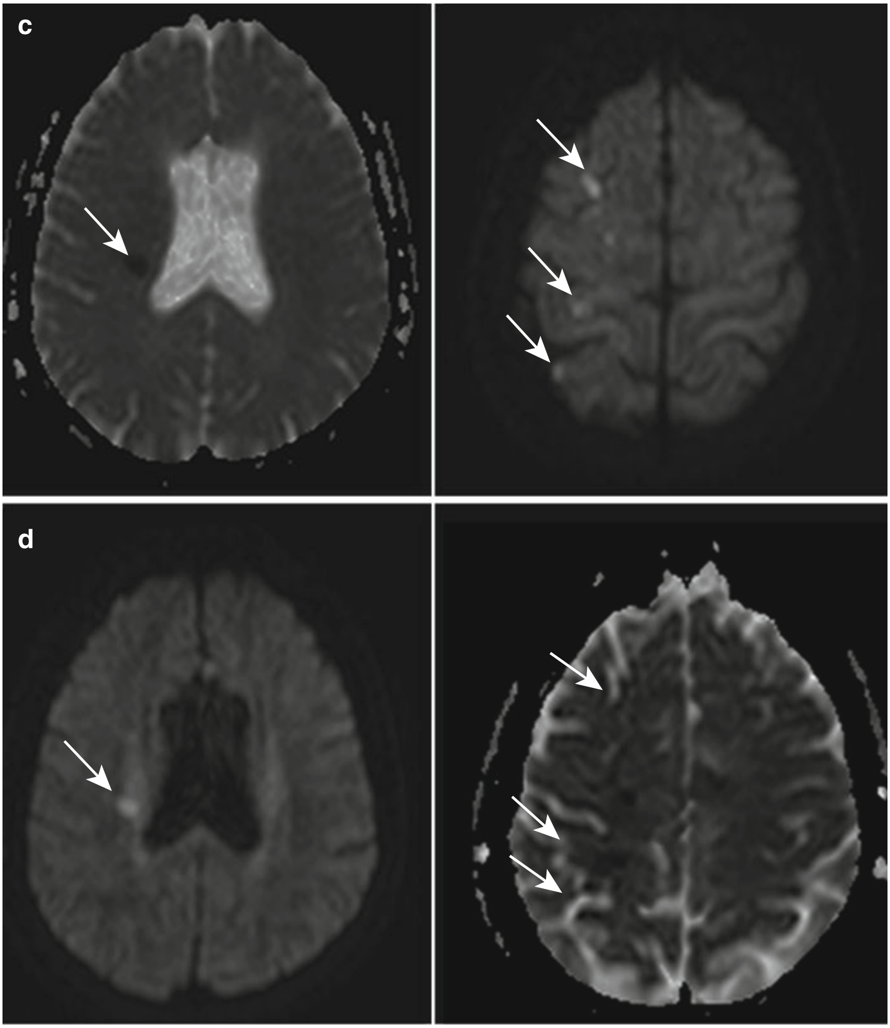

Fig. 1 (continued)

3. Concomitant angioplasty
4. Managing intra-procedural ruptures, whether at the time of microcatheter/coil placement or during intubation

Balloon Configuration

- Prior to incorporating microballoons within the repertoire of endovascular techniques, one must have an understanding of the basic subtypes of microballoons and their advantages and disadvantages.
- Until recently, balloons had two basic geometric shapes (with some minor variation in size to extend the range of aneurysms that can be managed):

- Sausage configuration.
  - Most widely utilized balloon: sausage configuration, oblong shaped.
  - One such balloon of this type is the HyperGlide™, ev3 (Covidien).
  - 3–6 mm diameter size and lengths from 10–30 mm.
  - Most commonly used: the 4 × 10–15 mm length.
- Rugby or football configuration (when unconstrained).
  - Typically more compliant than sausage configuration
  - One example: HyperForm™, eV3 (Covidien, Plymouth, MN, USA)
  - Available in two sizes: 4 × 7 mm and 7 × 7 mm

Hyperglide-Type Balloon

- Typically less compliant, which tends to determine its use for selective catheterization of branches arising at or within the proximal sac, in order to protect.
- Generally more predictable during placement and sequential inflation.
- During inflation, usually just prior to vessel occlusion, this balloon type has a tendency to move forward. With practice this can be anticipated for and compensated for by a small pull of the balloon just prior to vessel occlusion.
- The converse is equally true: the balloon tends to jockey proximally upon deflation.
  - For the most part, this motion is manageable and of little impact upon the subjacent microcatheter.
  - Can be extreme in some patients.
  - Extra care needs to be taken particularly with very small aneurysms where this movement can potentially propel the microcatheter through the aneurysm sac.

Microballoon Preparation (Fig. 2)

- Preparation of the microballoon is of utmost importance, with avoidance of introducing microbubbles within the system a prerequisite.
- Preparation is best undertaken within a designated area.
- Using a separate trolley makes for a natural "zone" to work within and by virtue creates "safe zone" to avoid contamination of the contrast-saline mixture.

There are several key stages:

Stage 1

Contrast-Saline Mixture

- A small gally pot is used to make the desired mixture by first placing 20 ml of saline, followed by 20 ml of 300 omnipaque contrast.
- The gally pot could be labeled for additional safety.

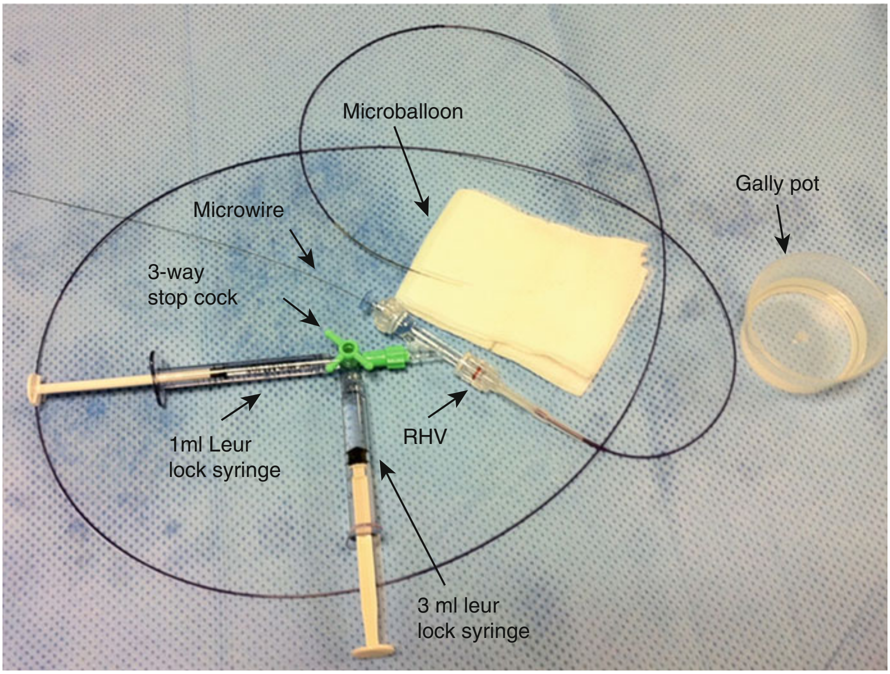

Fig. 2 Pictorial representation of microballoon configuration

- The importance of identifying the correct contrast-saline mixture cannot be overemphasized, to avoid inflating a balloon with clear saline and the inherent risk of overinflation and vessel rupture.
- Using neat contrast makes deflation of the balloon protracted, potentially necessitating microwire withdrawal to achieve deflation of the balloon.
- May potentially contaminate the microballoon with blood, making subsequent inflation difficult, reduce visibility, and make subsequent deflation impossible, even once the microwire has been completely withdrawn.

Stage 2

Preparing the Microballoon

- A 1 ml Luer-Lok syringe is filled with the contrast-saline mixture and attached to a 3-way stopcock, which in turn is attached to a RHV (rotating hemostatic value), without introducing any bubbles. This then is attached to the microballoon, which is subsequently flushed. This ensures the microballoon "system" is flushed with the desired contrast-saline mixture and free of microbubbles.
- A 3 ml Luer-Lok syringe is attached, again flushed with the contrast-saline mixture, to the vacant hub of the 3-way tap.

Stage 3

- The Luer-Lok is opened sufficiently to introduce the appropriate microwire for the balloon and advanced into the balloon microcatheter system, but avoiding occluding the balloon.
- Once the wire is sufficiently advanced, the 3 ml syringe is used to flush the hub of the RHV in a retrograde fashion, to ensure no bubbles have been inadvertently introduced into the system.
- Wire is advanced across the balloon and little beyond to seal the system, and a test inflation and deflation performed.
- The wire should be withdrawn to just protrude out of the microballoon; catheter tip; this will ensure no air or blood entry into the balloon.

Safety and Efficacy

- Use of balloons in treating intracranial aneurysms has come under considerable scrutiny.
- Initial experience was associated with higher thromboembolic sequelae. More contemporary published literature (some in the form of randomized multicenter trials) shows no increased complication rates but infers safer procedural rates, with reduced embolic phenomena, reduced rupture rates, and better packing density. The latter feature of the remodeling technique is being associated with reduced early re-hemorrhage and recurrence.
- Increasingly recognized safety profile of the balloon remodeling technique compared to unassisted coil embolization likely reflects increased practitioner experience, improved technology, and use of anticoagulation and antiplatelet regimes.
- One should be cognizant that more complex aneurysms tend to be treated with microballoon/multicatheter techniques.

Principle of Balloon Remodeling Technique

- Principle: Place a nondetachable balloon across the aneurysm neck.
- Balloon is temporarily inflated using a prepared mixture of contrast and saline, to a maximum volume predetermined by the particular balloon manufacturer.
- Balloon inflation is controlled under fluoroscopic guidance and maintained during coil placement.
- Once a coil is successfully placed within the aneurysm sac, the balloon is totally deflated.

- Subsequent coil placement is performed with the balloon reinflated.
- Process is repeated until a dense coil packing is achieved.
- Duration of balloon inflation should be minimized, avoiding extended times of inflation, beyond 2 min.

Aneurysm Morphology and Remodeling Technique

Type 1: Sidewall Aneurysm (Fig. 3)

- Basic utilization of the remodeling technique first described for managing sidewall aneurysms.
- Temporary inflation of a microballoon within the parent vessel artificially reduces the neck size, consequently improving the neck-to-dome ratio, allowing safe coil placement within the aneurysm sac.
- This mitigates for coil migration or coil prolapse into the parent vessel in wide-necked aneurysms.

Type 2: Broad-Necked Aneurysm, with Branches at the Neck, Single Balloon (Fig. 4)

- A single balloon is placed across the neck of the aneurysm, with protrusion of balloon such that it protects the second unengaged vessel.
- Either hyperglide- or hyperform-type balloons can be used.

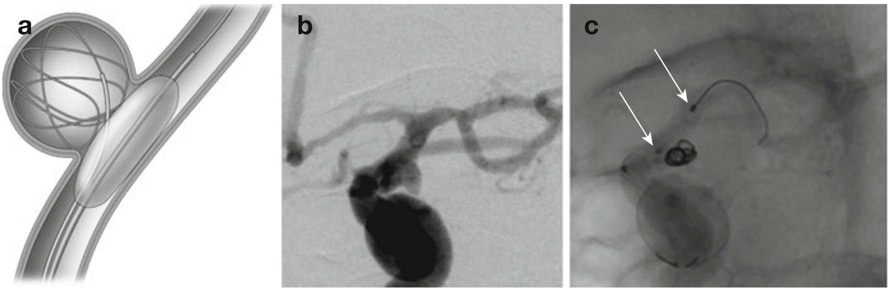

Fig. 3 Treatment of sidewall aneurysm using remodeling technique. (**a**) Schematic – showing sidewall aneurysm and balloon placement bridging the neck. (**b**) Angiogram of wide-necked left PCOM-origin aneurysm. (**c**) Balloon placed across left PCOM aneurysm, tips of which are delineated by *white arrows*

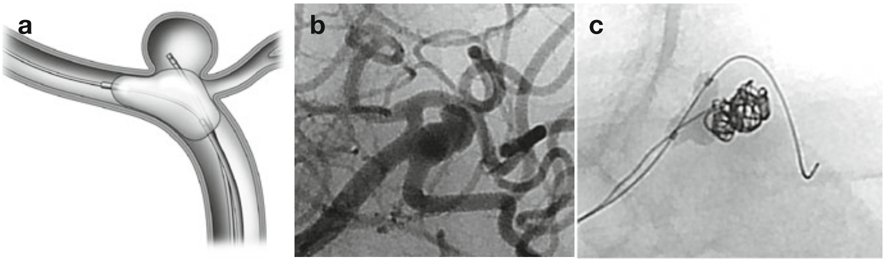

Fig. 4 Treatment of wide-necked aneurysm, with vessel incorporation using a single balloon: (**a**) Schematic – showing left MCA wide-necked aneurysm, with inflated balloon crossing the neck and protecting the second unengaged branch. (**b**) Broad-necked left MCA bifurcation aneurysm. (**c**) Single hyperform-type balloon, shown inflated protecting both the catheterized and the non-engaged MCA branches with the balloon

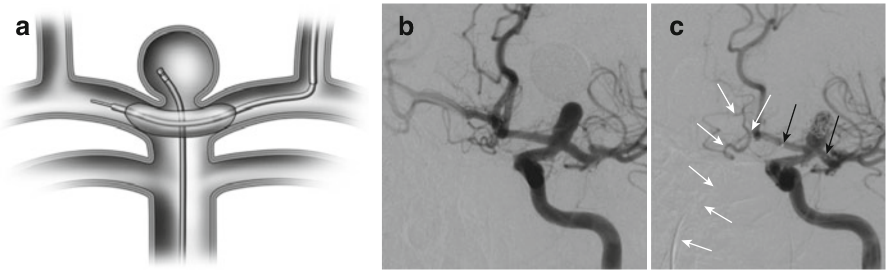

Fig. 5 (**a**) Schematic of parallel balloon placement utilizing Integraty of the Circle of Willis. (**b**) Left carotid "T" bifurcation aneurysm, with wide neck and a widely competent ACOM complex anastomotic channel. (**c**) Balloon placed parallel across aneurysm sac (*black arrows* marking balloon position), via contralateral right ICA-ACOM complex (*white arrows* demark the path of the balloon via the right ICA, ACA, ACOM, left A1 segment)

Type 3: Figure 3. Broad-Necked Aneurysm, Balloon Placed Parallel to Neck via Circle of Willis (Fig. 5)

- Greater coverage of the neck can be achieved by placing a balloon parallel to the neck of the aneurysm, such as:
  - A basilar or carotid "T" bifurcation aneurysm, via PCOM (posterior communication)
  - ACOM (anterior communication) anastomotic channels the Circle of Willis, respectively

Type 4: Broad-Necked Aneurysm, with Branches Arising at Neck/Proximal Sac, Double Balloon (Fig. 6)

- Tackling more complex aneurysm morphologies should only be considered once sidewall aneurysms have been treated successfully using microballoons.
- Appreciating the interaction (interplay) between microcatheter(s) and microballoon(s) is paramount when approaching such cases.

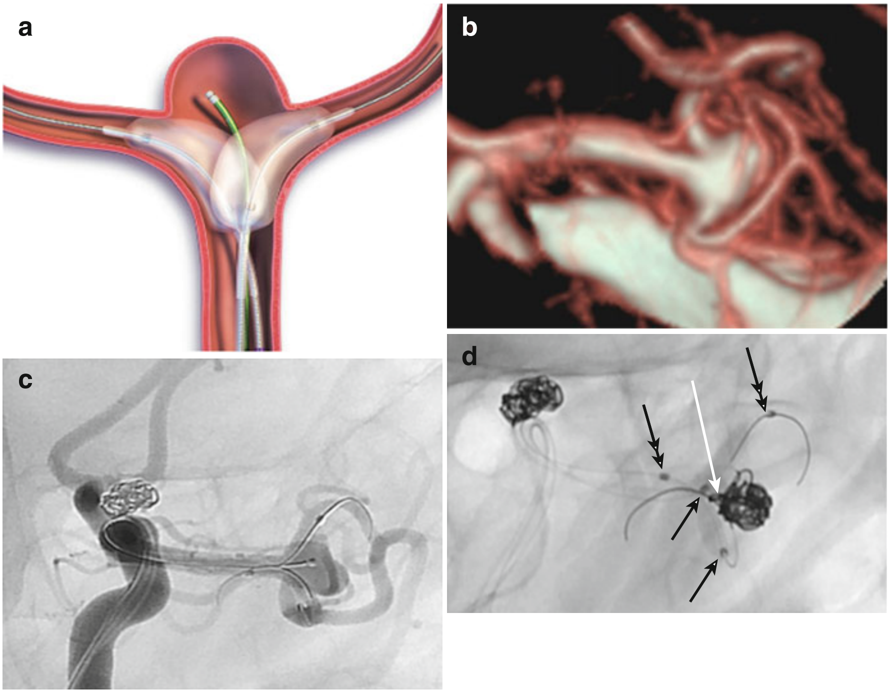

Fig. 6 (**a**) Schematic showing placement of two balloons across the broad aneurysm neck, with selective branch catheterization of the branches. (**b**) CTA showing complex left MCA morphology, with superior branch incorporated with the proximal sac and inferior branch an integral part of the neck/sac interface. (**c**) Corresponding angiographic run of left MCA aneurysm shown in CTA. Balloons and microcatheter in situ, bridging the broad aneurysm neck. (**d**) Balloons inflated with several coils deployed within aneurysm sac, showing successful remodeling, formation of a new parent vessel-sac interface (*white arrow*). Superior balloon markers show as double black arrows and inferior as single *black arrows*

- Not infrequently, beyond wide-necked aneurysms, complex aneurysms have a variable configuration of branches at the aneurysm neck/sac, with each branch needing to be preserved.
- A typical aneurysm incorporating more than one branch at the neck or proximal sac is a MCA bi/trifurcation aneurysm.
- Selectively the order of branch catheterization needs planning, with preference for the more difficult branch first. Although, one must be prepared to change strategy, and thus an alternative must be contemplated in advance.

Type 5: Small Aneurysm, with Branch Arising from Sac, Single Balloon/Multicatheters (Fig. 7)

- Small aneurysms associated with branches from the neck or proximal sac comprise a group of aneurysms that are difficult to treat.
- A balloon or a microcatheter can be positioned into the origin and proximal segment of the vessel needed to be "protected."

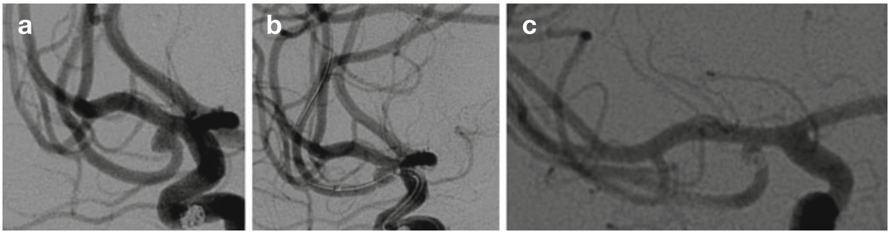

Fig. 7 Balloon utilization to protect a small branch arising from aneurysm sac. The vessel could alternatively be protected with a large microcatheter (0.21″): (**a**) Angiogram, showing a small 2 mm aneurysm arising from a right anterior temporal branch, which is incorporated within the aneurysm sac. (**b**) Balloon place within the anterior temporal branch, with accompanying anatomical distortion. (**c**) Post-embolization with anatomical restoration, occlusion of the aneurysm with preserved flow within the temporal branch

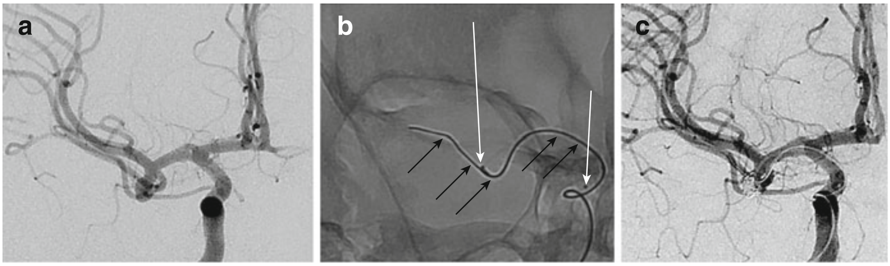

Fig. 8 Multicatheter technique. (**a**) Angiogram, showing right MCA bifurcation aneurysm, with inferior branch incorporated in neck. (**b**) First microcatheter positioned within aneurysm sac, distal tip show with *white arrow*. Second, larger microcatheter course shows with *black arrows*. (**c**) Angiogram, after second coil placement, showing dual catheter placement, with preservation of local anatomy

- Care is needed with subsequent microcatheter placement.
- Alternatively, the balloon can be further advanced into the more distal portion of the vessel, allowing the microcatheter to be positioned. However, withdrawing the balloon can displace the microcatheter and may require controlled forward pressure on the microcatheter during maneuvering of the balloon.
- An alternative to using a balloon to protect a branch is to use a microcatheter, such as a PROWLER®SELECT™ Plus (Cordis Neurovascular, Inc., Miami Lakes, FL, USA) with a large caliber, 0.021″. This will afford protection to the branch, without local anatomical distortion. The degree of protection is often less than with a balloon, and one must be prepared to rescue the branch with stent placement if necessary, a further reason for selecting a large microcatheter (Fig. 8).

Key Points

- There has been a progressive incremental paradigm shift for treating intracranial aneurysms, both ruptured and unruptured, via endovascular techniques.
- The appeal of endovascular techniques for patients is in its minimally invasive approach and reduced recovery periods.
- Several trials have shown efficacy of endovascular treatment against traditional neurosurgical techniques for both ruptured and elective cases.
- The major challenge for endovascular management of intracranial aneurysms is twofold:
  - Endovascular results need to be durable.
  - Endovascular techniques need to able to manage complex aneurysms, including large, wide necked, and branches arising from the aneurysm sac.
- Treatment of complex aneurysms has been advanced by utilization of hypercompliant microballoons, particularly in acutely ruptured aneurysms, where the permanent deployment of a device, such as a stent, as an adjuvant device is prohibited, largely due to increased complications.

Suggested Reading

1. Cekirge HS, Yavuz K, Geyik S, Saatci I. HyperForm balloon remodeling in the endovascular treatment of anterior cerebral, middle cerebral, and anterior communicating artery aneurysms: clinical and angiographic follow-up results in 800 consecutive patients. J Neurosurg. 2011;114(4):944–53. Epub 2010 May 14.
2. Moret J, Cognard C, Weill A, et al. Reconstruction technique in the treatment of wide-neck intracranial aneurysms: long-term angiographic and clinical results apropos of 56 cases. J Neuroradiol. 1997;24:30–44.