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LONG TERM OUTCOME OF INTRACRANIAL ANEURYSMS TREATED BY WRAPPING



SUBMITTED FOR M.Ch NEUROSURGERY

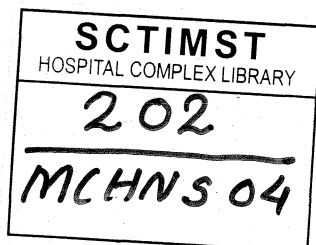
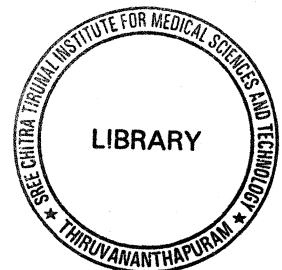
by

Dr. Mukund Prasad

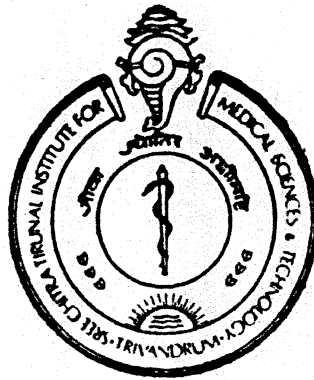
November 2004

DEPARTMENT of NEUROSURGERY

**SREE CHITRA TIRUNAL INSTITUTE
FOR
MEDICAL SCIENCES AND TECHNOLOGY
TRIVANDRUM-695011**



LONG TERM OUTCOME OF INTRACRANIAL ANEURYSMS TREATED BY WRAPPING



Submitted By : Dr Mukund Prasad

Programme : M.Ch Neurosurgery

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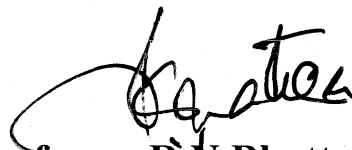
CERTIFICATE

*This is to certify that the study "LONG TERM OUTCOME OF
INTRACRANIAL ANEURYSMS TREATED BY WRAPPING"*

has been carried out by Dr. Mukund Prasad

in

Department Of Neurosurgery,
Sree Chitra Tirunal Institute for Medical Sciences and
Technology



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Introduction

An aneurysm is an abnormal dilatation of any blood vessel. Intracranial aneurysms become symptomatic due to rupture, mass effect, embolism or seizure. Subarachnoid hemorrhage due to aneurysm is a major cause of mortality & morbidity among the patients harboring aneurysms. Aneurysms require treatment to prevent rebleed & its subsequent complications. Surgical treatments aim at exclusion of the aneurysm from circulation by clipping or by trapping with or without bypass of the parent vessel. Other method to prevent rebleed is to reinforce the wall of the aneurysm. Newer modality of treatment is embolization of the aneurysm by endovascular means.

In 1930, Dott¹ performed the first successful operation on a ruptured middle cerebral artery aneurysm and wrapped the aneurysm with muscle hammered onto gauze. This method of treatment became popular in 1954 when Gillingham advocated wrapping of all MCA aneurysms. However wrapping of aneurysms gradually became obsolete due to advent of microsurgical techniques, clips, poor efficacy of wrapping as a treatment modality, and adverse effects of materials used for wrapping. Today, the treatment of choice is clipping and almost aneurysms every possible configuration can be treated by a single clip or by a combination of clips. Still, on a number of occasions, clipping of the aneurysm may not be possible due to a number of reasons and the surgeon resorts to reinforcement of the aneurysmal wall by wrapping or coating.

Aim

This retrospective study is carried out to study the efficacy of wrapping in preventing rebleed, the factors that led to the wrapping or coating of aneurysms, the long term angiographic outcome of wrapped aneurysms, and factors that affect the outcome.

Review of Literature

Intracranial aneurysm rupture is a serious disease. First episode is the major cause of death following subarachnoid hemorrhage (SAH). Thirty day mortality for subarachnoid hemorrhage has been reported as 40- 45 %^{2, 3}. Of these, first episode of bleed is the cause of maximum mortality (75%)^{2,3}. Rebleed and vasospasm account for 22% and 6% of early deaths following SAH. Thus rebleeding is the second major cause of death. The risk of rebleeding is the highest in the first 24 hours following SAH i.e. four percent. It then declines to about 1 percent per day for first 2 weeks for a cumulative risk of 15 %-25% over this time. Subsequently it further declines to reach a baseline of 2 %-3% per year. Several studies suggest that factors that influence the death rate are decreased consciousness, age, amount of subarachnoid blood, time to admission and preoperative hypertension. Most of the therapeutic strategies will not alter these factors. The International Cooperative study on timing of aneurysm surgery showed that early surgery helped in preventing rebleed but there was no difference in the overall outcome between early and late surgery.

Thus the role of surgery in managing patients of subarachnoid hemorrhage is to prevent rebleed. Though surgery cannot modify all the factors responsible for mortality and morbidity in cases of subarachnoid hemorrhage, it does prevent rebleed. The era of modern aneurysm surgery started in 1933 with Egas Moniz demonstrating an aneurysm by cerebral angiography. Dott conducted the first planned intracranial operation for a saccular aneurysm in 1930. He controlled the bleeding from a middle cerebral artery aneurysm by wrapping with muscle & gauze. The long-term outcome was good. First clipping was performed by Dandy in 1937 of an intracranial aneurysm. Later, with the

development of a number of clips of various configurations, introduction of operating microscope & availability of endovascular treatment, the treatment of intracranial aneurysms by wrapping or coating became obsolete.

The treatment of aneurysms by wrapping became popular when Gillingham advocated treatment of all middle cerebral artery aneurysms by wrapping. He reported a series of 81 cases with an overall mortality of 4%. Pool & Potts used the technique of wrapping with muslin gauze and stated that wrapping was the treatment of choice for those aneurysms that were not amenable to clipping. After that there was a resurgence of interest in treating aneurysms with wrapping. A number of studies appeared in literature with variable reports of efficacy of wrapping of aneurysms in preventing rebleed.

Mount and Antunes⁴ reported on the results of wrapping and coating on 58 aneurysms in 52 patients. The reasons for wrapping or coating were absence of discrete neck, branch arising from aneurysm, atherosclerotic plaque and other peculiar anatomical features. Of these 6 were lost to follow up. Four patients died in the follow up period. One patient died due to poor pre operative grade. Two patients had fatal rebleed. One died due to rebleed 3 weeks after discharge and another 3 years after wrapping. Fourth patient died after deterioration in the post op period and necropsy showed no rebleed but evidence of encephalomalacia due to emboli from the aneurysm was found. Thus the rebleed rate was 3.8 %. The sites most commonly involved were middle cerebral, posterior communicating, anterior communicating, internal carotid, vertebrobasilar and anterior cerebral in that order. The mean follow up period was 37 months. Post op angiography was performed in eight patients. In six of them, aneurysms were not visualized; one ACA aneurysm was reduced in size while one PCA aneurysm was

markedly increased in size in an angiogram obtained 15 years after the original operation. It is not clear when the postoperative angiogram was obtained in rest of the patients.

Taylor & Chaudhury⁵ reported results of gauze wrapping of 35 ruptured MCA aneurysms followed for 2 to 15 years. No specific characteristic of aneurysm was used for selection of the wrapping procedure. The patients were operated after 7-10 days when they were in Boterell's grade 1 or 2. Waiting period for grade 3 patients was longer allowing time to return to grade 1 or 2. There were 4 deaths with 3 in early postoperative period. Of the 3 early deaths only 1 death was due to rebleed, which occurred because of failure of fibrosis around the aneurysm. One late death occurred due to intracranial hemorrhage after initial surgery. However the bleed was not from the wrapped aneurysm as autopsy revealed the hematoma on the contralateral side and the aneurysm was found to be encased in a thick fibrotic wall.

Cudlip et al⁶ reported 15 patients with solitary ruptured aneurysms treated by wrapping with muslin. All, but one patient, were followed for 5 years. None of the patients had rebleed. There were 7 MCA, 4 acom, 2 ICA bifurcation, 1 ophthalmic and 1 pcom aneurysms. The reasons for wrapping were presence of perforators, preoperative rupture, broad neck, fusiform aneurysm and presence of atheroma.

Dutton⁷ reported 106 aneurysms treated by acrylic coating (79 MCA, 26 acom & 1 pcom aneurysms) followed for 1-10 years. According to him there were no deaths attributable to rebleed from the wrapped aneurysms.

In a report by Todd et al⁸ a total of 181 surgically treated ruptured aneurysms were studied. Sixty patients had their aneurysms wrapped while 121 underwent clipping of the aneurysms. All patients had single aneurysms. The patients were followed up for a

period of 10 years. The definite rebleed rate for clipped aneurysms was 3.3% or 0.33% per year. For wrapped aneurysms definite early rebleed rate was 8.6% (less than 6 months). The late rebleed rate was 13.9 % or annual rebleed rate of 1.5 % per year for the wrapped aneurysm group. The material used for wrapping was gauze with muscle, alone or with methylmethacrylate. The results of the study led the authors to conclude that wrapping does prevent against early rebleed. Postoperative angiography was obtained in 4 patients with wrapped aneurysms which revealed one obliterated aneurysm, one with reduced size, one which remained stable and one which increased in size. The study was obtained between 2 to 8 months post wrapping.

All studies did not favor wrapping as a treatment option for ruptured aneurysms. Study by Minakawa et al⁹ analyzed 23 aneurysms treated by coating. The aneurysms were coated with Biobond as clipping was not technically feasible. Mean follow up period was 11.2 years. There were total of 6 rebleeds with a rebleed rate of 26%. The recurrent hemorrhage occurred between 3 months & 10.5 years. Rebleeding was confirmed with CT scan in 3 patients and by blood stained CSF in two patients. As, only two of the aneurysms were completely coated in the patients who suffered rebleed the true failure of coating in preventing rebleed was 8.7 % only (2 of 23 aneurysms). Both the rebleeds occurred after a mean period of 9 years 7 months. There were no early rebleeds in the aneurysms coated completely. Thus although the investigators made out a case of too high a rebleed rate following wrapping, in fact it was low & prevented rebleed in the early postoperative period.

Fujiwara et al¹⁰ concluded wrapping to be ineffectual method of treatment for intracranial aneurysms. In their series of 29 patients, which were followed up for a mean

period of 11 years, wrapping or coating was done with muscle, gauze or bioadhesives like Biobond & aron alpha (alkylcyanoacrylate monomer). There were 5 rebleeds, 2 less than 6 months and 3 between 6 months & 6 years. All cases were fatal and the rerupture rate is 17 %, which is high. There was no mention whether microsurgical techniques were used for dissection of the aneurysms before wrapping or whether the aneurysms were wrapped completely.

Cossu et al¹¹ published the results of long-term follow up in 47 cases of ruptured aneurysms treated by wrapping. The mean follow up period was 13.7 ± 8.2 years. Eight patients suffered rebleeding with an overall rate of 17 %. Early fatal rebleed rate was 6.4 %. After the first month rate of rebleeding was 0.93 % per year. They also showed that without the use of bioadhesive agents the rebleeding rate was higher. The rerupture rate was higher for those patients treated in premicrosurgical era (25 %) as compared to those treated in the microsurgical era (8.7 %). This study has failed to report the criteria used to diagnose rebleed.

Nussbaum & Erickson¹² reported on the outcome of coagulation & wrapping of unruptured micro aneurysms, which were associated with other larger ruptured aneurysms, in twenty cases. None of these patients suffered from rupture of treated aneurysm. Angiogram obtained in the immediate post op period and at 1 year follow up showed obliteration of treated aneurysm in 19 cases. Only one aneurysm was seen on follow up angiogram and it was of the same size as at the time of first surgery.

Considering all the reports, the overall early rebleed rate is 3.2% which is significantly less than the cumulative risk of rebleeding in untreated ruptured aneurysms in the first 6 months which is 50%. Therefore the protection provided by wrapping

against early rebleed is significant. The long term studies have shown the aneurysms treated by wrapping or coating to rebleed at the rate of approximately 1.5 % per year. The rebleed rate for conservatively treated ruptured aneurysms is reported as 2 to 3 % per year. Thus the protection afforded by wrapping or coating against rebleed in the long term is minimal. Of the 401 aneurysms treated by wrapping in the above mentioned studies, only 42 (10.5%) have been assessed by follow up angiogram. The results are shown in table III.

The most important indication for wrapping of aneurysm was the presence of a wide based neck because it was technically not possible to satisfactorily clip the aneurysm without compromising the lumen of the parent vessel. The next most important indication of wrapping of aneurysm was the presence of perforators in close proximity to the aneurysm (table IV).

Various clinical and laboratory studies have reported on the efficacy of different materials used for wrapping or coating of aneurysm. The various materials reported in literature are muscle alone or with gauze, muslin, gauze alone, Selverstone material (polyvinyl polyvinyledene chloride with second layer of epoxy polyamide resin), Aron alpha (alkyl Cyanoacrylate monomer), Biobond, plastic sheath, gelatin sponge, oxidized cellulose. The results of clinical studies indicate that muscle or gauze without any bio adhesive has high rate of failure. Cossu et al reported a rate of rebleeding of 10.5% when bioadhesives were used and 44.5 % when bioadhesives were not used. While Minakawa et al reported rebleeding in 33% of cases where bioadhesive (Biobond) was used for coating. A clinico experimental study by K.Ebina¹³ et al showed that bemsheet was superior to muscle, fascia, and bioadhesives like alkyl cyanoacrylate and biobond. They

demonstrated that muscle and fascia showed necrotic changes within 1 to 2 months of surgery. Bioadhesives had poor adhesiveness to the vessel wall resulting in their failure to protect against rebleeding. In contradiction to this, Yodh¹⁴ et al have shown good protection against rebleeding when Cyanoacrylate was used as encasing material. Thus there is no consensus as to what material should be used for wrapping of aneurysms where indicated.

One of the major complications that can occur with using artificial material, especially muslin, for wrapping is optochiasmal arachnoiditis¹⁵. It has been reported where anterior communicating artery aneurysms were wrapped with muslin. The treatment of arachnoiditis is difficult with poor prognosis. Use of gauze is also found to cause complications like "gauzoma" that also carries a poor prognosis.

Allcock and Canham¹⁶ showed that the growth rate of an aneurysm is not consistent and can change considerably during the follow up period. They could not find an association between growth rate and blood pressure (BP), patient age, size of aneurysm, or angiographic follow up time.

Several studies have shown that the risk of SAH from unruptured aneurysms is 1%-2% per year and the risk of SAH in normal population is 0.01% to 0.05% per year. The International Study of Unruptured intracranial aneurysms showed the rates of SAH from unruptured aneurysms less than 10 mm to be 0.05% and for those 10mm to 25mm to be 0.7%.

Juvela S¹⁷ et al reported the probability of new aneurysm formation to be 1.6%- 2.2% per year. This yielded a risk of SAH from a de novo aneurysm to be 22-31 per 100000 per year during first 10 years. This is similar to incidence of SAH in the general adult

population. From the discussion above, it can be concluded that the evidence for or against the efficacy of wrapping or coating of the aneurysm in the literature is not definite due to non uniformity of case selection, different materials used for wrapping, completeness of wrapping & use of micro neurosurgical techniques.

Table I: Summary of results from published series.

Study	No of pts (Number of aneurysms).	FU (yrs) Mean	Rebleed		
			Early <6 months	Late >6 months	Overall
Mount & Antunes 1975	52 (58)	37 months	1(1.7 %)	0	1 (1.7 %)
Taylor & Choudhary 1977	35 (35)	2yrs – 15 years	1 (2.8%)	0	1(2.8%)
Todd et al 1989	60 (60)	10 years	5 (8.3%)	6 (10%)	11(18.3%)
David et al 1999	8 (8)	?	0	1 (12.5%)	1 (12.5%)
Minakawa et al 1987	23 (23)	11.2	1 (4.34 %)	5 (21.7%)	6 (26.1%)
Fujiwara et al 1990	29 (29)	11 years	2 (8.7 %)	3 (13.04%)	5 (21.74%)
Cossu et al 1993	47 (47)	13.7 years	3 (6.4%)	5(10.6%)	8 (17%)
Cudlip et al 1998	15 (15)	5 years	0	0	0
Dutton 1969	106(106)	1-10 yrs	0	0	0
Nussbaum et al. 1999	20 (20)	1 year	0	0	0
Total	395 (401)		13 (3.2%)	20 (4.9%)	33 (8.2 %)

Table II: Sites of wrapped or coated aneurysms

study→	Mount 1975	Eric 1999	Taylor 1977	Todd 1989	Minakawa 1987	David 1999#	Fujiwara 1990	Cossu 1993*	Cudlip 1998	Dutton 1969	Total
Location ↓											
MCA	19	8	35(1)	36	5	-	10(4)	15	7	79	206
Pcom	12	-	-	-	-	-	-	-	1		13
Acom	10	5	-	-	11(5)	-	9	13	4	26	73
ICA	8	6	-	4	6(1)	-	7(1)	15	2		42
Vertebro basilar	6	1	-	-	1	-	2	-	-		9
Anterior cerebral	3(1)	-	-	20	-	-	-	2	-		25
P1 of PCA	-	-	-	-	-	-	1	2	-		3
OSA	-	-	-	-	-	-	-	-	1		1
PICA		-								1	1
Total	58(1)	20 (0)	35(1)	60 (11)	23 (6)	8 (1)	29 (5)	47 (8)	15 (0)	106 (0)	401

*= Distribution of aneurysms with rebleed not known.

#= Sites not known, Fig in parentheses indicate number of aneurysms which rebled

Table III: Number of aneurysms with follow up angiogram in published series.

Study	Number	Obliterated	Decreased	Static	Increased
Todd 1989	8	6	1	0	1
Dutton 1969	0	0	0	0	0
Cossu 1993	2	0	0	0	2
David 1999	8	0	0	7	1
Fujiwara 1990	0	0	0	0	0
Cudlip 1998	0	0	0	0	0
Taylor 1977	4	1	1	1	1
Eric 1999	20	19	0	1	0
Total	42	26	2	9	5

Table IV: Reason for wrapping aneurysms in the literature

Study	Reason for wrapping						
	Wide neck	Adhesion	Vessels near neck	Intraop rupture	Micro-aneurysms	Giant aneurysm	Branch from aneurysm
Cossu et al 1993	32	6	6	2	-	1	-
Todd 1989	-	-	-	-	-	-	-
Mount 1975	22	-	-	-	-	-	21
Taylor 1977	-	-	-	-	-	-	-
David 1999	-	-	-	-	-	-	-
Fujiwara 1990	13	-	4	-	-	5	-
Cudlip 1998	2	-	6	4	-	-	-
Eric 1999	-	-	-	-	20	-	-
Dutton 1969	-	-	-	-	-	-	-
Minakawa 1987	-	-	-	-	-	-	-
Total	67	6	10	2	20	6	21

Materials & Method

This study has been carried out at Sree Chitra Tirunal Institute for Medical Sciences and Technology, a premier institute for neurosurgery in South India. Between 1987 and 2003 a total of 1369 patients with intracranial aneurysms were treated. Fifty three (3.8%) patients with intracranial aneurysms were identified who had intracranial aneurysms treated by wrapping alone. Four patients died in the post op period due to causes other than rebleed. One patient died of cardiac arrest two months after discharge from the hospital. Six patients were lost to follow up. Forty two patients with sixty nine aneurysms were included in the study (table V). Hospital records of these forty two patients were analyzed with respect to clinical features, examination findings, computed tomography (CT) findings, findings on digital subtraction angiography (DSA), the reason for wrapping, material used for wrapping, whether the wrapped aneurysm was ruptured or unruptured aneurysm. In patients with history suggestive of subarachnoid hemorrhage like sudden onset severe headache with or without altered sensorium, associated vomiting etc., aneurysms were considered to be the source of hemorrhage if there was a single aneurysm on four vessel DSA and there was evidence of subarachnoid blood in CSF obtained by lumbar puncture or evidence of SAH on CT scan, otherwise the it was considered to be a case of doubtful SAH. For patients with multiple aneurysms the wrapped aneurysm was considered to be the cause of SAH if the site of subarachnoid blood corresponded with the site of wrapped aneurysm on CT or during surgery. Patients with a minimum follow up of 1 year were included in the study. The patients were called for review and were subjected to four vessel cerebral angiogram after obtaining informed consent.

The angiograms were digitized by taking their photographs with a digital camera. The follow up angiograms were then compared with the pre operative angiograms to determine the fate of the wrapped aneurysms. The size of the aneurysms was measured using Adobe Photoshop 7.0 and it was compared to the diameter of the internal carotid artery 1 cm proximal to the bifurcation (3.56 mm) in case of anterior circulation aneurysms and to the diameter of the basilar artery (3.2 mm) in case of posterior circulation aneurysms as described by Parlea et al¹⁸. The diameter of the aneurysm perpendicular to the parent vessel was taken as the size of the aneurysm as neck could not be made out in most of the cases. Multiple measurements of the same aneurysm were taken and then averaged to increase the accuracy of measurement. Depending on the change in the size, the outcome was classified as increased in size, static in size, and completely obliterated. One aneurysm that decreased in size but was not completely obliterated was included in the static group.

Statistical analysis was done using SPSS 10.0. Chi-square test was used to analyze the difference in outcome with respect to sex and status (ruptured or unruptured) of the aneurysm. Analysis of variance was used to determine the statistical significance of age and pre operative aneurysm size. Independent samples t-test was used to analyze the difference in size with respect to duration of follow-up between the increased & static groups.

The Results

Over 17 years a total of fifty three patients out of 1639 (3.23%) were treated by wrapping. Table VI shows the year wise distribution of patients with intracranial aneurysms treated by wrapping. The figure 1 shows the line to be closest fit to the observed data indicating the trend in the percentage of aneurysm cases being treated with wrapping over the years. The slope of the line is - 0.075 which indicates a decreasing percentage of cases being treated by wrapping. However this rate of decrease is not significant as $p = 0.46$.

According to the inclusion criterion a total of 42 patients were included in the study. The mean age was 42 years (15yrs.-64 yrs). There were 28 males & fourteen females. There were 18 patients with single aneurysms. Twenty four patients with multiple aneurysms harbored a total of fifty one aneurysms of which 26 were wrapped. Twenty three were clipped & two remained untreated.

Patients with Single Aneurysms

Eighteen single aneurysms in eighteen patients were studied. Thirteen had presented with history suggestive of SAH. Only 11 had evidence of bleed according to the inclusion criteria (table VII). These eleven patients with single aneurysms presented with subarachnoid hemorrhage. They have been followed for a mean of 8.6 years (1 year-14 years). None of these patients had rebleed at the time of follow up. They consisted of five anterior communicating artery (A-comm) aneurysms, two distal anterior cerebral artery (DACA) aneurysms, two anterior choroidal artery (AChoA) aneurysms, one ophthalmic segment (OSA) & one posterior communicating artery (p-comm) aneurysms. Of these eight underwent four-vessel DSA after a mean follow up period of 9.8 years.

Four were a-comm aneurysms of which 3 were obliterated while one had grown in size. This last patient was reoperated. Earlier the aneurysm was wrapped due to multiple feeders associated with the aneurysm. This time the aneurysm could be clipped but the dissection of the aneurysm proved to be difficult due to fibrosis as a result of previous surgery. The patient is doing well six months after the surgery. Of the remaining four, 1 DACA is obliterated while the OSA and AChOA were found to be of the same size on follow up DSA. The p-comm had decreased in size. Two patients who had presented with clinical features of a vascular event but had no evidence of SAH either by CT or LP did not suffer from similar episode during follow up. Of these one patient underwent CT angiogram and was found to have no evidence of aneurysm. (Table VIII)

Five patients had unruptured symptomatic single aneurysms treated with wrapping were (table IX). None of these patients had subarachnoid hemorrhage. Two of these patients underwent DSA. One had basilar tip aneurysm & the other had left MCA bifurcation aneurysm. In the former the aneurysm was obliterated while in the second the aneurysm showed some increase in size. Due to increase in size of aneurysm the patient was operated upon and aneurysm was clipped. In this case also the aneurysm was found to be encased by dense fibrosis which made the dissection difficult.

Patients with Multiple Aneurysms

Twenty four patients were found to have multiple intracranial aneurysms (Table X). Twenty three presented with clinical features suggestive of vascular event. On investigation twenty two were found to have subarachnoid hemorrhage. All of them underwent clipping of a larger aneurysm & wrapping of a smaller aneurysm except for two patients where all the aneurysms were wrapped. Five patients had evidence that the

aneurysm that was wrapped was the cause of bleed. None of these had subsequent rebleed.

Eighteen patients (Table XI) with mean follow up period of 5.8 years had aneurysms which did not bleed (no angiographic or operative evidence) but were found in association with other ruptured aneurysm when DSA was done for clinical features suggestive of intracranial bleed. One aneurysm was not seen on the pre op angiogram but was seen intraoperatively and follow up DSA did not show this aneurysm (Patient 6, Table XI) Another patient (Patient 19, table XI) who presented with decreasing vision in left eye due to left ophthalmic segment aneurysm underwent carotid ligation for the OSA and wrapping of right P-com fusiform aneurysm. On follow up CT angiogram there was no evidence of P-com aneurysm but a de novo a-com aneurysm was observed. This patient is on follow up for eight months now without any symptoms.

Five patients (table XII) with multiple aneurysms had wrapped aneurysms as the source of subarachnoid blood. Only one patient agreed for a follow up cerebral angiogram which showed static aneurysm without any enlargement after 2 years. One patient with left MCA & left ICA aneurysm presented with left temporal hematoma. Left MCA aneurysm was wrapped and this patient did not have a rebleed on one year follow up. Fourth patient with bilateral wrapped p-com aneurysms was reexplored on follow up in an attempt to clip the aneurysms. But fibrosis around both aneurysms precluded any dissection and clipping and the procedure was abandoned.

Outcome of Ruptured Aneurysms Treated By Wrapping

Sixteen of 44 aneurysms that were wrapped were the ones which had caused subarachnoid hemorrhage. All but one (with hemiplegia) turned up for follow up but only

nine patients with nine ruptured (56.25%) aneurysms underwent DSA or CT angiogram. Four (44.4%) were obliterated, 3 (33.3 %) were found to be the same size, 1 (11.1%) decreased in size and only one showed increase (11.1%) in size. The most frequent of these was a-com aneurysms with highest obliteration rate, followed by p-com & others (table XIII).

Outcome of Aneurysms Which Did Not Bleed but Were Wrapped

Of 28 unruptured wrapped aneurysms, eleven (39.3%) could be evaluated with DSA/CT angio in 2003. One fusiform (19, table VI), one with no pre operative angiogram (2, table IV) and one where aneurysm was not seen on preoperative angiogram (6, table VI) are not included. Of these 1 (12.5 %) increased in size, 1 (12.5%) was obliterated and 6 (75 %) remained static in size (Table XIV)

Statistical Analysis.

Table XV indicates the pre operative and post operative aneurysm size and their follow up duration. There is no difference between the mean size of ruptured (4.49mm) & unruptured aneurysms (4.43mm) ($p=0.93$). The difference in the mean size of aneurysms between the increased (5.1 mm) and obliterated (3.2 mm) group was statistically significant ($p = 0.02$). The difference in the mean size of the aneurysms in the increased and the static groups and increased & obliterated group was not significant ($p = 0.91$). The mean period of follow up in the increased, static and the obliterated groups were 13 years, 6.6 years and 10 years respectively. On comparison of the follow up years between the increased and static groups p values obtained was 0.052 using two tailed independent samples t-test. The outcome with respect to the site of aneurysm could not be analyzed due to small number of patients. The frequency of wrapped aneurysms was pcom, acom,

b-tip, MCA, DACA and others in decreasing order. However acom aneurysms are the most likely to be obliterated (3 of 5), pcom are the most likely to remain static. Except in two patients where the aneurysms were wrapped because of proximity of perforators and one where the ophthalmic aneurysm was partly extradural, rest all aneurysms were wrapped because of wide neck.

Material Used For Wrapping

In all cases muscle was used for wrapping the aneurysm.

Table V: Distribution of patients and aneurysms included in the study.

	No. of pts.	No. of aneurysms						
		Wrapped	Clipped	Untreated	Total	Double	Triple	total
Multiple	24	26	23	2	51	21	3	51
Single	18	18	0	0	18	0	0	18
Total	42	44	23	2	69	21	3	69

Table VI: Number of cases treated by wrapping every year at SCTIMST

Year	Total no. of patients treated	No. of patients treated by wrapping	Percentage
1987	29	1	3.448276
1988	45	1	2.222222
1989	45	3	6.666667
1990	71	0	0
1991	99	5	5.050505
1992	89	4	4.494382
1993	104	4	3.846154
1994	110	2	1.818182
1995	120	2	1.666667
1996	87	1	1.149425
1997	105	4	3.809524
1998	98	3	3.061224
1999	109	2	1.834862
2000	127	4	3.149606
2001	131	4	3.053435

Table VII: Details of patients with ruptured solitary aneurysms.

AGE	SEX	bleed	SAH(on CT)	LP	Site	DSA/CT angio	Outcome	FU yrs.	reason for wrapping
45	M	y	no	y	acom	y	increased	14	multiple perforators
24	F	y	no	y	DACA	no	-	10	Small with wide neck
50	M	y	no	y	acom	no	-	1	Small with wide neck
39	M	y	no	y	acom	y	obliterated	14	Small with wide neck
27	M	y	no	y	acom	y	obliterated	11	Small with wide neck
26	M	y	y	n	AChoA	y	persisting	10	Small with wide neck
48	F	y	no	y	LOSA	y	persisting	10	not possible to clip as the aneurysm was partly extradural
48	M	y	y	no	LACHoA	no	-	5	Small with wide neck
52	M	y	y	no	DACA	y	obliterated	5	Small with wide neck
54	F	y	y	no	R pcom	y	decreased	2	wide neck
26	M	y	y	no	acom	y	obliterated	13	Small with wide neck
28	M	Y	No	No	Rp1-p2	No	-	2	Perforators
56	F	Y	No	No	R M1	Ct angio	-	3	Small with wide neck

Acom- anterior communicating artery aneurysm, DACA= distal anterior cerebral artery aneurysm, AChoA- anterior choroidal artery aneurysm, OSA- ophthalmic artery/segment aneurysm, pcom- posterior communicating artery aneurysm, R- right, L-left, y=yes

Table VIII: Patients with no evidence of SAH

AGE	SEX	bleed	CT	sah(On CT)	LP	reason for wrapping	WRAP	DSA	outcome	FU yrs.
28	M	y	y	no	no	perforators	R p1-p2	no fu		2
56	F	y	y	no	no	small sessile	R M1	ct angio	obliterated	3

R p1-p2- right p1-p2 junction aneurysm, RM1- right M1 segment aneurysm

Table IX: Patients with symptomatic unruptured solitary aneurysms

AGE	SEX	SAH (on CT)	LP	reason for wrapping	Site	MATERIAL	DSA 03	angiography outcome	FU yrs.	CI/F
55	F	no	NA	small with wide neck	LMCA	muscle	Y	increased	10	Sudden onset ptosis
37	M	no	NA	Basilar tip involved with feeders	Btip	muscle	Y	obliterated	9	Blurring of vision
43	M	no	NA	small with wide neck	ROSA	muscle	No	-	6	Detected during surgery for clinoidal meningioma
32	F	no	NA	large with wide neck	LOSA	muscle	No	-	1	Galactorrhea amenorrhea syndrome
42	M	no	NA	very wide neck	acom	muscle	No	-	1	Non specific headache.

NA- data not available, Btip- basilar top aneurysm, MCA- middle cerebral artery bifurcation aneurysm, OSA- ophthalmic artery/segment aneurysm, Acom- anterior communicating artery aneurysm

Table X: Details of patients with multiple aneurysms

Bleed (no. of patients)	Number of aneurysms					
	Double aneurysms		Triple			Total
	Clip	wrap	Wrap	clip	untreated	
23(+)	19	21	4	3	2	49
1(-)	1	1	0	0	0	2
SAH	Number of aneurysms					
22(+)	18	20	4	3	2	47
1(-)	1	1	0	0		2
Total	20	22	4	3	2	49
Grand total	42		9			51

Table XI: Patients with multiple aneurysms.

No	AGE	SEX	sah(On CT)	LP	reason for wrapping	Site	CLIP	UNTREAT	DSA	RESULT	FU yrs.
1	42	M	y	no	Small with wide necks	LMCA	LMCA	-	No	-	14
2	36	M	no	y	Small with wide neck	LMCA	acom	-	Y	persistent	10
3	55	M	y	no	Small with wide neck	L pcom	RMCA	-	Y	persistent	6
4	62	M	y	no	wide necks	acom	Btip	-	ct angio	persistent	5
5	53	M	y	no	Small with wide neck	LChoA	acom	RMCA	No	-	5
6	50	M	y	no	Small with wide neck	LOSA	acom	-	Y	not seen	5
7	45	F	y	no	wide neck	R pcom	L pcom	-	Y	persistent	3
8	26	F	y	no	wide neck	L pcom	LMCA	-	No	-	2
9	45	M	y	no	wide neck	L pcom	LChoA	-	No	-	1
10	40	M	y	no	small broad neck	acom	L pcom	-	No	-	2
11	48	M	y	no	small broad neck	LMCA	Lacom,Lpcom	-	No	-	1
12	36	F	no	y	small broad neck	LOSA	L pcom	-	No	-	1
13	28	M	y	y	small broad neck	R pcom	RChoA	-	No	-	13
14	25	F	y	no	perforators	Btip	LICA	-	Y	persistent	12
15	42	M	y	no	not possible to clip	R pcom	RMCA	-	No	-	11
16	15	M	y	no	wide neck	L pcom	LICA	-	No	-	7
17	43	M	y	no	wide neck	Btip	RMCA	-	no	-	5
18	55	M	y	no	wide neck	R pcom	L pcom	-	no	-	3
19	40	M	no	na	fusiform	pcom	LOSA	-	Y	New acom	10

Acom- anterior communicating artery aneurysm, DACA= distal anterior cerebral artery aneurysm, AChoA- anterior choroidal artery aneurysm, OSA- ophthalmic artery/segment aneurysm, pcom- posterior communicating artery aneurysm, R- right, L-left, NA- data not available, Btip- basilar top aneurysm, MCA- middle cerebral artery aneurysm, ICA-internal carotid artery bifurcation aneurysm,NA- not available, y - yes

Table XII: Patients with multiple aneurysms where wrapped aneurysm was the cause of SAH

AGE	SEX	bleed	CT	sah(on CT)	LP	reason for wrapping	wrapping	CLIP	UNTREAT	DSA 03	RESULT	FU yrs.
47	F	y	y	y	n	blebs	L pcom,acom	-	ROSA	no	-	5
50	F	y	y	y		bleb	acom	R pcom	-	no	-	5
64	F	y	y	y	no	bleb	R pcom	L pcom	-	no	-	4
43	F	y	y	no	y	small broad neck	L,R pcom	-	-	y	persistent	2
60	M	y	y	No(LTH)†	no	Small with wide neck	LMCA	LICA	no	no	-	1

†LTH= Left temporal hematoma, Acom- anterior communicating artery aneurysm, pcom- posterior communicating artery aneurysm, R- right, L-left, NA- data not available, MCA- middle cerebral artery aneurysm, ICA-internal carotid artery bifurcation aneurysm, y- yes

Table XIII: Outcome of ruptured wrapped aneurysms

	Increased	Obliterated	decreased	Persistent	Total
A-com	1	3		-	4
P-com	-	-	1	1	2
OSA	-	-		1	1
AChoA	-	-		1	1
DACA	-	1		-	1
Total	1(11.1 %)	4 (44.4 %)	(11.1 %)	3 (33.3 %)	9

Table XIV: Outcome of unruptured wrapped aneurysms.

	Increased	Obliterated	Persistent	Total
P-com	-	-	3	3
MCA	1	-	1	2
B tip	-	1	1	2
A-com	-	-	1	1
R M1		1		1
Total	1 (11.1%)	2 (22.2%)	6 (66.6%)	9

Table XV: Mean size of ruptured and unruptured aneurysms

	Ruptured	Unruptured
	5.5	4.7
	7.2	4.7
	5.3	4.1
	3.5	6.0
	2.7	4.3
	7.3	3.8
	3.5	3.5
	2.0	4.3
	3.4	
Mean	4.488889	4.425

Table XVI: Pre & post operative sizes of aneurysms.

groups	site	Size Pre op	Size Post op	mean	CI ∞	fu years	mean	CI
Increased	acom†	5.5	7.6	5.1	0.8	15	13	4
	MCA‡ bifurcation	4.7	5.5			11		
Static	pcom¶	7.2	5.1	5.0	0.9	2	6.6	2.4
	acom	4.7	4.3			6		
	MCA bifurcation	4.1	4.4			10		
	OSA#	5.3	5.3			10		
	Btip*	6	5.9			12		
	pcom	4.3	4.2			6		
	pcom	4.3	4.1			3		
	AChoA§	2.7	2.8			11		
	pcom	7.3	7.3			3		
	pcom	3.8	3.8			3		
Obliterated	Btip	3.5	0	3.2	0.6	9	10	3.3
	DACA‡	3.5	0			4		
	acom	2	0			14		
	acom	3.4	0			11		
	acom	3.5	0			12		

†acom- anterior communicating artery aneurysm, * Btip- basilar tip aneurysm, § AChoA- anterior choroidal artery aneurysm, ‡MCA- middle cerebral artery, #- ophthalmic artery aneurysm, ¶ pcom- posterior communicating artery aneurysm, † DACA- distal anterior cerebral artery aneurysm, ∞ - confidence interval with level of significance 0.05

Table XVII: Reason for wrapping and outcome of aneurysms.

	Proximity to perforators	Broad neck*	Fusiform	Others	Total
P-com	-	6 (1 decreased, 5 static)	1	-	6
A-com	1 (increased)	4 (obliterated)	-	-	5
B-top	1 (persistent)	1 (obliterated)	-	-	2
MCA	-	2 (1 increased, 1 static)	-	-	2
DACA	-	1 (obliterated)	-	-	1
OSA	-	1 (obliterated)	-	1 (Part was intracavernous)	2
AChoA	-	1 (static)	-	-	1
R-M1	-	1 (obliterated)	-	-	1
Total	2	17	1	1	20

Acom- anterior communicating artery aneurysm, DACA= distal anterior cerebral artery aneurysm, AChoA- anterior choroidal artery aneurysm, OSA- ophthalmic artery/segment aneurysm, pcom- posterior communicating artery aneurysm, Btip- basilar top aneurysm, MCA- middle cerebral artery bifurcation aneurysm, RM1- right M1 segment aneurysm

Table XVIII: Size of aneurysm with respect to site

Site of aneurysms	Pcom	Acom	Btip	MCA	DACA	OSA	AChoA
Size of aneurysms	7.2	5.5	6	4.7	3.5	5.3	2.7
	4.3	4.7	3.5	4.1			
	4.3	2					
	7.3	3.4					
	3.8	3.5					
Mean	5.38	3.82	4.75	4.4	3.5	5.3	2.7

STATISTICAL ANALYSIS

Means of different variables in the three outcome groups.

Case Processing Summary

	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
SIZE * OUTCOME	17	100.0%	0	.0%	17	100.0%
AGE * OUTCOME	17	100.0%	0	.0%	17	100.0%
FUYRS * OUTCOME	17	100.0%	0	.0%	17	100.0%

Report

OUTCOME		SIZE	AGE	FUYRS
INCREASED	Mean	5.1000	50.0000	13.0000
	N	2	2	2
	Std. Deviation	.5657	7.0711	2.8284
STATIC	Mean	4.9700	43.7000	6.6000
	N	10	10	10
	Std. Deviation	1.4840	12.0743	3.8355
OBLITERATED	Mean	3.1800	36.2000	10.0000
	N	5	5	5
	Std. Deviation	.6611	10.5688	3.8079
Total	Mean	4.4588	42.2353	8.3529
	N	17	17	17
	Std. Deviation	1.4470	11.5463	4.2270

ANOVA Table

			Sum of Squares	df	Mean Square	F	Sig.
SIZE * OUTCOME	Between Groups	(Combined)	11.612	2	5.806	3.714	.050
	Within Groups		21.889	14	1.564		
	Total		33.501	16			
AGE * OUTCOME	Between Groups	(Combined)	324.159	2	162.079	1.254	.315
	Within Groups		1808.900	14	129.207		
	Total		2133.059	16			
FUYRS * OUTCOME	Between Groups	(Combined)	87.482	2	43.741	3.087	.078
	Within Groups		198.400	14	14.171		
	Total		285.882	16			

**One way ANOVA to test the significance of difference
between the sizes in the three outcome groups**

Test of Homogeneity of Variances

SIZE

Levene Statistic	df1	df2	Sig.
2.411	2	14	0.126

ANOVA

SIZE

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	11.612	2	5.806	3.714	.050
Within Groups	21.889	14	1.564		
Total	33.501	16			

Post Hoc Tests

Multiple Comparisons

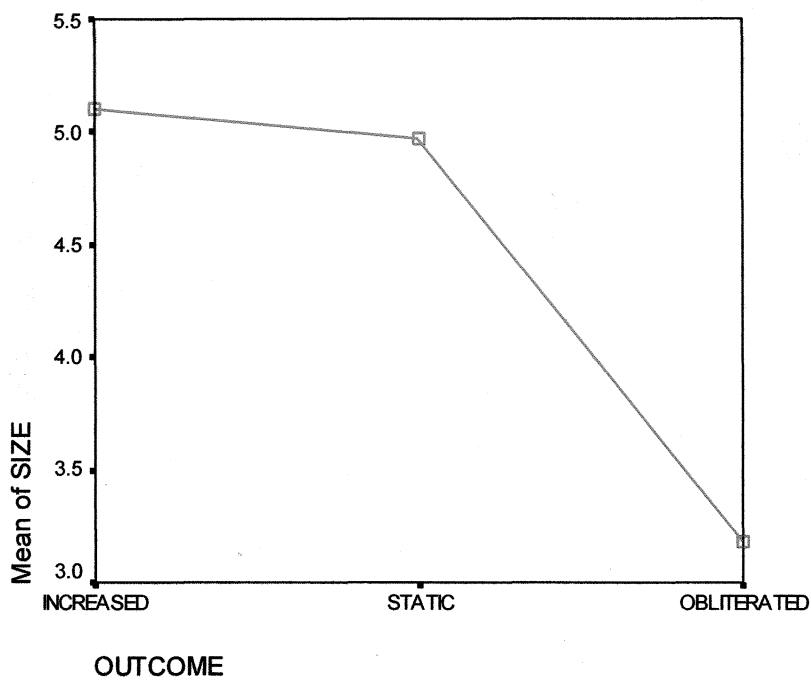
Dependent Variable: SIZE

	(I) OUTCOME	(J) OUTCOME	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Tamhane	INCREASED	STATIC	.1300	.9686	0.996	-2.1096	2.3696
		OBLITERATED	1.9200	1.0462	0.146	-1.3493	5.1893
	STATIC	INCREASED	-.1300	.9686	0.996	-2.3696	2.1096
		OBLITERATED	1.7900	.6849	0.020	.2713	3.3087
	OBLITERATED	INCREASED	-1.9200	1.0462	0.146	-5.1893	1.3493
		STATIC	-1.7900	.6849	0.020	-3.3087	-.2713
Dunnett T3	INCREASED	STATIC	.1300	.9686	0.995	-1.9660	2.2260
		OBLITERATED	1.9200	1.0462	0.125	.	.
	STATIC	INCREASED	-.1300	.9686	0.995	-2.2260	1.9660
		OBLITERATED	1.7900	.6849	0.019	.2832	3.2968
	OBLITERATED	INCREASED	-1.9200	1.0462	0.125	.	.
		STATIC	-1.7900	.6849	0.019	-3.2968	-.2832
Games-Howell	INCREASED	STATIC	.1300	.9686	0.976	-1.9288	2.1888
		OBLITERATED	1.9200	1.0462	0.095	-.7117	4.5517
	STATIC	INCREASED	-.1300	.9686	0.976	-2.1888	1.9288
		OBLITERATED	1.7900	.6849	0.017	.3250	3.2550
	OBLITERATED	INCREASED	-1.9200	1.0462	0.095	-4.5517	.7117
		STATIC	-1.7900	.6849	0.017	-3.2550	-.3250
Dunnett C	INCREASED	STATIC	.1300	.9686	a	-5.8167	6.0767
		OBLITERATED	1.9200	1.0462	a	-4.8422	8.6822
	STATIC	INCREASED	-.1300	.9686	a	-6.0767	5.8167
		OBLITERATED	1.7900	.6849	a	.1198	3.4602
	OBLITERATED	INCREASED	-1.9200	1.0462	a	-8.6822	4.8422
		STATIC	-1.7900	.6849	a	-3.4602	-.1198

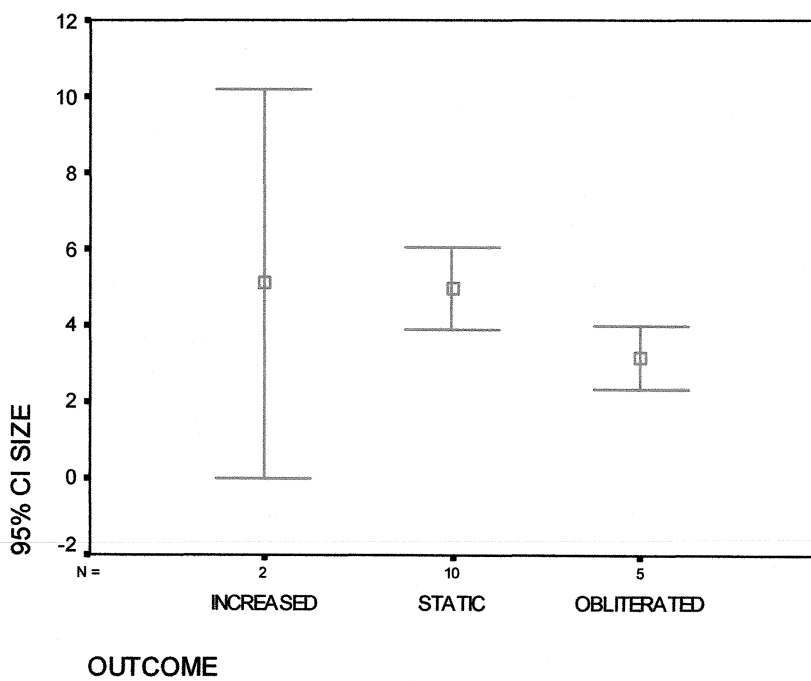
The mean difference is significant at the .05 level.

a Range values cannot be computed.

Plot of mean size versus outcome



Size versus the outcome



**T-Test to evaluate the difference in follow up duration
between the static and increased groups.**

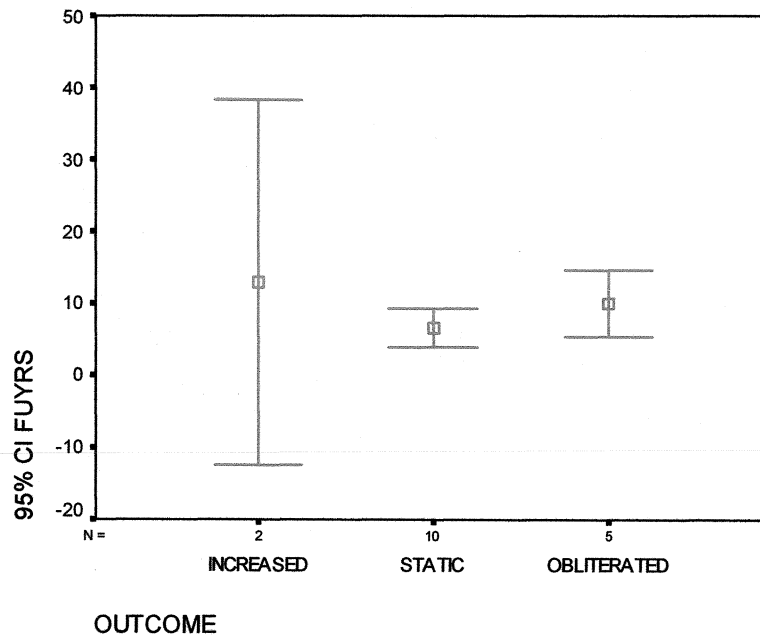
Group Statistics

	OUTCOME	N	Mean	Std. Deviation	Std. Error Mean
FUYRS	INCREASED	2	13.0000	2.8284	2.0000
	STATIC	10	6.6000	3.8355	1.2129

Independent Samples Test

		t-test for Equality of Means					95% Confidence Interval of the Difference	
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
FUYRS	Equal variances assumed	2.205	10	.052	6.4000	2.9024	-6.6979E-02	12.8670
	Equal variances not assumed	2.736	1.843	.122	6.4000	2.3390	-4.5313	17.3313

Follow up versus outcome



PRE OPERATIVE ANGIOGRAMS AND ANGIOGRAMS ON FOLLOW UP

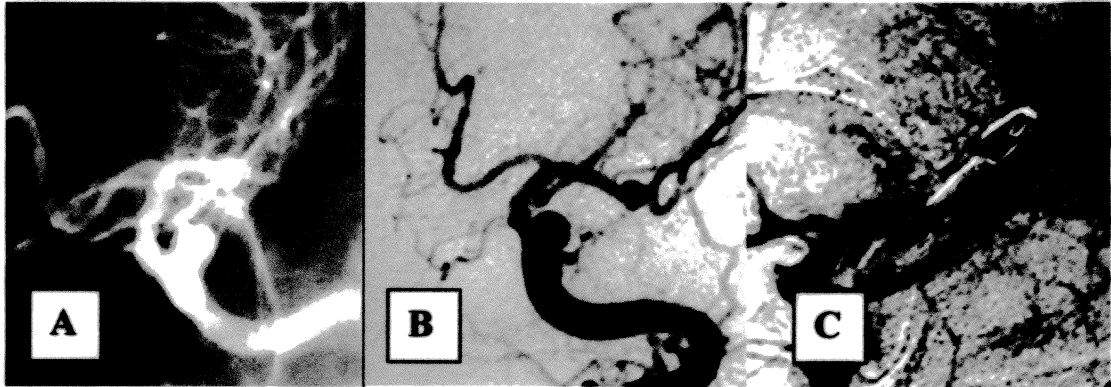


Fig 1: A) Pre operative angiogram of unruptured middle cerebral artery aneurysm which was wrapped. B) Angiogram obtained 11 years later shows increase in size of the aneurysm C) Angiogram showing non filling of the same aneurysm after reexploration

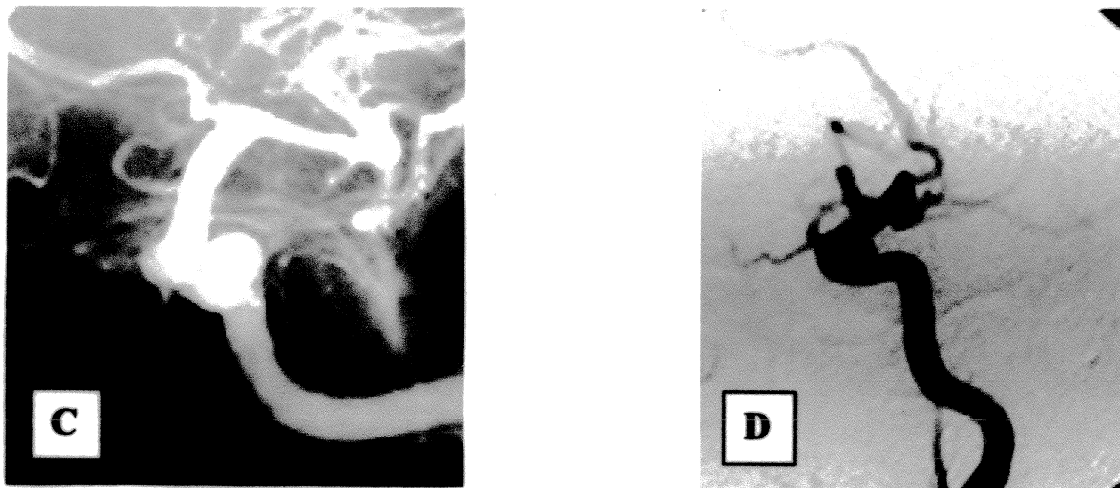


Fig 2: C) Pre operative angiogram of a ruptured ophthalmic artery aneurysm which was partly intradural and partly extradural and hence was wrapped. D) Angiogram 10 years later showing aneurysm of the same size.

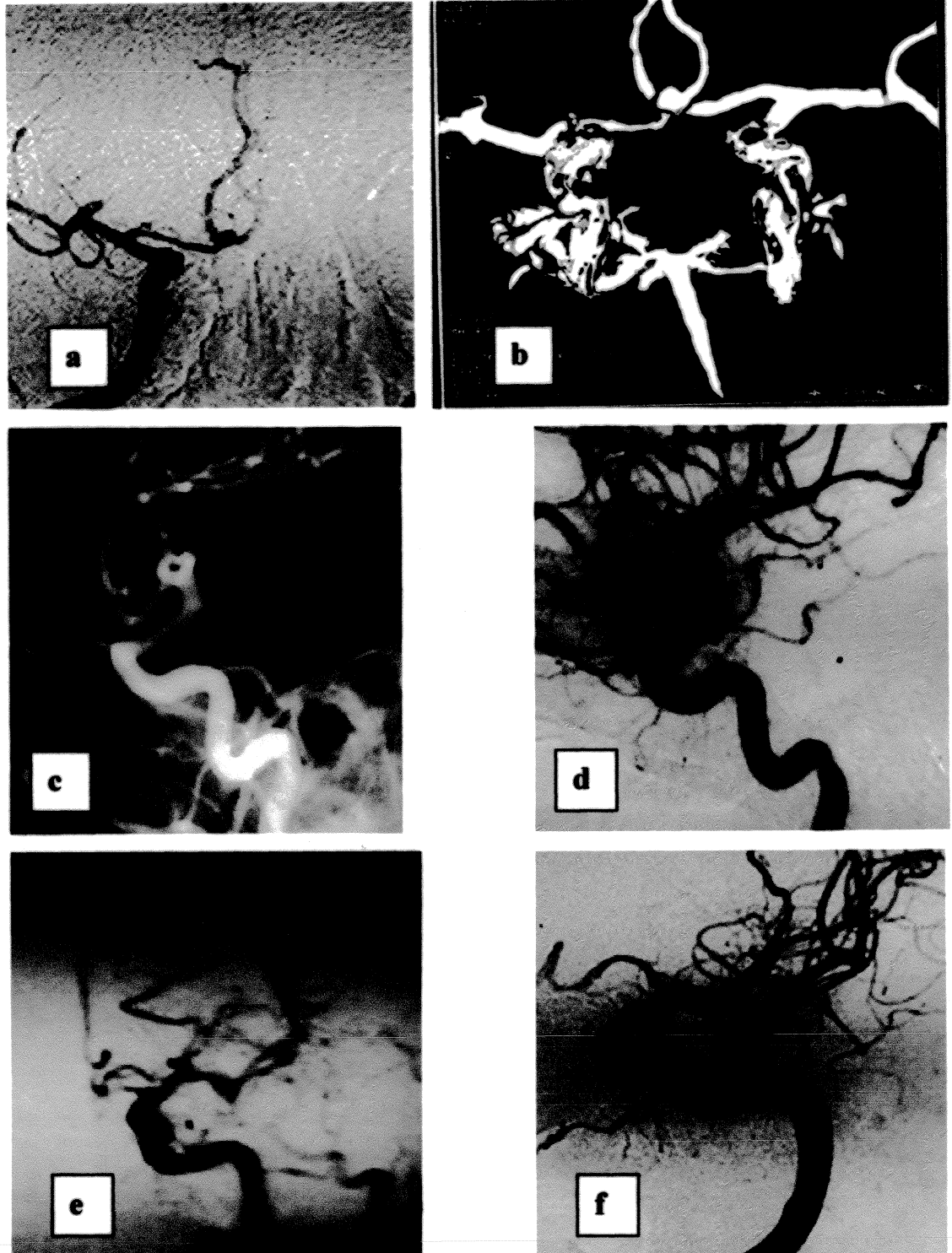


Fig 2: a) Pre wrapping angiogram of unruptured anterior communicating artery aneurysm b) 6 years post wrapping CT angiogram of the same. c, d) pre & post wrapping angiograms of ruptured anterior choroidal artery aneurysm (follow up= 11 years). e) & f) pre & post wrapping images of unruptured middle cerebral artery aneurysm.

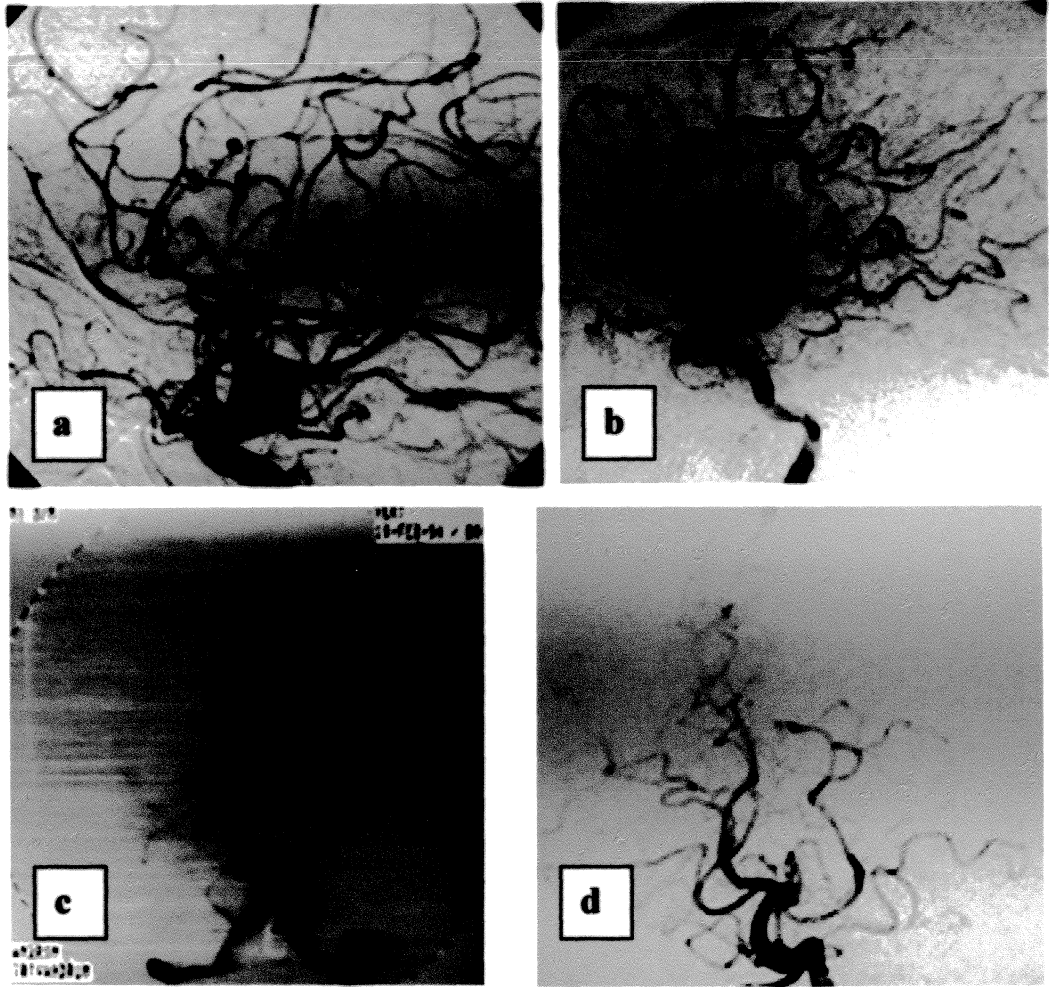


Fig 3: Pre (a) and post (b) wrapping images of a ruptured DACA aneurysm showing complete obliteration of the aneurysm. Pre (c) and post (d) wrapping images of unruptured basilar top aneurysm showing non filling of the aneurysm.

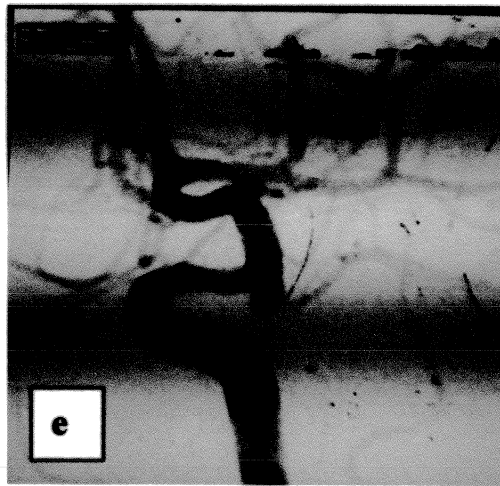
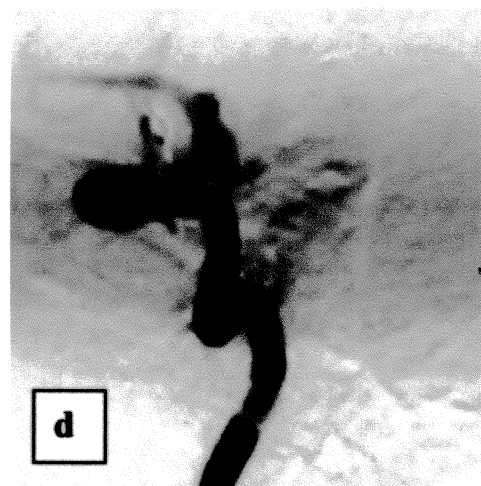
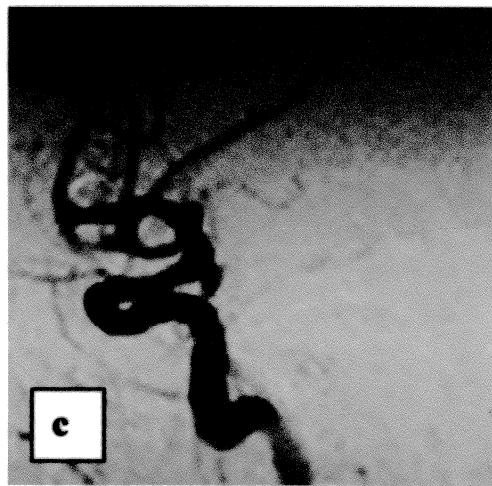
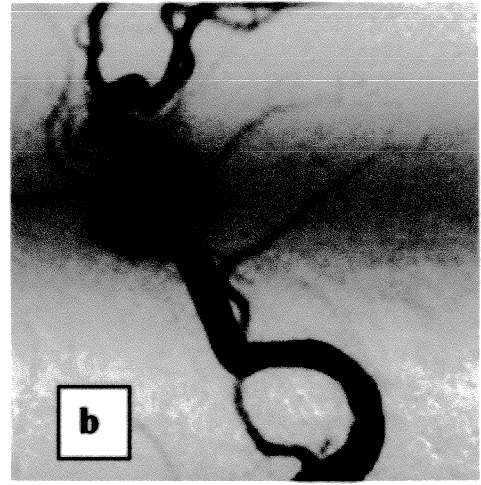
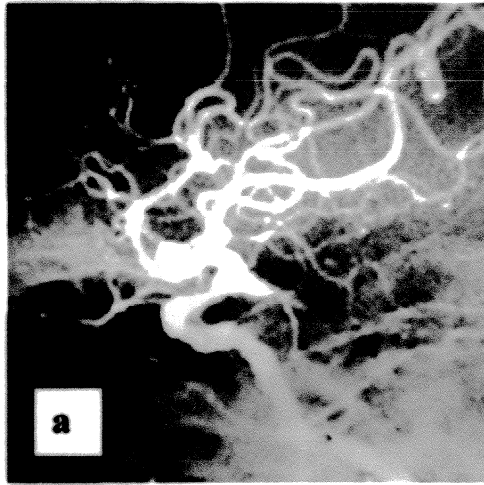


Fig 4: Pre operative angiograms of unruptured posterior communicating artery aneurysms (a), (c) & (f). Post wrapping angiograms of the same after 2, 6 & 3 years respectively (b), (d) & (f).

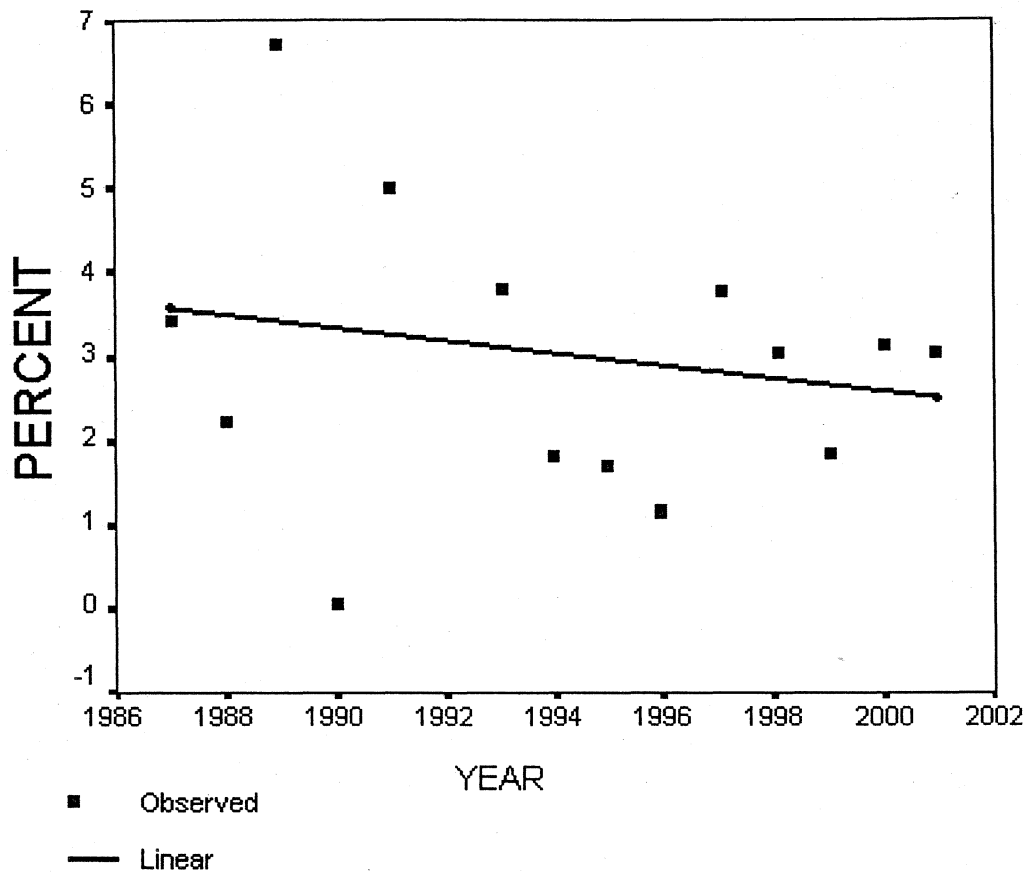


Fig 5: Solid squares represent the percentage of cases treated by wrapping every year. The dark straight line represents the decreasing trend of percentage of aneurysms treated by wrapping. The slope of the line is -0.0775 which is very low and p value is 0.46 indicating that the decreasing trend is not statistically significant.

Discussion

The Institute is a major neurosurgical centre treating large number of cases of intracranial aneurysms with the intent to clip the aneurysm. At times, however, it is not possible to clip the aneurysm due to a number of factors. These situations are few as indicated by the small percentage (3.23%) of aneurysms treated by wrapping alone. The figure 1 indicates the decreasing percentage of aneurysms being treated by wrapping over the years. However the slope of the line is very small and the regression analysis shows that this decreasing trend is not statistically significant. This implies that in spite of the availability of better tools of micro neurosurgery and experience of the surgeon, there will always be a small number of aneurysms which cannot be clipped and hence must be wrapped. It is difficult to carry out a prospective study as treating aneurysms by wrapping where clipping is possible will be against ethics.

The protection from rebleed depends upon the material used as shown by Cossu et al¹¹. The rate of rebleeding was higher in patients where bioadhesive was not used. However in the present study no bioadhesive was used. The only material used was muscle. The high incidence of rebleed is attributable to incomplete coating or wrapping in many of the early series as the use of microsurgery was not very common in these series. Latter studies like that of Cossu et al¹¹ and Cudlip et al⁶ have shown that the rebleed rate was lower in the cases where microsurgical techniques were used for dissection and wrapping of the aneurysm. In this study all aneurysms have been treated by use of microsurgical techniques. Another reason for no incidences of rebleed in this study may be due to the surgical intervention in two cases where the aneurysm had

increased in size. Failure to intervene might have led to rupture of these aneurysms at a future date.

Many of the studies indicated that some of the cases which were considered to be rebleed were in fact due to rupture of de novo aneurysms. In this series there was one case of de novo aneurysm after a total follow up period of 327 patient years or 0.3%/year.

Most of the series have not consistently followed up the cases of wrapped or coated aneurysms with angiography. The only complete follow up of aneurysms treated by coagulation and wrapping is that of Nussbaum et al¹² where 19 of 20 aneurysms were seen to be obliterated at 1 year and one was found to be stable. However all these aneurysms were unruptured micro aneurysms (< 3 mm). In the present study 38.6 % of aneurysms were evaluated by follow up angiography.

The aneurysms that remained static were significantly larger than the ones that were obliterated. The mean size of aneurysms that increased (5.1mm) was not found to be significantly larger than those that were obliterated due to small number (n=2) in the increased group. Statistical analysis in this study has not shown any significant difference between the proportion of aneurysms that increased, remained stable or disappeared in the ruptured and unruptured groups. Irrespective of the fact, that aneurysms were ruptured or unruptured, the aneurysms smaller than 4 mm were obliterated by wrapping whereas those larger than 4 mm remain patent. The mean follow up period of aneurysms that increased (13 ± 4 years) in size was more than those that remained stable (6.6 ± 2.4 years) though not statistically significant. The mean follow up period of aneurysms that were completely obliterated was 10 ± 3.3 years has not been considered for analyzing difference in the follow up period as the aneurysms must have been obliterated at the

time of the first surgery. There are no studies to indicate the outcome of wrapped aneurysms depends upon the preoperative size or duration of follow up of aneurysms. Allcock and Canham¹⁷ did not find any consistent change in the size of the unruptured untreated aneurysms on angiographic follow up depending upon BP, age, size or duration of follow up. However Juvela et al¹⁶ demonstrated that the unruptured aneurysms that ruptured subsequently had increased significantly than at the time of first angiography. Therefore aneurysms larger than 4 mm treated by wrapping need to be monitored by serial angiography to detect any increase in the size of the aneurysm. The lack of statistical significance in difference in the duration of follow up of increased and static aneurysms is due to small number of cases.

Statistical analysis did not reveal any association between the site and size of the aneurysms. However the most common sites of wrapped aneurysms were anterior communicating artery and posterior communicating artery-ICA junction. Anterior communicating artery aneurysms are common due to large number of anomalies occurring at this site which can be explained by its embryology. Wrapping in case of posterior communicating aneurysms are common as application of clip might have compromised the lumen of the ICA or posterior communicating artery.

. Muscle is as effective as bioadhesives in reinforcing the aneurysmal wall as evident from the dense fibrosis present in the patients who underwent surgery. In two the aneurysm could be clipped after difficult dissection. However in the third the procedure had to be abandoned due to presence of dense fibrosis which made dissection very difficult. The patients in whom the aneurysm could be clipped the follow up periods were 15 and 11 years. The third patient underwent reexploration after 2 years only. This fact

supports the fact that wrapped aneurysms may grow with time and that the growth may be dependent on time.

There were no complications like optochiasmal arachnoiditis as reported in the literature that occurs following wrapping of acom aneurysms with muslin¹⁵.

Conclusion

This study shows that wrapping with muscle is an effective way of preventing rebleeds provided wrapping is done to include whole of aneurysm. Though clipping of aneurysm is the gold standard of treatment, aneurysms can be wrapped with muscle to reinforce the wall of the aneurysm and prevent it from rebleeding. Autologous muscle is an excellent material for wrapping of aneurysms as it causes dense fibrosis around the wrapped site and persists for many years. It is free from side effects and any known complications. The patients with aneurysms treated by wrapping need to be followed up by regular angiography to detect any enlargement of the aneurysm at which time the patient should be offered resurgery. The only major disadvantage being that should a reoperation be required the dissection is very difficult due to the dense fibrosis.

Therefore to conclude, muscle wrapping will continue to be used in rare cases where clipping becomes impossible due to various reasons.

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