ORIGINAL RESEARCH

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# Single-centre Microsurgery Treatment Methods for Unruptured Intracranial Aneurysms of the Anterior Circulation and Results

## Kanamamış İntrakraniyal Ön Sirkülasyon Arter Anevrizmaları Tek Merkez Mikrocerrahi Tedavi Yöntemi ve Sonuçları

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## Abstract

**Objective:** Intracranial artery aneurysms can result in high morbidity and mortality when ruptured. Preventive treatments might be necessary to avoid adverse results. This paper aims to discuss and share the first-term findings of unruptured intracranial artery aneurysms (UIAs) of the anterior circulation surgery at a newly established clinic in light of our clinical principles and surgical approaches.

**Method:** Patients diagnosed with UIAs of the anterior circulation in our establishment in September 2020 and November 2022 and treated with microsurgery clipping operations were retrospectively evaluated. Assistive devices such as a sodium fluorescein integrated microscope, videoangiography, and micro-Doppler ultrasonography were intraoperatively used. We actively used a second surgeon with a third hand in the microscopic field. With case studies, we provided various techniques, and our experiences were used to avoid complications. We compared our surgical findings with radiological and clinical data.

**Results:** In our institution, 44 aneurysms and 40 patients diagnosed with UIAs of the anterior circulation were treated with 42 operations. The mean age was 50 years (31/69 years), and the follow-up time was 379 days (30/828 days). The modified Rankin scale (mRS) of the patients was evaluated; the mRS of patients was evaluated as three due to previous subarachnoid haemorrhage history, and postoperative change was not detected. Three patients had postoperative epileptic seizures; therefore, their mRS was evaluated as 1, and the mRS of 36 patients was 0 after follow-up. In the postoperative digital subtraction angiography of two patients, a rest was detected in the aneurysm neck; therefore, one patient underwent another surgery, and the endovascular team treated the other patient. Infarction due to loss of

## Öz

**Amaç:** İntrakraniyal arter anevrizmaları, yırtıldığı takdirde yüksek morbidite ve mortalite ile sonuçlanmaktadır. Olumsuz sonuçlarla karşılaşmamak için önleyici tedavi gerekebilmektedir. Bu makale ile yeni bir kliniğin kanamamış intrakraniyal ön sirkülasyon arter anevrizması (KİKAA) cerrahisinde klinik prensip ve cerrahi yaklaşımlarımızın ışığında ilk dönem sonuçlarımızı tartışmayı ve paylaşmayı amaçladık.

**Yöntem:** Eylül 2020-Kasım 2022 tarihleri arasında merkezimizde KİKAA saptanan ve mikrocerrahi klipleme operasyonu ile tedavi edilen hastalar retrospektif değerlendirildi. İntraoperatif olarak, mikroskopa entegre sodyum floresein video anjiyografi ve mikro-Doppler ultrasonografi gibi yardımcı cihazlar kullanıldı. Mikroskopik sahada ikinci cerrahı üçüncü bir el ile sahada aktif olarak deneyimledik. Komplikasyonlardan kaçınmak için kullandığımız çeşitli teknikleri ve deneyimizi olgu örnekleri ile sunduk. Cerrahi sonuçlarımızı radyolojik ve klinik verilerle karşılaştırdık.

**Bulgular:** Kurumumuzda KİKAA tanısı ile toplam 40 hasta, 44 anevrizma 42 operasyon ile tedavi edilmiştir. Ortalama yaş 50 yıl (31/69 yıl), takip süresi 379 gündür (30/828 gün). Hastaların modifiye Rankin skoru (mRS) bir hasta daha önce geçirilmiş subaraknoid kanamaya bağlı mRS 3 olarak değerlendirilmiş ve postoperatif değişiklik saptanmamıştır, üç hasta postoperatif epileptik nöbet geçirmesi nedeniyle mRS 1 olarak değerlendirildi, 36 hasta ise takip süresi sonunda mRS 0'dı. İki hastada postoperatif dijital subtraksiyon anjiyografide anevrizma boynunda rest saptanması üzerine bir hasta tekrar cerrahiye alınırken, diğer hasta endovasküler ekip tarafından tedavi edildi. Hiçbir hastada parent arter ve perforan arter kaybına bağlı enfarkt görülmedi. %20 hastada minor komplikasyon görüldü.

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## Abstract

the parent artery and the perforating artery was not observed in any patient. Minor complications were seen in 20% of the patients.

**Conclusion:** An increase in the variety and use of intraoperative assistive techniques and the active participation of the second surgeon using a third hand can decrease the complication rate. Additionally, the complication rate will decrease as the surgical experience increases in vascular institutions dealing with such cases.

**Keywords:** Aneurysm clipping, micro-Doppler ultrasonography, microsurgery, sodium fluorescein, videoangiography

## Öz

**Sonuç:** İntraoperatif yardımcı tekniklerin çeşitliliğinin ve kullanımının artması, ikinci cerrahın üçüncü bir el ile sahada operasyona aktif katılımı komplikasyon oranının düşmesini sağlayabilir. Ayrıca olgu akışının sağlandığı vasküler merkezlerde cerrahi tecrübenin de artmasıyla komplikasyon oranı azalacağı kanaatindeyiz.

**Anahtar kelimeler:** Anevrizma klipleme, mikrocerrahi, mikro-Doppler ultrasonografi, sodyum floresein, videoanjiyografi

## Introduction

An aneurysm is the outward expansion of the wall of a blood vessel due to a weakness in the blood vessel walls (1). It is seen in ≈3.2% (95% confidence interval, 1.9-5.2% of the adult population (mean age: 50) (2). Aneurysms are observed 1.5 times more in women than men (3,4). In 90% of the cases, aneurysms are smaller than 10 mm and are generally located in the anterior cerebral circulation. Between 20% to 30% of the patients have multiple aneurysms (5).

In cases of growth in the follow-ups of unruptured intracranial artery aneurysms (UIAs) diagnosed with secondary findings with the increasing use of imaging methods, the rupturing risk can change between 2% to 10% based on the size, location, and shape of the aneurysm (6). The 5-year rupturing risk of aneurysms can change between 1.5% to 50% according to factors such as localization and size (7,8). If an aneurysm is ruptured, mortality and morbidity rates increase severely. In the ruptured aneurysm series, the mortality rate was revealed to vary between 27% to 47% based on their locations (9). Precisely 30% of surviving patients have to live with neurological and neurocognitive deficits. (10)

Mortality in UIAs is 1-3%, and the severe morbidity rate is 4-10.9% (8). The aim of the treatment is to avoid complications and ensure the clipping of the aneurysm neck by protecting the parent artery, distal extension, and perforating arteries (11,12). Even though vascular structures can be observed using an operational microscope, vessel patency and a residual aneurysm cannot be observed with microscopes; therefore, intraoperative monitoring methods are required. High-technique resources such as angiography conducted with microscope-integrated sodium fluorescein were developed to achieve this goal (13-15). Technical equipment such as micro-Doppler ultrasonography is also used intraoperatively (17-19). The literature mentions that intraoperative assistive techniques help mortality and morbidity decrease in vascular surgery for giant and complex aneurysms, as well (16,20-23).

UIAs have critical mortality and morbidity rates in the follow-up and treatment processes. In addition to the experience of the institution and learning curve, surgical approaches and principles also change according to the technical equipment used. This paper aims to discuss and share the findings of a single center with 40 patients and 44 intracranial artery aneurysm cases in light of our specific clinical principles and surgical approaches.

## Materials and Methods

### Patient Selection

Patients include those who underwent microsurgery UIAs of the anterior circulation clipping operations in our institution. This single-cantered study presents the results of operations conducted by two vascular neurosurgeons. All 40 patients operated on in September 2020 and November 2022 were included in the study. All data were retrospectively examined and compiled after approval (no. 2022-281) was granted by the ethical Committee of University of Health Sciences Turkey, Başakşehir Çam and Sakura City Hospital.

Patients generally arrived at the neurology or neurosurgery outpatient clinic with headache complaints. Those with UIAs of the anterior circulation on computed tomography (CT)-angiography or magnetic resonance imaging (MRI)-angiography were correlated with digital subtraction angiography (DSA).

### Pre-surgical Procedure

The microsurgical clipping indications of patients were decided on during a meeting held with the interventional radiology team of our institution. For preoperative diagnosis, a four-system of DSA was carried out on all patients.

### Surgical Procedure

Conventional pterional craniotomy was used for anterior circulation aneurysms as a surgical technique. In accordance with microsurgical principles, chiasmatic,

carotid (if necessary), the opening of lamina terminalis cistern and dissection of the Sylvian fissure, exploration of the proximal artery starting from the periphery of the aneurysm, and dissection of the perforating arteries and venous structures adhered to the dome, especially in large aneurysms, from the aneurysm neck, were performed (Figure 1).

We tended to apply temporary clipping for proximal parent arteries, except for small aneurysms. A temporary clip application enabled the aneurysm dome's internal pressure to decrease and be compatible circumferential dissection (Figure 2). Temporary clipping areas were chosen as places that would be affected the least because they are suitable for recurring manipulations. Placing the pilot clips specifically helped the domes in large aneurysms needing to be wrapped and revealed the relationship with the surrounding anatomical structures; pilot clip placement also minimized the risk of rupture until placement of the final clipping. The presence of an active second surgeon with a third hand in the field, in terms of dynamic retraction and manipulation, helped with clipping repositioning and placement of multiple clips in additional ways when needed (Figure 3).

In all operations, a Leica 530 OH-X surgical microscope with an FL560-integrated fluorescence module was used (Leica Microsystems GmbH, Wetzlar, Germany).

After the optimum clip position was confirmed with surgical observation and micro-Doppler following the aneurysm clipping (Hadeco Inc. Japan, Koven Technology Inc., USA), sodium fluorescein videoangiography was made with the FL560 module of the microscope. Sodium fluorescein (Flusible 500 mg/5 mL IV solution for injection) was administered to all patients in bolus using a central venous catheter. This method was used at least once and at most three times during any given operation. The maximum dose to be administered to patients was accepted as 20 mg/kg (16). A total of 5 mg/kg was calculated for every application during the operations (Figures 2, 4-7).

CT were examined in the postoperative period (2-6 h) for future comparisons and to exclude the possible complications of cases and asymptomatic structural changes, such as silent stroke and contusion. In postoperative follow-up, patients were evaluated with CT,

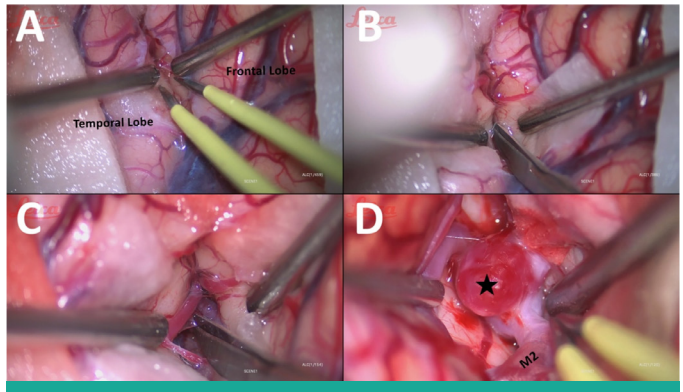


**Figure 1.** Various images of left sylvian fissure dissection in surgery for an unruptured aneurysm in the left middle cerebral artery bifurcation. Finally, the pre-clip view of the aneurysm dome (star) dissected from the surrounding structures

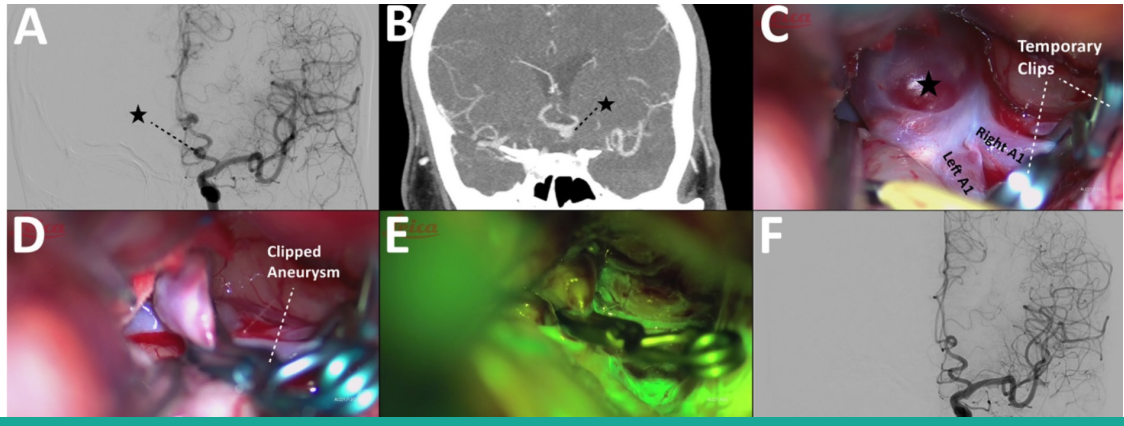


**Figure 2.** A 56-year-old male patient was operated on due to an unruptured anterior communicating segment (Acom) artery aneurysm. **A.** In preoperative digital subtraction angiography (DSA), in the anterior-posterior view, an aneurysm (star) with a wide neck, approximately 6×5 mm in size, at the A1 segment-Acom junction of the left anterior cerebral artery can be seen. **B.** In the coronal slice of preoperative computed tomography brain angiography, an aneurysm dome (star) is visible. **C.** The aneurysm dome (star) and the temporary clips placed in the A1 segment of the left-right anterior cerebral artery are seen. **D.** The aneurysm is closed with a single permanent clip. **E.** In videoangiography mode after sodium fluorescein injection, the aneurysm dome did not fill up. **F.** In the anterior-posterior view of postoperative DSA, the residual aneurysm filling was not detected, and parent artery loss was not seen

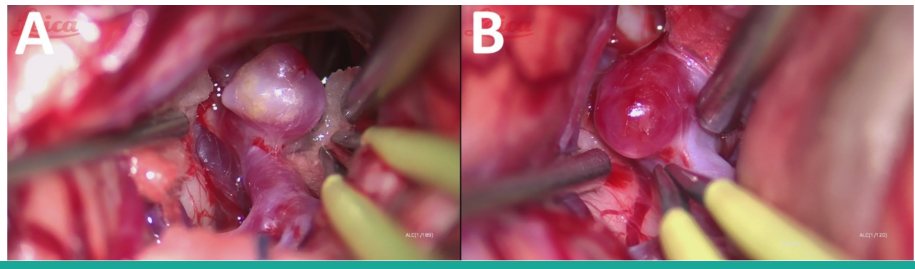


**Figure 3.** Before and after aneurysm clipping, the retraction and aspiration conducted with the help of an aspirator by the second surgeon using the third hand of the second surgeon technique can be seen in two different phenomena

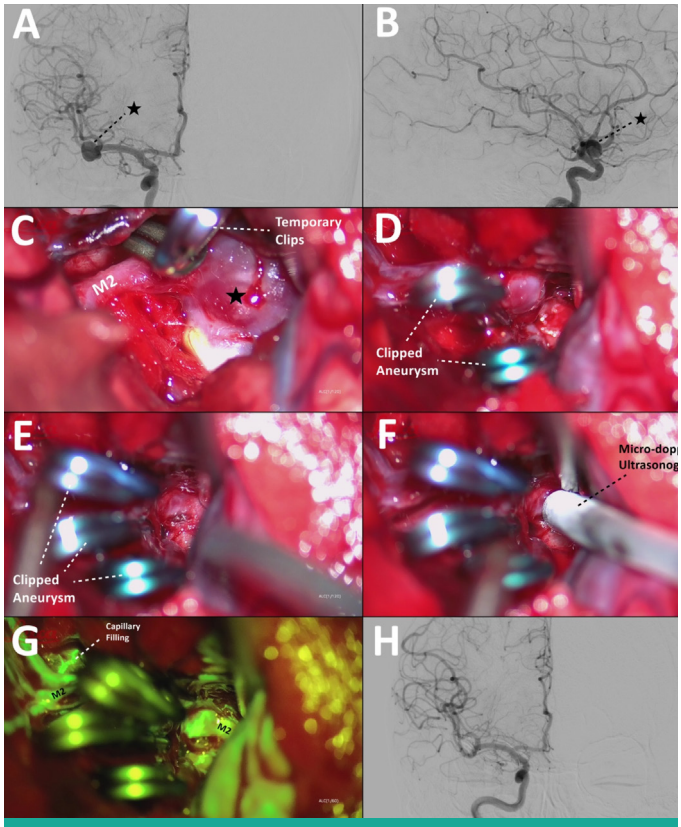


**Figure 4.** A 45-year-old female patient was operated on due to an aneurysm incidentally detected in the bifurcation of the right middle cerebral artery (MCA). **A, B.** In the anterior-posterior and lateral views of the preoperative digital subtraction angiography (DSA), laterally and superiorly oriented, a wide neck saccular aneurysm (star), 9×6.7 mm in size at the widest point, originating from the right MCA bifurcation can be seen. **C.** The aneurysm dome (star) and the temporary clip placed in the M1 segment of the right MCA can be seen. **D, E.** The aneurysm was vertically serial clipped with three permanent aneurysm clips. **F.** The flow in MCA branches and aneurysm dome are checked using micro-Doppler USG. **G.** In videoangiography mode after sodium fluorescein injection, the aneurysm dome did not fill up, and MCA distal branches were coloured. **H.** In the anterior-posterior views of the DSA, residual aneurysm filling was not detected, and parent artery loss was not seen

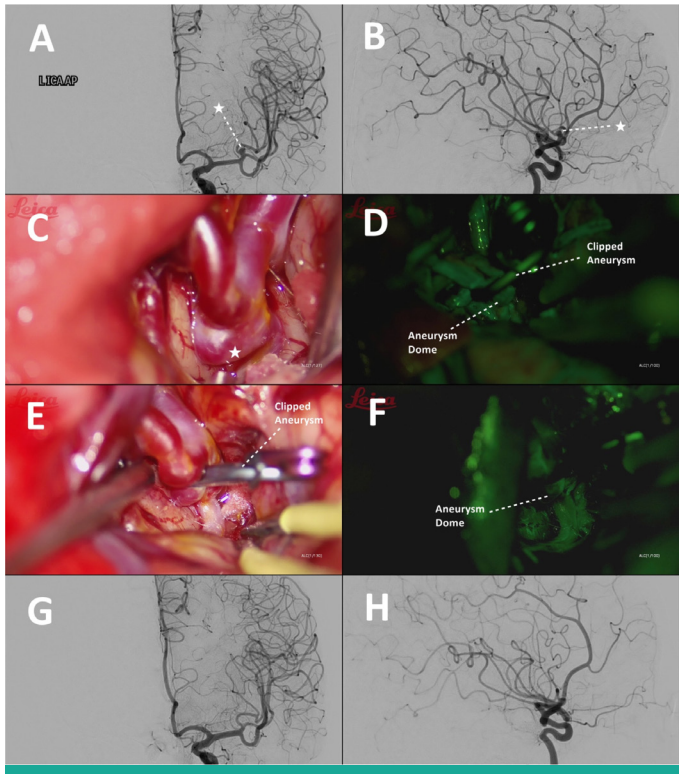


**Figure 5.** A 61-year-old female patient was coiled with endovascular treatment by interventional radiology due to a ruptured saccular aneurysm in the posterior communicating segment of the right internal carotid artery. The unruptured left middle cerebral artery (MCA) at the trifurcation level was operated on due to an aneurysm. **A, B.** In the anterior-posterior and lateral views of the preoperative digital subtraction angiography, a saccular aneurysm (star) with a regular surface and wide neck, approximately 4×3 mm in size, located at the upper trunk at the left MCA trifurcation level can be observed. **C.** Aneurysm morphology (star-aneurysm) **D.** After the aneurysm clip and sodium fluorescein injection, it can be seen that the aneurysm dome was coloured. **E.** Image after the revision of aneurysm clipping. **F.** In the videoangiography mode after revision of the aneurysm clipping and second sodium fluorescein injection, the aneurysm dome did not fill up. **G.** In the anterior-posterior and lateral views of the postoperative digital subtraction angiography, residual aneurysm filling was not detected, and parent artery loss was not seen

MRI, brain diffusion sequence, and computed perfusion tomography. First, DSA was chosen in all postoperative patients to see whether aneurysms demonstrated rest and to evaluate parent artery occlusion or stenosis. In 12 patients, CT and brain angiography were preferred because of the invasive DSA and the potential for complications (the tendency of patients to experience thrombosis, the development of complications in the previous DSA, or patients not giving consent).

### Statistical Analysis

The analysis of the data was made using the SPSS 24.0 package program.

## Results

During the study phase, 40 patients and 44 UIAs of the anterior circulation were treated with 42 operations. The mean age of the patients was 50 years (min/max: 31/69 years). The mean follow-up time of the patients was 379 days ($30^{th}$-$828^{th}$ day). Multiple aneurysms were detected in 16 patients. Two different aneurysms of three patients were clipped in the same operation. One patient was operated twice for two different aneurysms. Re-operation was performed in one patient after a residual aneurysm was detected. The other aneurysms of 12 patients were followed up radiologically because operations took place in different surgical corridors and due to low bleeding risk.

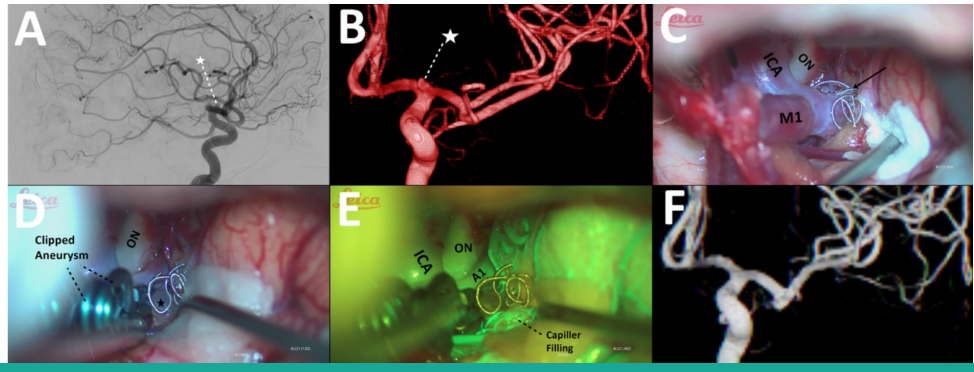


**Figure 6.** A 35-year-old female patient with a twenty-year history of endovascular coil embolization operation for an aneurysm in the left internal carotid artery (ICA) bifurcation was operated on after recurrence was detected. **A, B.** In the lateral and three-dimensional views of the preoperative digital subtraction angiography (DSA), a superior oriented recurring aneurysm (star), 3.3×2.6 mm in size, in the left ICA bifurcation, with opacities attached to the coils can be seen. **C.** The left ICA, the M1 segment of the middle cerebral artery (MCA), the optic nerve, and the coil (arrow), a portion of which protruded outside the aneurysm dome. **D.** The aneurysm (star) is closed with two permanent clips. The remaining coil after a portion is removed can be seen. **E.** In videoangiography mode after sodium fluorescein injection, the aneurysm dome did not fill up, and ICA, middle cerebral artery, and its branches were coloured. **F.** In the three-dimensional view of the postoperative DSA, residue aneurysm filling was not detected, and parent artery loss was not perceived

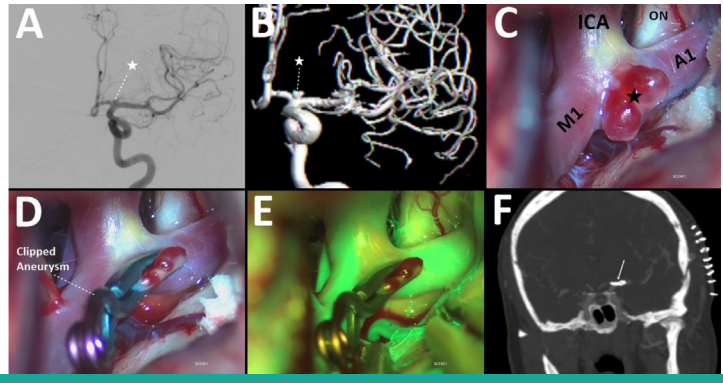


**Figure 7.** A 52-year-old female patient was operated on due to an unruptured aneurysm in the left internal carotid artery (ICA) bifurcation. **A, B.** In the anterior-posterior and three-dimensional views of the preoperative digital subtraction angiography, a saccular aneurysm (star), 3.5×2.5 mm in size, in the left ICA terminus, superiorly oriented, bilobed, contoured, with a narrow neck can be seen. **C.** The left ICA and its branches, optic nerve, and aneurysm dome (star) can be observed. **D.** The aneurysm is closed with a permanent clip. **E.** In videoangiography mode after sodium fluorescein injection, the aneurysm dome did not fill up, and ICA and its branches were coloured. **F.** In the coronal slice of the postoperative brain computed tomography-angio, an aneurysm clip is seen (arrow), residue aneurysm filling was not detected, and parent artery loss was not observed

The demographic data of the patients are given in Table 1. The aneurysm location and patient numbers were recorded and can be seen in Table 2. A total of nine patients had subarachnoid haemorrhage and treatment history. At the end of the 379th-day follow-up after treatment, the patients were evaluated using their modified Rankin scale (mRS) scores. One patient's preoperative mRS was 3 due to a prior subarachnoid haemorrhage; the postoperative follow-ups continued with mRS 3, and the mRS of three patients was evaluated as 1 due to postoperative epileptic seizure. The mRS of 36 patients was 0.

Rest was found in the aneurysm neck in the postoperative DSA imaginings of two patients. One of the patients with rest was operated on again, and the other patient was treated by the endovascular team using a flow diverter stent.

Considering the surgical complications, no cerebral infarction was seen in any patient due to the parent artery and the perforating artery.

Two patients had CSF fistulas. One of these patients showed symptoms of rhinorrhoea, and the other showed signs of CFS leakage from a skin defect. These two patients were operated on using revision surgery; the patient with CSF leakage from the skin also developed meningitis and was given antibiotic therapy.

Three patients had epileptic seizures, and antiepileptic treatments were applied. Cerebral hyperperfusion syndrome was found in the further examination of a patient with seizure attacks following postoperative DSA. This patient was diagnosed with CT-perfusion (Figure 8). The patient who developed cerebral hyperperfusion syndrome was followed up in the intensive care unit for three days. The patient's blood pressure was reduced to normal limits in a controlled and gradual manner. Triple antiepileptic therapy was given, and no postoperative bleeding was observed. The patient was discharged with no deficits after follow-up.

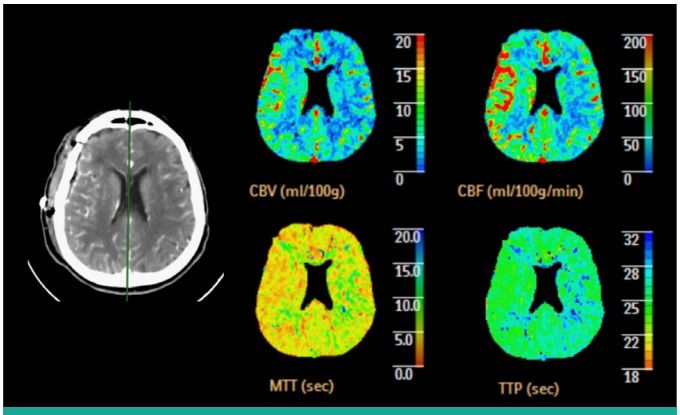


**Figure 8.** A 69-year-old male patient was operated for an aneurysm in the unruptured right middle cerebral artery (MCA) M2 bifurcation. On the 4th postoperative day, after digital subtraction angiography, computed perfusion tomography images show increased cerebral blood volume (CBV), increased cerebral blood flow (CBF), decreased mean-transient time (MTT), and decreased time-to-peak (TTP). Hyperperfusion is observed in the right MCA feeding area. Reference values are located on the right side of all images

Two patients had skin healing problems. The source of the problem experienced by one of our patients was thought to have stemmed from immunosuppressive treatments for existing rheumatic diseases. For the other patient, the source of the problem was the production of *Staphylococcus aureus* in the wound swab culture; it was treated with antibiotics.

In one patient, a cerebral contusion was observed outside the surgical field. Data on the complications are summarized in Table 3.

**Table 1. Demographic characteristics of patients**

| **Total amount of patients** | **40** |
|---|---|
| Patient's age, range and mean (years) | 31-69 (50.6) |
| Patient sex, female/male | 27/13 |
| Total amount of aneurysms | 44 |
| Total number of surgery | 42 |
| Multipl/single aneurysms | 16/24 |
| Follow-up period of patients, range and mean (days) | 2-828 (379) |

**Table 2. Aneurysm localizations**

| **Aneurysms** | **Value** | **Percent** |
|---|---|---|
| Anterior communicating artery | 7 | 15% |
| Middle cerebral artery bifurcation/ trifurcation | 26 | 60% |
| Middle cerebral artery-M1 branches | 2 | 4% |
| Middle cerebral artery-M2 branches | 1 | 3% |
| Posterior communicating artery | 2 | 4% |
| Internal carotid artery-distal | 5 | 11% |
| Anterior cerebral artery-A1 branches | 1 | 3% |
| Total | 44 | 100% |

**Table 3. Post-surgical complications**

| **Complications** | **Value** | **Percent** |
|---|---|---|
| Seizure | 3 | 7.5 |
| Meningitis | 1 | 2.5 |
| Cerebrospinal fluid leaks | 2 | 5 |
| Hyperperfusion syndrome | 1 | 2.5 |
| Contusion | 1 | 2.5 |
| Skin wound problem | 1 | 2.5 |

## Discussion

With the recent increase in imaging techniques, UIAs can be detected at higher rates (24). Although some standards are accepted in deciding indications for treatment and treatment methods, discussions continue on this topic in the literature (2,8,24-27). The size, location, and other morphological characteristics of aneurysms, growth patterns documented in serial imaging, patient age, previous subarachnoid haemorrhage history, and the presence of multiple aneurysms or other cerebrovascular pathologies affect the decision process in terms of indications and treatments (2,8,26,27). Therefore, a decision must be taken in a multidisciplinary way by the endovascular and neurovascular teams in the treatment planning process (2,9). Various reviews and guidelines have revealed that aneurysms showing a growth of 7-10 mm in radiological follow-ups, those with previous subarachnoid haemorrhage history, and those located in anterior and posterior communicating arteries tend to have higher rupturing risks (2,9,24). In this study, 40 patients and 44 aneurysms were treated with 42 operations. Guideline criteria were taken into consideration for surgical indications. During the operations, we used assistive devices such as sodium fluorescein videoangiography and micro-Doppler ultrasonography. For more efficient dissection, we used microsurgery, the participation of a second surgeon with a third hand to the field, and various clipping methods such as pilot, serial, and temporary clipping during our surgical practices.

Subarachnoid haemorrhage has a very complex pathogenesis and can cause mortality and morbidity in ruptured cerebral aneurysms (27). However, in UIA treatment, permanent neurological deficits or death, specifically, are completely neurosurgical intervention complications. Some suggestions were introduced to prevent complications. In institutions with 20 or more annual cases, surgeries and assistive preoperative modern equipment are used (2,27,28).

Sodium fluorescein videoangiography is a practical intraoperative device that can show the aneurysm sac occlusion and the patency of the cerebral vessels surrounding the aneurysm after clipping (10). The most significant advantage of sodium fluorescein videoangiography is its ability to obtain three-dimensional scans simultaneously with the microscope while continuing the surgical operation. It is advantageous, especially in deep-localized aneurysms or small perforating arteries in danger (16). Some studies indicated that the main disadvantage of the intravenous use of sodium fluorescein is its long-term stay in the artery walls and aneurysm dome because of its long half-life, which will limit its recurrent use in case of reclipping (29). However, we benefitted from the recurring use in suitable doses, as mentioned in one of our previous studies (30).

Sodium fluorescein videoangiography's advantages in micro-Doppler ultrasonography aneurysm surgery are its practicality, low complication, and reusable structure (18,31). However, micro-Doppler ultrasonography can be insufficient in evaluating small perforations. Also, neighbourhood vascular structures can produce false positive results (32). We gradually used the micro-Doppler alongside sodium fluorescein videoangiography in our study. We believe combining various methods can positively impact perfecting surgical results. Every piece of equipment has its advantages and disadvantages.

It is essential to minimize the neural tissue and vascular injury during dissection and clip placement using microsurgical techniques. In the standard approach, the minimal use of retractors directly decreased brain damage (33-35). Some highly-regarded institutions stated that they included a second surgeon in the field (36). In our series, instead of keeping Leyla retractors constantly in the field, we had a second surgeon with a third hand participate in the surgery field. Various studies have reported 3% to 9% of brain damage associated with retractor use (37,38). Spetzler et al. (39) reported an incidence of approximately 10% in retraction-related complications in skull base surgery. In our study, we observed a 2.5% postoperative contusion. The contusion was not related to retraction. In addition, we experienced more practicality with a dynamic retraction in a narrow space in the surgical field compared to a fixed retraction.

When intraluminal thrombosis is present, the first part closer to the aneurysm neck is generally seen as easily closable with a permanent clip. However, the artery wall around the aneurysm neck is usually thick and calcific, making it very difficult and risky to clip (20). Therefore, some researchers have suggested thrombectomy in such cases, which notably increases the time the temporary clips stay in place (20,36). We did not operate on a giant aneurysm in our series; however, we should mention that we experienced an increase in thrombus visibility with the growth of the aneurysm dome. Closing with a single clip was nearly impossible in cases with calcified thrombus. We did not apply thrombectomy in our cases, but we ensured vascular modelling using serial-multiple clips.

A previously coiled aneurysm makes the surgery and the total obliteration of the dome difficult (36), and it was present in one of the patients in our series. We observed that coils punctured through the aneurysm dome and protruded out, and not knowing the exact localization of the defect posed an additional risk for rupture. Instead of completely removing the coil pieces from the dome, we ensured the closure of the dome using multiple clippings.

Complications occurring in intracranial aneurysm surgery can be categorized into two groups: Vascular and non-vascular. Vascular complications include thromboembolism during the perforating artery injury, parent artery occlusion, premature aneurysm rupture, and atherosclerotic lesion manipulation. The non-vascular complication class includes focal brain contusion, cranial nerve damage, excessive CSF drainage, intracerebral hematoma, and surgical wound infection. The mortality and permanent neurologic deficit rates are higher in vascular complications compared to the other group (21). We treated 40 patients and 44 aneurysms in this study with 42 operations. We did not encounter any mortalities or severe morbidities in patients. The mRS was evaluated as 1 in three the patients due to the detection of a newly developed epileptic seizure.

Proximal artery control should be ensured to prevent early rupture in aneurysm surgery. A sensitive approach is required for proximal control. Proximal artery control should be used to avoid premature rupture during aneurysm surgery. Some studies have reported vasospasm associated with the use of temporary clips (40). We did not detect vasospasm due to temporary clip use in our research.

Patients developing hyperperfusion syndrome because of temporary clips have been reported in the literature. Araki et al. (41) stated that a temporary clipping time longer than 20 minutes increased risk. In our study, one patient developed hyperperfusion syndrome after DSA, but a temporary clip was not used.

Sylvian, frontobasal, and frontal bridge veins should be protected with a good microdissection. In addition, ensuring that the perforators and distal branches are protected using assistive equipment after clipping is necessary (22). Minor complications such as bone flap infection and postoperative hematoma can be prevented by paying close attention to sterile conditions and careful haemostasis towards the end of the surgery (21).

Particular attention should be paid to the aneurysms oriented to the M1 segment of the middle cerebral artery, the A1 segment of the anterior cerebral artery, and the anterior communicating posterior due to its close relationship with the lenticulostriate artery (22). While the neck of an aneurysm that has simple, narrow, and non-complex anatomy can be closed with a single clip, using fenestra and clips at various angles might be required in cases where the complex-wide neck, perforating, and parent arteries stick to the neck or move away from the neck of the aneurysm (22,36). Additionally, bifurcation might require reconstruction with multiple clips using different approaches (23). It should be noted that it would not be inappropriate to wrap the aneurysm without clipping when faced with complications, despite experience in the field (36). Studies have shown that rests can remain after clipping the aneurysms at a 3.8% to 8% ratio; it was previously stated that these rests show a growth pattern in later years (42,43). We diagnosed two patients in our series (5%) with postoperative rest, and this was treated with secondary intervention.

### Study Limitations

We are sharing the first-term findings of a newly established clinic. Therefore, having a small number of complicated cases with high difficulty levels, such as bypass surgery limits our study.

## Conclusion

The variety and use of assistive devices such as sodium fluorescence videoangiography and micro-Doppler ultrasonography can ensure reliable results and lead to few complications without hindering surgical flow during the operation. A good preoperative evaluation always ensures better postoperative performance. The second surgeon joining the field as the third hand will help with the retraction and minimize the damage to neural tissue and vessels. Additionally, the complication rate will decrease as surgical experience increases in vascular institutions that deal with such cases.

### Ethics

**Ethics Committee Approval:** All data were retrospectively examined and compiled after approval (no. 2022-281) was granted by the ethical Committee of University of Health Sciences Turkey, Başakşehir Çam and Sakura City Hospital.

**Informed Consent:** The waiver of consent was not required due to the retrospective design of the study.

**Peer-review:** Internally peer-reviewed.

### Authorship Contributions

Concept: B.E., E.A., S.D., L.Ş.P., Design: B.E., E.A., S.D., L.Ş.P., Data Collection or Processing: Y.K., S.D., E.A., O.B., Analysis or Interpretation: B.E., L.Ş.P., Y.K., Critical Review: L.Ş.P., Final Approval and Accountability: B.E., S.D., O.B., Technical or Material Support: O.B., Y.K., S.D., Supervision: L.Ş.P., Writing: B.E., S.D.

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