



Original Article

Can further subdivision of the Raymond-Roy classification of intracranial aneurysms be useful in predicting recurrence and need for future retreatment following endovascular coiling?

Rukhtam Saqib, Siddhartha Wuppalapati, Hemant Sonwalkar, Karthikeyan Vanchilingam, Somenath Chatterjee, Gareth Roberts, Nihal Gurusinghe

Department of Interventional Neuroradiology, Royal Preston Hospital, Lancashire, United Kingdom.

E-mail: *Rukhtam Saqib - rukhtamsaqib@doctors.org.uk; Siddhartha Wuppalapati - siddhartha.wuppalapati@lthtr.nhs.uk; Hemant Sonwalkar - hemant.sonwalkar@lthtr.nhs.uk; Karthikeyan Vanchilingam - karthikeyan.vanchilingam@ggc.scot.nhs.uk; Somenath Chatterjee - somenath.chatterjee@lthtr.nhs.uk; Gareth Roberts - gareth.roberts@lthtr.nhs.uk; Nihal Gurusinghe - nihal.gurusinghe@lthtr.nhs.uk



***Corresponding author:**

Rukhtam Saqib,
Department of Interventional
Neuroradiology, Royal
Preston Hospital, Lancashire,
United Kingdom.

rukhtamsaqib@doctors.org.uk

Received : 01 October 2021

Accepted : 14 March 2022

Published : 29 April 2022

DOI

10.25259/SNI_991_2021

Quick Response Code:



ABSTRACT

Background: The Raymond-Roy classification has been the standard for neck recurrences following endovascular coiling with three grades. Several modified classification systems with subdivisions have been reported in literature but it is unclear whether this adds value in predicting recurrence or retreatment. Our aim is to assess if these subdivisions aid in predicting recurrence and need for retreatment.

Methods: A retrospective review of all patients undergoing endovascular coiling between 2013 and 2014. Patients requiring stent assistance or other embolization devices were excluded from the study. The neck residue was graded at time of coiling on the cerebral angiogram and subsequent 6, 24, and 60 months MRA. Correlation between grade at coiling and follow-up with need for subsequent retreatment was assessed.

Results: Overall, 17/200 (8.5%) cases required retreatment within 5 years of initial coiling. 4/130 (3.1%) required retreatment within 5 years with initial Grade 0 at coiling, 6/24 cases (25%) of those Grade 2a, 4/20 cases (20%) Grade 2b, 3/8 (38%) Grade 3, and none of those with Grade 1. Large aneurysms ≥ 11 mm had an increased risk of aneurysm recurrence and retreatment. About 9.7% of ruptured aneurysms required retreatment versus 4.4% for unruptured. About 55% of carotid ophthalmic aneurysms were retreated.

Conclusion: Although the modified classification system was significantly predictive of progressive recurrence and need for retreatment, no significant difference between the subdivisions of Grade 2 was observed. Similar predictive value was seen when using the Raymond-Roy classification compared to the new modified, limiting the usefulness of the new system in clinical practice.

Keywords: Coiling, Intracranial aneurysms, Raymond-Roy, Recurrence

INTRODUCTION

Endovascular treatment (EVT) of intracranial aneurysms has become the treatment norm over surgical clipping for both ruptured and unruptured aneurysms since the International Subarachnoid Aneurysm Trial (ISAT).^[14] Although there was improved independent survival

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at 7 years, the trial did show a higher retreatment rate with EVT versus surgical clipping.^[14] A meta-analysis of aneurysm recurrence demonstrated recurrence in 24.4% of 1316 cases following EVT with retreatment requiring in 9.1%.^[15] The risk of recurrence varies in literature ranging from 3.6 to 33.6%.^[3,4,6,12,18,20] Although there are multiple factors which have been associated with increased risk of bleeding and recurrence, one of the major factors in the control of the neurointerventionalist is the degree of aneurysm occlusion.^[2,9] The Cerebral Aneurysm Rerupture After Treatment study showed higher risks of re-bleed with reduced degree of aneurysm occlusion.^[7,23] The overall risk of rebleed was 1.1% for complete occlusion, 2.9% for 91–99% occlusion, 5.9% for 70–90%, and 17.6% for <70%.^[7,23] It is difficult to accurately calculate the degree of occlusion as a percentage using angiographic images and is rarely described from our experience. Instead, various classification systems have attempted to categorize the degree of aneurysm occlusion based on patterns of residual aneurysm filling.^[10,15,21,27] The Raymond-Roy classification has been the standard for neck recurrences followed endovascular coiling with three grades; Grade 1: complete obliteration; Grade 2: residual neck; and Grade 3: residual aneurysm [Figure 1].^[21] There have been several attempts to create a modified Raymond-Roy classification system in literature recently which are thought to aid in the management of recurrences.^[10,21,27]

Our modified classification system is a similar version published in recent literature.^[27] The main subdivisions of the Raymond-Roy classification are focused on Grade 2, which are subclassed into central aneurysm or lateral residual filling. Another addition is Grade 4 where there is a new aneurysmal growth adjacent to the original sac. This has formed the basis of our classification system; Grade 0: no neck residue or interstitial filling; Grade 1: flat disc-like filling at the base of the aneurysm which is <10% of the total aneurysm volume; Grade 2a: central dome-like neck filling with coils on either side of the base and <20% of the total aneurysm volume; Grade 2b: dog ear/side wall neck filling of the aneurysm <20% of the total volume; Grade 3: interstitial filling within the aneurysm; and Grade 4: new growth from the base of the aneurysm [Figure 2]. However, it is unclear whether these subdivisions of Grade 2 are useful clinically in predicting further interstitial aneurysmal



Figure 1: Raymond-Roy aneurysm neck recurrence classification system.

filling which could put the patient at high risk of rebleed and require retreatment.^[15,21,27] Small neck remnants such as those in Grade 0, 1, 2a, and 2b are considered to have a low risk of rebleeding and usually conservatively managed with follow-up imaging in our practice. Interstitial refilling of the aneurysm or new growth (Grades 3 and 4) are regarded as higher risk of rebleeding and we subsequently offer patients retreatment. All cases are discussed in a neurovascular multidisciplinary meeting for decision-making regarding retreatment. The grade of recurrence did form a factor in determining whether retreatment was offered but other factors such as patient choice, whether previous ruptured or unruptured aneurysm and patient comorbidities were crucial in the decision-making.

Our aim was to assess whether the modified aneurysm neck recurrence classification system can predict progressive aneurysm recurrence and subsequent retreatment.

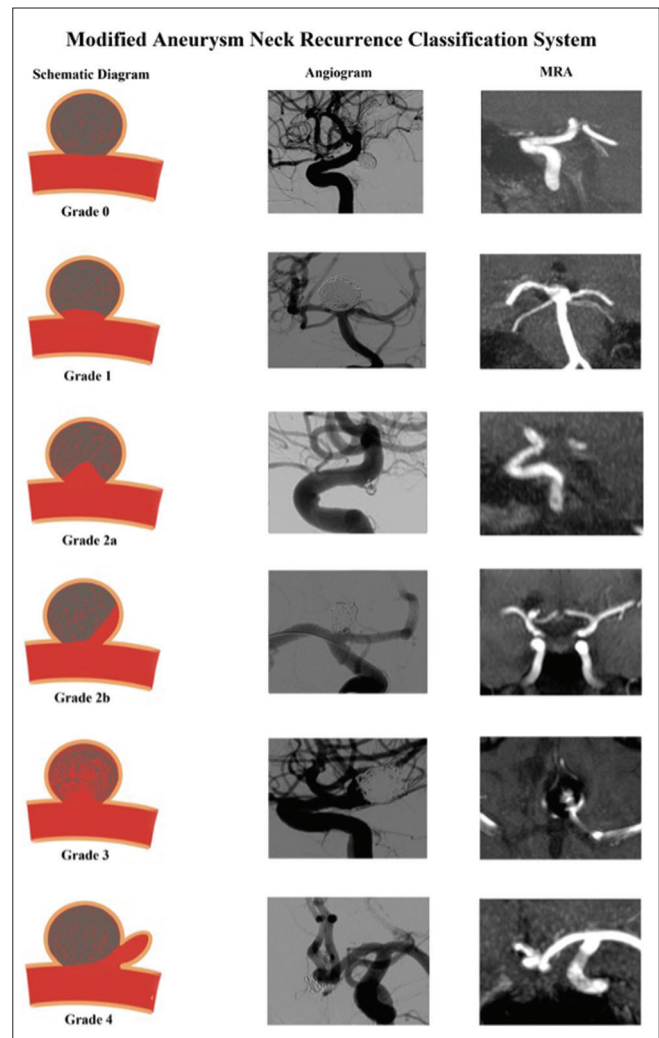


Figure 2: A schematic, angiographic, and MRA representation of the modified aneurysm recurrence classification system.

MATERIALS AND METHODS

Patient selection

A retrospective review of all patients whom underwent endovascular coiling at our institution between 2013 and 2014 was conducted. This period was chosen to ensure follow-up was available for patients upto 5 years post procedure at the time of the study. Both ruptured and unruptured aneurysms were included in the study. Cases which required stent assistance or involved the use of other embolization devices, such as Webs, were excluded from the study. It is our routine practice to use a balloon in the majority of endovascular coiling case. If a patient had more than 1 aneurysm treated during the study period, each aneurysm was included as a separate case. The procedures were performed by two experienced consultant interventional neuroradiologists. All procedures were performed on a Philips Allura FD20 biplane. Follow-up imaging was performed on 3T MRA time-of-flight imaging, with inclusion of additional standard diagnostic sequences.

Data collection and analysis

Using the initial cerebral digital subtraction angiogram, the location, size, side, and ruptured status of the aneurysm were noted. The aneurysm size was divided into small (≤ 5 mm), medium (6–10 mm), and large (≥ 11 mm).

The grade of the neck residue was assessed on the initial coiling angiogram DSA. In our practice, we follow up patients with a 6-month and 24-month time-of-flight 3T MRA. One of the three vascular neurosurgeons also performs a 60-month MRA follow-up; these were also reviewed. The neck recurrence was assessed using the modified and Raymond-Roy aneurysm recurrence classification system on each subsequent follow-up MRA. Each scan was reviewed an interventional neuroradiologist who had no involvement in the procedure to reduce bias followed by a reviewed by a consultant interventional neuroradiologist. Any disagreements of classification were discussed among the other authors, with the majority agreement being the final classification. For patients with MRA findings concerning for recurrence, a cerebral angiogram DSA was performed to confirm and patient retreated if required. Progression of neck grade recurrence was analyzed from the time coiling as baseline to 6, 24, and 60 months. Change in aneurysm recurrences between 6–24 months and 24–60 months was also assessed separately. A Chi-square test was performed to assess for correlation.

For cases which required retreatment of aneurysm recurrence, the method of retreatment and any subsequent recurrence of the neck residue within the 1st year post retreatment were noted. Factors such as the size of aneurysm, location, and whether the aneurysm was ruptured or unruptured were analyzed for any correlation.

RESULTS

A total of 200 cases were performed within the 2-year period. One hundred aneurysms were ≤ 5 mm, 77 aneurysms were between 6 and 10 mm, and 23 were ≥ 11 mm. Fifty-six aneurysms were on the left side, 74 aneurysms on the right side, and 70 aneurysms did not have a side as they occurred in a single vessel such as basilar artery or anterior communicating artery (ACOM). One hundred and forty-four were female and 56 were male. Forty-five were unruptured and 155 ruptured aneurysms. Ninety of the procedures were performed by one consultant and the remaining 110 by the other. The aneurysm locations were 12 anterior cerebral artery, 55 ACOM, four anterior choroidal artery, 13 basilar top, nine carotid ophthalmic, 17 communicating segment internal carotid artery, 39 middle cerebral artery, two posterior cerebral artery, 42 posterior communicating artery, three posterior inferior cerebellar artery, and four superior cerebellar artery. One hundred and ninety-nine cases were balloon-assisted coiling with only case it not being utilized.

[Figure 3] outlines the breakdown of aneurysm recurrence grades at the time of coiling and subsequent follow-up on MRA up to 60 months.

Retreatment postcoiling

Overall 17/200 (8.5%) cases required retreatment within 5 years of initial coiling. 4/130 (3.1%) cases required retreatment within 5 years with initial Grade 0 at coiling, 6/24 cases (25%) of those Grade 2a, 4/20 cases (20%) Grade 2b, and 3/8 (38%) Grade 3. No cases of Grade 1 at coiling required retreatment. If aneurysm neck recurrence grading at 6 months follow up is used as a predictor for retreatment; 1% of grade 0 (1/100 cases), 0% of grade 1, 13% of grade 2a (5/38 cases), 23% of grade 2b (3/13 cases) and 89% of grade 3 cases (8/9) went onto having re-treatment within the follow up period of our study. 7/17 cases were retreated between after MDT discussion of the first follow-up MRA at 6 months. 4/17 cases were retreated after the second follow-

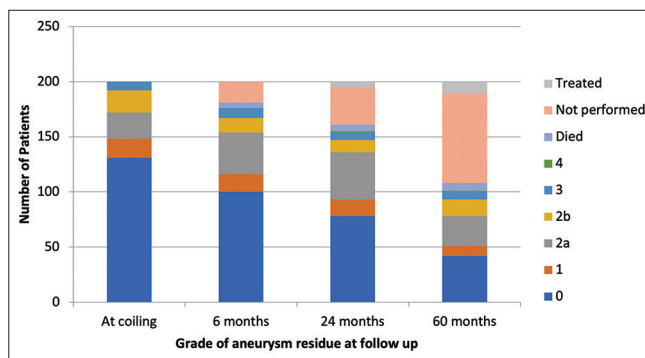


Figure 3: A graph showing the breakdown of grades of aneurysm residue and retreatment at different stages of follow-up.

up at 24 months and 6/17 after 60 months follow-up. Both aneurysm neck residues at the time of coiling at 6 months were statistically significant ($P < 0.05$) for risk of progression and retreatment, with greater correlation being seen with classification at 6 months follow-up. However, the degree of correlation was also similarly significant with the Raymond-Roy classification and no difference in predictability was seen between this newer and the Raymond-Roy classification. No statistical difference was seen between Grades 2a and 2b for predicting progression or risk of retreatment.

15/17 (88%) were initially ruptured aneurysms and 2/17 (12%) unruptured. However, this was not statistically significant ($P = 0.30226$). Of those retreated, 9/17 were large (≥ 11 mm), 5/17 medium (6–10 mm), and 3/17 small (≤ 5 mm) size; this was statistically significant ($P < 0.05$). 5/17 were carotid ophthalmic (29%), 5/17 ACOM (29%), 4/17 MCA (24%), 2/17 ICA communicating segment (12%), and 1/7 basilar top (6%). When accounting for total cases, the overall location for cases retreated was 5/9 (55.6%) were carotid ophthalmic, 5/55 ACOM (9.1%), 4/39 MCA (10.3%), 2/17 ICA communicating segment (11.8%), and 1/13 basilar top (7.7%); $P < 0.05$. 5/17 (29%) were male and 12/17 females (71%); gender was not a statistically significant factor for recurrence ($P = 0.901$). The location was statistically significant. [Table 1] summarizes the cases which required retreatment.

DISCUSSION

Several factors have been previously been described in the literature as predictors of aneurysm recurrence, including incomplete aneurysm occlusion at coiling, packing density, large aneurysm size, and ruptured aneurysm prior to treatment.^[5,7,9-11,17,21,22,27] Aneurysm location is reported to have a role in recurrence, with more technically challenging ACOM and PCOM aneurysms, as well as carotid ophthalmic, having a higher risk.^[5,10,11,17,21,22,27] The risk of rebleed is highest in the first 24 h.^[13,14] ISAT found the rebleed risk to be 2.5% in the 1st year, with 0.2% annual rebleeding risk in the next 4 years.^[13,14] The risk of late rebleeding of a coiled aneurysm after 6 years is negligible.^[13,14] We do not routinely follow-up treated aneurysms beyond 5 years but the data on need for further delayed aneurysm retreatment are limited. There are substantially less data on the risk bleeding of unruptured aneurysms postcoiling, but overall, they have a much reduced risk when compared to ruptured aneurysms.^[15,26] Naggara *et al.* demonstrated that the annual risk of bleeding after EVT of unruptured aneurysms was 0.2%, but the follow-up was short.^[15]

In our study, we found no significant increased risk of recurrence between Grades 2a and 2b at time of coiling and subsequent follow-up. There was low risk of recurrence

Table 1: A summary of cases which required retreatment following endovascular coiling.

Sex	Type	Site	Size (mm)	Coiling	6 months grade	24 months grade	60 months grade	Time retreated?	What was the retreatment?
M	Unruptured	Basilar top	14	0	3	-	-	6	Flow diversion
F	Ruptured	MCA	5	3	3	3	3	6	Clipping then pipeline stent at 6 years
M	Ruptured	ICA communicating	12	3	3	-	-	6	Flow diversion
F	Ruptured	Carotid ophthalmic	15	2b	3	-	-	6	Flow diversion
F	Ruptured	MCA	7	2a	3	-	-	6	Flow diversion
F	Ruptured	Carotid ophthalmic	15	2a	2b	-	-	6	Flow diversion
F	Ruptured	Carotid ophthalmic	15	2b	3	-	-	6	Flow diversion
M	Ruptured	ACOM	13	3	3	3	-	24	Flow diversion
F	Ruptured	MCA	8	2a	2a	4	-	24	Recoiling
F	Ruptured	ICA communicating	6	2b	2b	3	-	24	Recoiling then pipeline at 4 years
F	Ruptured	Carotid ophthalmic	9	2b	2b	3	-	24	Flow diversion
M	Ruptured	ACOM	18	2a	2a	2a	3	60	Flow diversion
M	Ruptured	ACOM	6	0	3	3	3	60	Flow diversion
F	Ruptured	MCA	16	2a	2a	2a	3	60	Stent-assisted coiling
F	Ruptured	ACOM	4	2a	2a	2a	4	60	Flow diversion
F	Ruptured	ACOM	4	0	2a	3	3	60	Stent-assisted coiling
F	Unruptured	Carotid ophthalmic	12	0	0	2b	3	60	Flow diversion

and retreatment for Grade 0 or 1 at the time of coiling and at 6 months follow-up, whereas, as expected, high risk for Grade 3. Acute ruptured aneurysm cases accounted for almost 90% of those needing retreatment. Overall, 9.7% of ruptured aneurysms required retreatment versus 4.4% for unruptured. However, our sample size included a larger proportion of ruptured aneurysms and the differences accounted were not statistically significant. Aneurysms >10 mm accounted for 53% of overall cases that required retreatment. About 39.1% of large aneurysms (≥ 11 mm) needed retreatment, compared to 6.5% of medium sized and 3% of small aneurysms. Frequently, we would allow a small neck residue for ruptured or large aneurysms, particularly those with a wider neck with a view to later treat by flow diversion as part of a two-stage procedure. This allows safe occlusion of the aneurysm with the prevention of risk of rebleed. Striving for a perfect angiographic result may not be in the best interest of the patient with a ruptured aneurysm, leading to risks of possible resultant parent artery or side branch occlusion, coiling migration, infarction, and possibly death. In addition, treating with flow diversion carries a bleeding risk due to preloading on dual antiplatelets to avoid stent occlusion, which we feel outweighs the benefits in ruptured aneurysms due to the significant increased bleeding risk. Aneurysm location was also an important factor with 55.8% of carotid ophthalmic aneurysms being retreated with flow diversion. The PUFs trial demonstrated a 93.4% cure rate in patients retreated with pipeline device.^[1] The remaining aneurysm locations where retreatment occurred had a recurrence risk between 7 and 12% which no significant difference. Although, 71% of cases which needed retreatment were female, when accounting for the total number of females and males, there is no significant difference (8.3% of females vs. 8.9% of males).

Although aneurysm neck recanalization is an important factor in determining whether retreatment is offered, it should not be the only factor.^[5,7,10,11,17,21,22,27] First, small neck remnants have a small bleeding risk which is often higher than the risk of retreatment.^[5,10,11,17,21,22,27] In the modified classification system, this includes Grades 0, 1, 2a, and 2b for which we usually offer conservative management with follow-up imaging. Patients are often fearful postaneurysm treatment and mention of aneurysm neck recurrences can lead to increased anxiety in patients and must be managed appropriately with risk benefit assessment of retreatment versus conservative management. Consideration of the patient's comorbidities, previously ruptured aneurysm and patient choice are very important factors in determining whether we offer retreatment. Additional patient factors may also influence the risk of aneurysm recurrence.^[8,16] For example, smoking is known to be a risk factor which could alter the individual's risk despite the lower initial aneurysm recurrence grade.^[8,16] Hypertension has also been shown to

play a role in aneurysm formation and recurrence.^[8,16] At our follow-up clinics, we re-emphasize smoking cessation and hypertension control to our patients to improve outcomes postcoiling.

For routine endovascular coiling at our institute, we routinely use HyperForm and HyperGlide balloons, and in our study, only case did not utilize a balloon. They provide a safety net in case of intraoperative aneurysm or vessel rupture, with inflation of the device providing a lifeline through temporary occlusion of the supplying vessel, thus helping to reduce the volume of blood loss before definitive treatment.^[19,24,25] They can also aid in treating wider neck aneurysms by contouring to the branching vessel and neck of the aneurysm, providing the ability to increase packing density and potentially reduced risk of recurrence.^[19,24,25] Sluzewski *et al.* showed a greater degree of aneurysm occlusion at time of coiling and in follow-up imaging using balloon assistance compared to without.^[25] A large meta-analysis demonstrated no significant increase in thromboembolic events or iatrogenic rupture, with a significant increase in aneurysm occlusion using balloon assistance versus without.^[24] Our use of balloon assistance may have led to improved aneurysm occlusion. The overall percentage of need for retreatment of 8.5% in our study was in line with published literature.^[15]

Limitations of the study

The retrospective single center nature of the study and variation in treatment approaches among colleagues in different centers could limit the usefulness of a classification system. Direct comparison of residual aneurysm between angiogram DSA and MRA can lead to interpretation discrepancies despite each case being reviewed individually by two authors. Most interpretation discrepancies were between Grades 2a and 2b. A prospective study with longer follow-up of a greater proportion of participants could be useful for further research.

CONCLUSION

In our study, we found no significant difference in progressive recurrence or need for retreatment between Grades 2a and 2b. There was no statistical difference in the predictive value between the Raymond-Roy and modified classification, which limits its clinical application benefit. The Raymond-Roy classification with three basic grades appears to be sufficient in aiding recurrence management, with Grade 3 being high risk of rebleeding and requiring retreatment and Grades 1–2 being lower risk. However, we do feel that the addition of Grade 4 new aneurysms growth is useful as this is a different entity and likely would require treatment. Further larger multicenter studies investigating the role of subdivisions could be useful in the future to evaluate their clinical role.

Declaration of patient consent

Patient's consent not required as patients identity is not disclosed or compromised.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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How to cite this article: Saqib R, Wuppalapati S, Sonwalkar H, Vanchilingam K, Chatterjee S, Roberts G, *et al.* Can further subdivision of the Raymond-Roy classification of intracranial aneurysms be useful in predicting recurrence and need for future retreatment following endovascular coiling? *Surg Neurol Int* 2022;13:170.