Should we still consider clips for basilar apex aneurysms? A critical appraisal of the literature

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Abstract

Background: Basilar apex aneurysms constitute 5–8% of all intracranial aneurysms, and their treatment remains challenging for both microsurgical and endovascular approaches. The perceived drawback of the microsurgical approach is its invasiveness leading to increased surgical morbidity. However, many high-volume centers have shown excellent clinical results with better occlusion rates compared to endovascular treatment. With endovascular therapy taking a larger role in the management of cerebral aneurysms, the future role of microsurgery for basilar apex aneurysm treatment is unclear.

Methods: We performed a literature search to review the microsurgical and endovascular outcomes for basilar apex aneurysms.

Results: Many studies have examined the efficacy of microsurgical and endovascular treatment for intracranial aneurysms, including large randomized trials such as ISAT and BRAT, prospective observational series such as ISUIA, and many single-center retrospective reviews. The recruitment number for posterior circulation aneurysms, specifically for basilar apex aneurysms, was limited in most prospective trials, thus failing to offer clear guidance on basilar apex aneurysm treatment. Recent single-center series report good clinical outcomes between 57–92% for surgical series and 73–96% in endovascular series. The durability of aneurysm occlusion remains superior in surgical cases. The techniques and devices in endovascular treatment have improved treatment aneurysm occlusion rates but more follow‑up is needed to confirm long‑term durability.

Conclusions: Both microsurgical and endovascular approaches should be complementing each other to treat basilar apex aneurysms. Although endovascular therapy has taken a larger role in the treatment of basilar apex aneurysms, many indications still exist for the use of microsurgery. Advancements in microsurgical

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Key Words: Basilar apex aneurysm, endovascular, microsurgical

INTRODUCTION

Basilar apex aneurysms constitute 5–8% of all intracranial aneurysms and about 50% of all posterior circulation aneurysms.\[^{[4,14,25,72,74]}\] As posterior circulation aneurysms rupture more frequently with poorer outcomes compared to anterior circulation aneurysms, elective occlusion of unruptured basilar apex aneurysms is recommended.\[^{[26,27,56,71,72]}\] Here, a “conservative” approach utilizing serial imaging and waiting for aneurysm growth while exposing the patient to the risk of subarachnoid hemorrhage is inadvisable. In general, patients with unruptured untreated aneurysms have 50% excess mortality compared to age-matched controls, which is reduced dramatically with treatment. This finding would likely be more substantial with regard to posterior circulation aneurysms given their propensity to rupture.\[^{[49]}\]

Microsurgical and endovascular approaches are the two treatment options for basilar apex aneurysms. The perceived drawback of the microsurgical approach is its invasiveness leading to increased surgical morbidity. Many studies have evaluated treatment results of microsurgical and endovascular treatment. However, as basilar apex aneurysms are less frequent than other locations, their optimal management remains controversial.\[^{[1]}\] We evaluate the literature to compare these two treatment options.

Historical perspectives for basilar apex aneurysm treatment

The first successful basilar apex aneurysm obliteration was performed in 1954 using a subtemporal approach by Herbert Olivecrona and his pupil Einar Bohn in Stockholm.\[^{[14]}\] Subsequently, Dr. Charles Drake in 1959 ligated a high basilar trunk aneurysm using the subtemporal approach.\[^{[14,15]}\] Between 1959 and 1992, Dr. Drake clipped nearly 900 basilar apex aneurysms, including 137 giant basilar aneurysms.\[^{[14]}\] He achieved excellent/good clinical outcomes in 90% of small (<12.5 mm) and 84% of large basilar apex aneurysms (12.5–25 mm).\[^{[14]}\] Although the subtemporal approach offers the shortest and most direct trajectory to the basilar apex, Dr. Drake’s experience demonstrated a risk of retraction injury to the temporal lobe and difficulty with visualization of the contralateral first segment of posterior cerebral artery (P1). Early surgery is recommended to achieve better clinical outcome in ruptured basilar apex aneurysm, especially in good grade cases.\[^{[22,44]}\]

In 1967, Dr. Gazi Yasargil introduced the operating microscope to neurosurgery. Following the introduction of the microscope, both Dr. Yasargil and Dr. Kenichiro Sugita popularized the pterional approach to basilar apex aneurysms.\[^{[66,75]}\] This approach provided better exposure of the contralateral P1 segment with less retraction injury. However, it also resulted in greater difficulty visualizing perforators posterior to the aneurysm, and the overall exposure and working angles were limited due to the anterior and posterior clinoid processes.

Additional alternative surgical techniques to reach the basilar apex now include the orbitozygomatic, pretemporal, epidural-transcavernous, anterior petrosal, and posterior petrosal approaches.\[^{[12,19,24,28,31]}\] Although microsurgical techniques have advanced, many neurosurgeons still achieve poor neurological outcomes for basilar apex aneurysms due to inexperience.

To date, the best treatment for basilar apex aneurysms remains debatable.\[^{[11,52]}\] The first randomized controlled trial of clipping versus coiling in ruptured cerebral aneurysms from Finland was published in 2000 and showed no significant difference in clinical outcome between treatment modalities. However, clipping provided a better total occlusion rate than coiling at one year (angiographic occlusion of 86% vs 77%).\[^{[30]}\] Subsequently, in 2002, the large randomized International Subarachnoid Aneurysm Trial (ISAT) compared clipping to coiling for ruptured cerebral aneurysms. This trial reported better neurological outcomes in coiling group with 2-month and 1-year good outcome of 73.9% and 76.5% compared to 63.1% and 69.1% in the clipping cohort, respectively.\[^{[39]}\] However, in the 5-year follow-up, 83% and 82% of patients in coiling and clipping groups achieved good clinical outcome showing similarity in long-term clinical outcome between both treatments.\[^{[40]}\] With regard to basilar apex aneurysms, the ISAT does not offer much guidance as only 17 out of 2143 cases (0.8%) were basilar apex location.\[^{[39]}\]

The Barrow Ruptured Aneurysm Trial (BRAT) was a single-center study that enrolled all subarachnoid hemorrhage patients resulting in good representation of posterior circulation (16.9%) and basilar apex aneurysms (4.7%). Even though their early results showed that posterior circulation aneurysms did better with endovascular care, there is a lack of anatomical parity of posterior circulation aneurysms between the two assigned cohorts. Posterior inferior cerebellar aneurysms, which incur a poorer outcome, were statistically over represented.
in the surgical cohort making analysis of outcomes for basilar apex aneurysms more difficult.\(^\text{[37,62]}\) After removal of PICA aneurysms from analysis (leaving mostly “top of the basilar” aneurysms), the posterior circulation aneurysms did not have a statistically significant difference in outcomes based on treatment in BRAT.\(^\text{[63]}\)

There is less data comparing the surgical and endovascular management of unruptured cerebral aneurysms and even less data for posterior circulation aneurysms. The randomized trials comparing clipping versus coiling of unruptured aneurysms failed to obtain significant recruitment.\(^\text{[11,52]}\) In the International Study of Unruptured Intracranial Aneurysms (ISUIA), prospective observations were made on the outcomes of surgical and endovascularly treated unruptured aneurysms. Of the 2368 unruptured aneurysms treated, 172 (7.3%) were of the basilar apex. Clinical outcomes were similar between both treatments in basilar apex aneurysms ≤12 mm. In addition, the obliteration rate was poor in the endovascular arm with only 51% of endovascular treated aneurysms becoming completely occluded.\(^\text{[72]}\) These results leave uncertainty concerning the best treatment of basilar apex aneurysms.

**Microsurgical approach basilar apex aneurysm [Figure 1]**

Before ISAT, there were many reports documenting the outcomes of basilar apex aneurysm surgery demonstrating good clinical outcomes of 40–87%. Mortality rates were reported between 0–31% and complete/near complete occlusion rates ranged 65–100% \([\text{Table 1}]\). After ISAT, basilar apex aneurysm microsurgery studies were scarcely reported in the literature as many neurovascular centers switched their treatment policy toward endovascular therapy. Studies published after ISAT reported improved results from prior studies with 57–92% achieving good clinical outcome, mortality rates of 2–12%, and complete/near complete occlusion rates of 90–98% \([\text{Table 2}].\]12,42,58,60,68 In our recent microsurgical series of basilar apex aneurysms, 78% patients undergoing

![Figure 1](image.png)

**Figure 1:** (a and b) Anterior and lateral view of angiography showed an unruptured medium sized basilar tip aneurysm. (c and d) A left-sided presigmoid approach was selected to clip the aneurysm. The exposure of the aneurysm and its surrounding structures were excellent and all vital neurovascular structures were preserved. (e and f) Anterior and lateral view of angiography showed total occlusion of the aneurysm while preserving all parent and branches vessels. An = aneurysm; BA = basilar artery; III = third nerve; P2 = second segment of posterior cerebral artery; Pcomm = posterior communicating artery.

| Studies                     | Number of patients | High grade HH (HH 3-5) | Final good outcome | Mortality | Complete and near complete occlusion |
|-----------------------------|--------------------|------------------------|--------------------|-----------|-------------------------------------|
| Chou, 1974\(^{[7]}\)        | 20                 | 60%                    | 40%                | 30%       | 63%                                 |
| Yasargil, 1984\(^{[73]}\)   | 50                 | 22%                    | 74%                | 8%        | N/R                                 |
| Sugita, 1979\(^{[66]}\)     | 23                 | 26%                    | 89%                | 6%        | 88%                                 |
| Dolenc, 1987\(^{[12]}\)     | 11                 | 45%                    | 73%                | 9%        | N/R                                 |
| Batjer and Samson, 1989\(^{[9]}\) | 126              | N/R                    | 81%                | 8%        | N/R                                 |
| Steinberg, 1993\(^{[46]}\)  | 83                 | N/R                    | 64%                | 31%       | 66%                                 |
| Redekop, 1997\(^{[94]}\)    | 31                 | 42%                    | 84%                | 7%        | 100%                                |
| Drake, 1996\(^{[16]}\)      | 895                | 11%                    | 84%                | 6%        | N/R                                 |
| Day, 1997\(^{[12]}\)        | 10                 | N/R                    | 60%                | 0%        | N/R                                 |
| Morcos, 1997\(^{[58]}\)     | 98                 | 29%                    | 68%                | 22%       | 86%                                 |
| Nukui, 1998\(^{[93]}\)      | 82                 | 27%                    | 70%                | 13%       | N/R                                 |
| Gruber, 1999\(^{[20]}\)     | 20                 | 30%                    | 65%                | 10%       | N/R                                 |
| Samson, 1999\(^{[57]}\)     | 302                | 52%                    | 81%                | 9%        | 94%                                 |
| Lozier, 2004\(^{[34]}\)     | 98                 | 29%                    | 68%                | 22%       | 86%                                 |
microsurgical clipping had good clinical outcome. Furthermore, unruptured or low-grade ruptured aneurysms achieved good clinical outcome in 90.5%. Conversely, high-grade ruptured and large aneurysms were significant negative predictors of outcome and these patients achieved good clinical outcome in only 50% of the cases.

**Endovascular approach to basilar apex aneurysm** [Figure 2]

The main advantage of endovascular over microsurgical treatment is less invasiveness, thus reducing procedural-related morbidity. However, studies with variable follow-up periods did not find significant differences in the final outcome between treatments. The main disadvantage of endovascular treatment is its durability of aneurysm occlusion. Good clinical outcome with the endovascular treatment of basilar apex aneurysms has been reported between 73% and 96% with mortality rates between 0% and 18% and complete/near complete occlusion rates of 64–89% [Table 3].

In a large study on the coiling of 316 basilar apex aneurysms between 1992 and 2005, Henkes et al. demonstrated a complete/near-complete initial occlusion rate of 86%. However, at 55.8 months of follow-up, the complete/near-complete occlusion rate decreased to 48%. Peluso et al. coiled 154 basilar apex aneurysms with an initial complete/near-complete occlusion rate of 94%. At 34 postprocedural months, 27 (17.5%) patients developed major recanalization that needed additional retreatment.

Endovascular treatment of cerebral aneurysms is changing more rapidly than microsurgical treatment. To improve endovascular treatment durability, multiple new devices and techniques have been developed. They include multiple microcatheter techniques, balloon remodeling, various stent-reconstruction, flow-diverters, intrasaccular devices, and devices for neck occlusion.

### Table 2: Microsurgical treatment to basilar apex aneurysm studies after ISAT

| Studies         | Number of patients | High grade HH (HH 3-5) | Final good outcome | Mortality | Complete and near complete occlusion |
|-----------------|--------------------|------------------------|--------------------|-----------|-------------------------------------|
| Sekhar, 2013    | 37                 | N/A (mean HH 2.6±1.2)  | 86%                | 8%        | 92%                                 |
| Nanda, 2013     | 52                 | 3%                     | 89%                | 9.6%      | 98%                                 |
| Krisht, 2007    | 50                 | 14%                    | 92%                | 2%        | 90%                                 |
| Sanai, 2008     | 106                | 43% **                 | 57%                | 10.5%     | 97%                                 |
| Hennesniemi, 2016 | 96               | 21%                    | 78%                | 11.5%     | 91%                                 |

**Table 3: Endovascular treatment to basilar apex aneurysm studies**

| Studies         | Number of patients | High grade HH (HH 3-5) | Long-term good outcome | Mortality | Complete/near complete occlusion |
|-----------------|--------------------|------------------------|------------------------|-----------|---------------------------------|
| McDougall, 1996 | 33                 | 24%                    | N/A                    | 12%       | 84%                             |
| Raymond, 1997   | 31                 | 45%                    | 87%                    | 6%        | 89%                             |
| Eskridge, 1998  | 150                | 25%                    | 77%                    | 18%       | N/A                             |
| Gruber, 1999    | 21                 | 29%                    | 90%                    | 0%        | 76%                             |
| Bavinski, 1999  | 45                 | 44%                    | 73%                    | 16%       | 70%                             |
| Tatehshima, 2000| 73                 | 29%                    | 86%                    | 11%       | 71%                             |
| Lusseveld, 2002 | 44                 | 7%                     | 89%                    | 4%        | 64%                             |
| Vallee, 2003    | 53                 | 18%                    | 92%                    | 6%        | 86%                             |
| Henkes, 2005    | 316                | 36%                    | 82%                    | 7%        | 59%                             |
| Peluso, 2007    | 154                | 46%                    | 95%                    | 8%        | 83%                             |
| Chalouhi, 2012  | 235                | 33%                    | 96%                    | 0%        | 69%                             |
| Sekhar, 2013    | 63                 | N/A (mean HH 3.0±1.3)  | 79%                    | 6%        | 67%                             |
| Tjahjadi, 2015  | 109                | 6%                     | 93%                    | 2%        | 80%                             |
reconstruction (e.g. PulseRider).[5,6,10,18,23,33,47,48,51,61,64,69] Like all new devices, clinical outcomes need evaluation with multicenter prospective series and long-term durability requires validation with angiographic follow-up.

Intracranial stents have revolutionized the endovascular treatment for cerebral aneurysms. Chalouhi et al. showed an initial occlusion-rate of 88.4% and 87.5% for conventional coiling method and stent-assisted technique, respectively. However, the long-term occlusion rate was improved with stenting (81% at a mean 17.3 months) compared to conventional coiling (61% at a mean follow-up of 27.7 months).[10] A recent meta-analysis with 9.7–36 months of follow-up demonstrated the superiority of stent-assisted coating compared to the coating only group. This study showed a recanalization incidence of 12.7% versus 27.9% favoring the stent group with no significant statistical differences in procedural complications.[10] A recent study from Tjahjadi et al. also showed the superiority of using a stent-assisted coating technique, especially in medium and large-sized aneurysms or wide-necked aneurysms. In long-term follow-up with a mean time of 43 months, the authors reported recanalization of 15% in the stent-assisted group compared to 25% in the non-stented group.[96] It is conceivable that the improved angiographic results with the use of stents would translate to outcomes specifically with basilar apex aneurysms as well.

**Future perspective of basilar apex aneurysm treatment**

In 2001, Ausman et al. predicted in an editorial paper that there would be a major shift in the paradigm of aneurysm treatment from microsurgery to endovascular procedures.[1] The ISAT report subsequently described the superiority of coiling over clipping for ruptured aneurysms. However, endovascular approaches do not completely remove the role of microsurgery in treating basilar apex aneurysms. Cases where microsurgery should receive more consideration include those with poor endovascular access, very small aneurysm domes, PI configuration that makes posterior cerebral artery preservation difficult, contraindications to stent placement such as intolerance to dual anti-platelet therapy or nickel allergy, and in younger patients where long-term durability is more desired.[41,58,60] Therefore, microneurosurgery still plays an important role in many basilar apex aneurysm cases and may be the only option for people in the developing world.

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**Conflicts of interest**

There are no conflicts of interest.

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