The Comparison of Conventional Pterional and Transciliary Keyhole Approaches: Pro and Con

Methee Wongsirisuwan MD*,
Anant Ananthanandorn MD*, Pravit Prachasinchai MD*

** Department of Surgery, Rajavithi Hospital*

For years, neurosurgical operations have developed. Treatment modalities involving new devices and instruments have been innovated. Another principle of management that has been created and developed is the approach to enter the intracranial structure. Yasargil was credited to the standard and may be the most important approach, pterional or frontotemporal approach. Many modifications of this approach by new neurosurgeons has been created. Until now the concept of minimally invasive neurosurgery has been well accepted. The fundamental tendency to be as minimally invasive as possible with a minimum of iatrogenic traumatization and to achieve a maximum of efficiency in the treatment of a patient has existed since the beginning of surgery. The development of unconventional or "difficult approaches", which is based on increased knowledge of microsurgical anatomy, improved preoperative diagnostic techniques, and well-adapted microsurgical instruments, definitely forms one important aspect of "refinement in microneurosurgical operating". The supraorbital keyhole via the eyebrow incision is one of the minimally invasive approaches. Until now, there are debates between the advantage and disadvantage of this approach. The authors present the comparative approaches between these young and old methods. The pros and cons are listed in detail.

Keywords : *Keyhole, Supraorbital, Transciliary*

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Surgical approaches for anterior cranial base and anterior circulation were developed for a long time ago. The most popular approach was frontotemporal or pterional approach as described by Yasargil[1,2]. This approach was used to attack many lesions in the sellar, suprasellar, planum sphenoidale, and Sylvian area. However, various surgical complications occurred such as facial branch injury, temporal muscle atrophy, frontal sinus invasion, and excessive skin exposure leading to a cosmeticaly unacceptable event. To overcome these problems, the transciliary orbital keyhole or frontolateral keyhole approach was developed[3-8]. Instead of a large craniotomy (frontotemporal), a small craniotomy was used under the concept of keyhole surgery as of Perneczky[9]. This approach claimed to be minimally invasive for access to the anterior cranial fossa including the sellar and parasellar areas. Potential advantages of this approach reduced operative morbidity of those described above, including prompt recuperation of the patients. However, there were also some limitations of this eyebrow keyhole approach such as the cosmetic result, illumination in the depth of field and so much more. The goal of this article was to compare the "Pros and Cons" of these two approaches.

Correspondence to : Wongsirisuwan M, Division of Neurosurgery, Department of Surgery, Rajavithi Hospital, 2 Phayathai Rd., Rajathevi, Bangkok 10400, Thailand. Phone: 0-2246-1234 ext.6300,6304, 01-6490772 E-mail: mathee@hotmail.com

Patients and Method

Between July 2001 and January 2003, 26 transciliary keyhole approaches and 65 conventional pterional approaches were done for anterior cranial base tumors and anterior circulation aneurysms. The authors eliminated those who had undergone surgery (recurrent lesions).

Of 26 transciliary keyhole, 19 were male and 7 were female, ranging in age from 16 to 78 years with an average age of 33 years. Diverse tumors involved the sellar, presellar or planum sphenoidale, parasellar,

and third ventricular areas. Most of the tumors were meningiomas and pituitary tumors, the rest were craniopharyngiomas, teratomas, germ cell tumors. While diverse anterior circulation aneurysms involved anterior communicating aneurysm, anterior cerebral artery (A1) aneurysm, posterior communicating aneurysm, internal carotid bifurcation aneurysm, and retrocarotid aneurysm.

Details of the diseases operated on by the keyhole approach are shown in Table 1 and Table 2 (shows the pterional approach).

Of 68 conventional pterional approaches, 46 were male and 22 were female, ranging in age from 17 to 86 years with an average age of 37 years. Diverse tumors and anterior circulation aneurysms were the same as the keyhole approach.

The average follow-up period was 10 months.

Surgical technique

For the conventional pterional approach, the procedure was the same as described by Yasargil elsewhere in standard textbooks[1,10].

For the transciliary keyhole approach, the procedure was as follows.

Positioning and skin incision

The patients were placed in the supine position, and in most cases, only 15-30 degrees rotations of the head were set. Fine adjustment of the head rotation could be accomplished during surgical approach by tilting the surgical table. Rotation of the head could be increased in cases of tumors or vascular lesions of the anterior and middle fossa and decrease in cases of third ventricle lesions. For middle cerebral artery aneurysm (usually M1), only 10 to 20 degree rotation was required (Fig. 1).

Eyebrow or transciliary incision was used in most cases except in the case of unacceptable cosmetic result when a frontotemporal incision was chosen (Fig. 2). Another trick to avoid the unwanted post-operative scar was the angle of the scalpel during the incision. The scalpel must be incised in an oblique position in relation to the surface of the skin so that cutting was parallel to the pilose follicles. This avoided the so-called "alopecia in the cicatrix" which leads to a markedly visible scar.

In the case of a frontotemporal incision, a small amount of hair could be shaved 2 fingerbreaths from the hairline; not in standard curvilinear fashion (Fig. 3), for cosmetic reasons. For a large frontotemporal incision, injury to the frontal branch of the facial

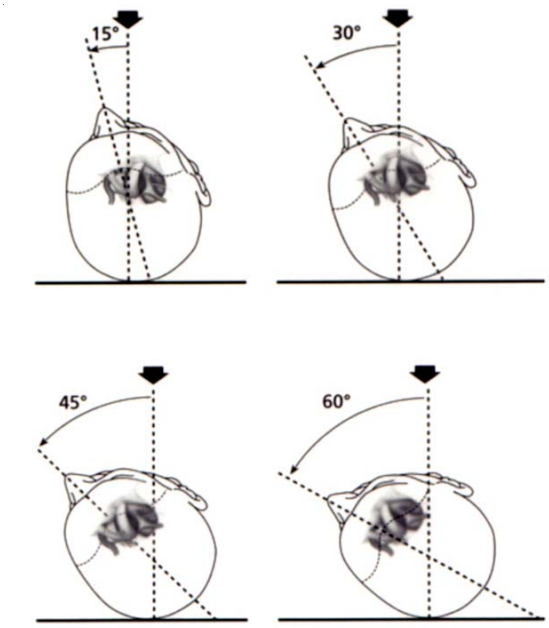


Fig. 1 Relationship between head rotation and lesions. Less degree of rotation is suit for third ventricular area and middle cerebral artery. While more degree is suit for the suprasellar and anterior fossa surgery.

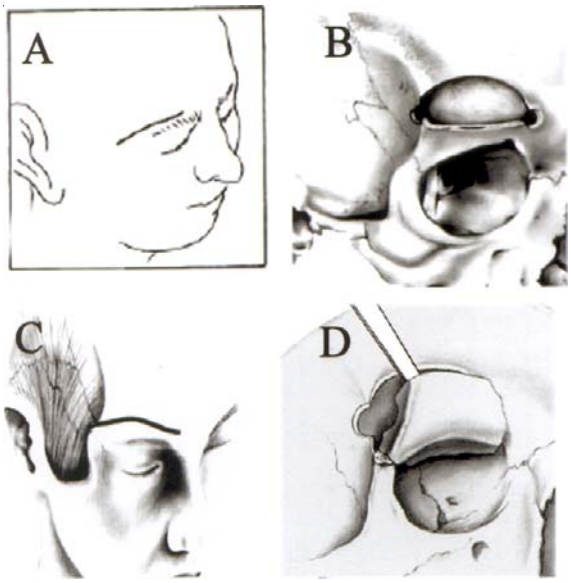


Fig. 2 Incision and extent of craniotomy. Standard transciliary supraorbital keyhole craniotomy are shown in 2A and 2B. Noted that the incision starts medial to supraorbital notch and end 2 cm beyond the tail of eyebrow. In 2C and 2D showthe extent of the incision start from the head of eyebrow and end up beyond the frontozygomatic sutureb which are over the temporalis muscle. This is the so-called "Mini frontorbitozygomatic craniotomy".

Fig. 3 Incision between the standard curvilinear (B) and modified behind the hairline (A). The shaded area is the area of supraorbital craniotomy.

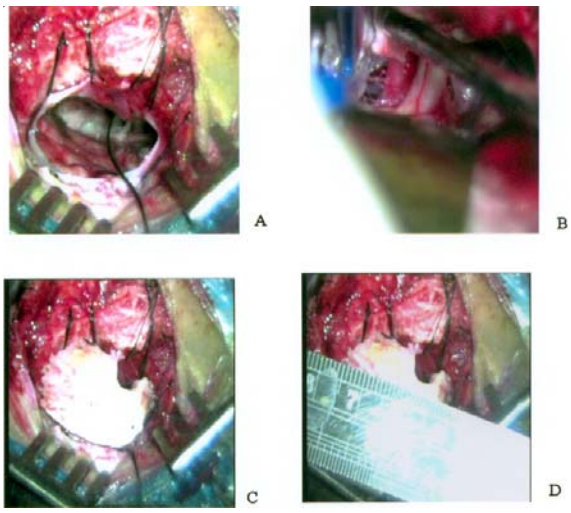


Fig. 4 Right transciliary supraorbital keyhole for planum sphenoidale minigioma. The operative steps are shown. 4A shows dural opening and CSF is released. 4B discloses the opic nerve, pituitary stalk (noted the striae pattern), and Lilequist's membrane. 4C shows the craniotomy bone flap. 4D shows the maximum diameter of 3 cm.

nerve must be avoided using "interfascial dissection technique".

Craniotomy, dural opening, approach, and surgical attack

One small burr hole at the frontozygomatic suture was made using a medium-sized burr drill (high speed drill). For cosmetic reasons, a high speed drill was used to cut the skull. The high speed drill has the potential advantage in that its slim hand piece is better for the surgeon during skull base opening. To avoid postoperative cerebrospinal fluid leakage, great care must be taken to prevent dural laceration during skull opening. Usually, a bone flap of 40 mm in greatest diameter is enough for deep brain dissection (Fig. 4). Dura was opened in the curvilinear fashion and reflected basally. The cerebrospinal fluid should be released by opening the preoptic/optic-carotid cisterns (via subfrontal approach) to facilitate brain relaxation. Avoidance of exert brain retraction should be kept in mind. In most cases, proximal Sylvian dissection without temporal lobe retraction can be done in this manner. In case of tight brain despite removal of cerebrospinal fluid via subfrontal approach, ventriculostomy may help.

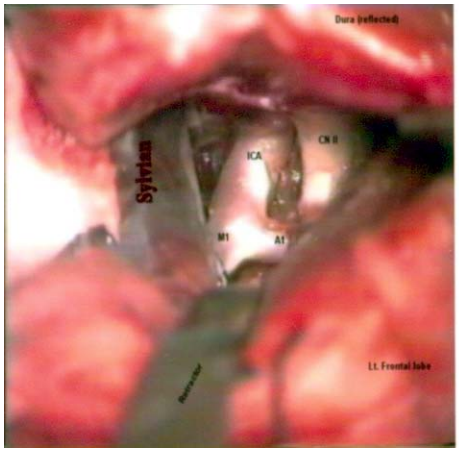
In most cases, the subfrontal approach without any Sylvian opening is enough for dissection (Fig. 5). In cases of anterior circulation aneurysms and proximal control of the internal carotid artery , the Sylvian fissure was opened. Anterior clinoid process can also be removed using the high speed drill using this keyhole approach. In our experience, Lilequist's membrane could be opened to remove a subarachnoid blood clot.

Dura, skull and skin closure

It is important to close the dura in a watertight fashion. If this is impossible then duraplasty using fascia or dural substitute are needed. The burred hole was filled up with Gelfoam and osseous shavings collected when the hole was created. Periorbital tear should be repaired to prevent enophthalmos. The skull was fixed by a titanium miniplate or Craniofix (titanium rivet anchoring system). The corrugator supercilii muscle was sutured in all cases to ensure function of the eyebrow. Absorbable suture material was used to close the skin incision in a subcuticular manner.

Results

The spaces obtained by these 2 approaches were different. Most cases of large cranial base tumors (large olfactory groove meningioma, large suprasellar tumor) were operated on using the conventional pterional approach due to excessive brain swelling despite aggressive preoperative medication. In cases of a more much lateral tumor extension (sphenoid wing meningioma), the conventional pterional approach was more helpful than the keyhole approach. From Table 1 and 2, there were only slight differences in



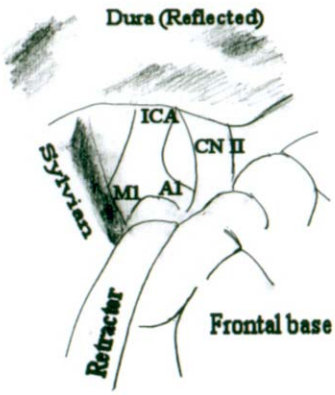


Fig. 5 Operative view under transciliary supraorbital keyhole minicraniotomy. Retractor was placed under the frontal base. Internal carotid artery (ICA), Anterior cerebral artery (A1), Middle cerebral artery (M1), and optic nerve (CN II) were seen clearly as in Pterional approach. Noted the sylvian vein on left lateral side of ICA. Also noted the retrocarotid and carotid-optic window.

disease populations between both approaches except that of a large tumor or middle cranial fossa extension.

For anterior circulation aneurysms, there was little difference between these two approaches (Fig. 6). Ther was no space limitation for dissection and clipping except for the more posterolateral circulation aneurysms such as basilar aneurysm, middle cerebral artery aneurysm (M2 or M3).

The only significant difference between these two approaches is the space required after dural opening. In case of severe brain edema or a large tumor, the small craniotomy obtained by the keyhole method was not large enough for the brain to expand after dural opening. In these cases, a large area for brain expansion was necessary to facilitate brain surgery without edge compression by dural hinge. Another postoperative complication was supraorbital numbness. The authors found that it improved significantly within weeks and returned to normal within a few months in most cases. Postoperative eyebrow immobility usually resolved within months. In cases of postoperative periorbital edema, surprisingly, a lesser degree occurred in keyhole than conventional approach.

For cosmetic concern, it seemed that patients operated on using the conventional approach could accept this problem much more than cases using the keyhole approach. However, most patients with an

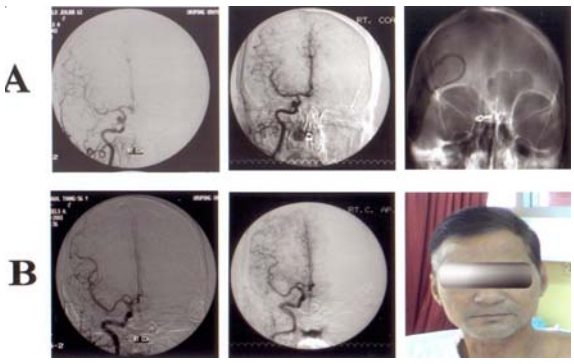


Fig. 6 Cases of anterior circulation aneurysms. 6A is anterior communicating aneurysm. 6B is anterior cerebral artery (A1) aneurysm.

Table 1. Operative details of diseases operated by keyhole approach

Diagnosis	Number of cases
Anterior circulation aneurysm	
Anterior communicating artery aneurysm	4
Anterior cerebral artery aneurysm (A1)	2
Middle cerebral artery aneurysm (M1)	1
Middle cerebral artery bifurcation/ trifurcation aneurysm	2
Internal carotid artery (ICA) bifurcation aneurysm	1
ICA-Posterior communicating artery aneurysm	2
ICA-Anterior choroidal artery aneurysm	1
Tumor	
Planum sphenoidale meningioma	5
Pituitary tumor	3
Anterior choroidal meningioma	1
Suprasellar meningioma	2
Suprasellar teratoma	1
Suprasellar craniopharyngioma	1

Table 2. Operative details of diseases operated by pterional approach

Diagnosis	Number of cases
Anterior circulation aneurysm	
Anterior commnunicating artery aneurysm	7
Anterior cerebral artery aneurysm (A1)	3
Anterior cerebral artery aneurysm (A2)	2
Middle cerebral artery aneurysm (M1)	2
Middle cerebral artery bifurcation/ trifurcation aneurysm	3
Middle cerebral artery aneurysm (M2)	1
Internal carotid artery (ICA) bifurcation aneurysm	2
Giant intracavernous and petrous aneurysm	1
ICA-Posterior communicating artery aneurysm	4
ICA-Anterior choroidal artery aneurysm	1
Basilar bifurcation aneurysm	2
Basilar-Posterior cerebral artery aneurysm	1
Multiple aneurysms (AcomA, ICA)	1
Tumor	
Planum sphenoidale meningioma	3
Pituitary tumor	8
Anterior clinoidal meningioma	1
Suprasellar meningioma	4
Suprasellar teratoma	1
Suprasellar craniopharyngioma	2
Olfactory groove meningioma	4
Sphenoidal meningioma	3
Astrocytoma/Glioblastoma multiforme	5
Metastatic tumor	3
Intraorbital tumor (meningioma/ hemangioma/glioma)	4

eyebrow incision did not complain about their postoperative scar (Fig. 7). Only one could not accept the scar.

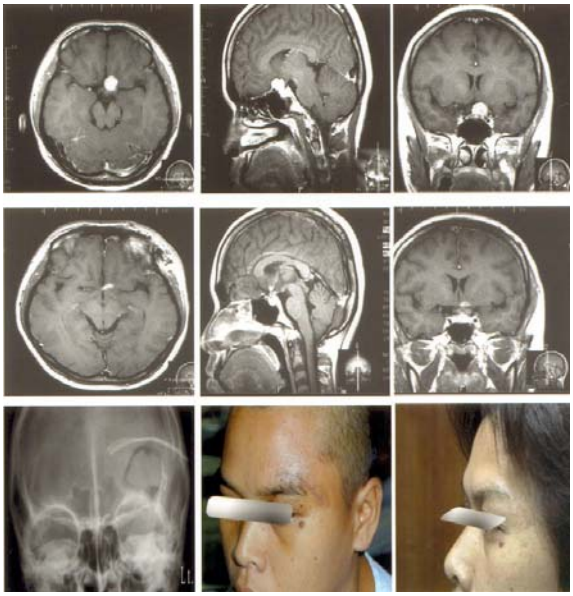


Fig. 7 A case of small anterior clinoidal tumor. This case is best suit to keyhole surgery. Also noted the scar of her eyebrow between immediate and 4 months postoperative period. The scar is rarely visible. She has good impression with the surgery and scar.

For the details of complications please referred to Table 3.

Discussion

For years after the advocate of Yasargil's pterional approach[1], it was well accepted as the standard approach for anterior cranial base surgery. Yasargil claimed that this approach could be done for most aneurysms including posterior circulation aneurysms[10]. But since the advocate of keyhole microneurosurgical concept by Perneczky[7,9], many

Table 3. Intraoperative and postoperative complications

Intraoperative/Postoperative complications	Number of cases	
	Keyhole	Pterion
Premature rupture of the aneurysm before proximal control	1	2
Periorbital edema - all are transient	4	12
Numbness of supraorbital area - transient	6	5
- permanent	2	2
Subgaleal collection from CSF leakage	4	3
Unacceptable cosmetic problem	1	4
Mucocoele from frontal sinus invasion	0	2
Inability to raise the eyebrow - transient	3	1
- permanent	0	0
Temporalis muscle atrophy caused visible cosmetic defect	0	0
Postoperative infection	0	3

neurosurgeons reported successful operations based on this concept. After that many modifications followed this concept to achieve minimal invasive neurosurgery[5,8,11-18]. Basically, the keyhole concept is the minimization of craniotomy size, and if possible, the skin incision size too. The size of the craniotomy should be small but large enough to operate without compromising the operative procedure. The pterional approach was more extensive, time-consuming, and invasive than the supraorbital keyhole approach.

From this study and numerous reports, the transciliary keyhole approach can be modified for many neurosurgical operations. For example, the authors can extend frontal craniotomy to frontoorbital craniotomy by cutting the orbital ridge for low anterior cranial base surgery. For cases of more lateral extension tumor, the authors can extend the craniotomy to the lateral aspect of the frontozygomatic suture and if needed a complete frontoorbitozygomatic craniotomy can be performed.

There are some limitations to the keyhole approach. The most important limitation is seen in the case of a tight brain such as a massive subarachnoid hemorrhage without a significant amount of hydrocephalus or in the case of a large tumor which requires larger area of initial dural opening. The angle of the approach during aneurysm clipping seems to be one of the important obstacles especially in a giant aneurysm. The limited size of the surgical corridor (bone flap) can compromise visualization and restrict manipulation of surgical instruments in many ways. So this keyhole approach must be done by a skillful microneurosurgeon and appropriate microinstuments under the aid of good operating microscope[19].

When dealing with a cranial base tumor, the authors found that planum sphenoidale and pituitary tumor with lesser degree of suprasellar extension are the most appropriate lesions to attack with keyhole surgery. For anterior circulation aneurysms, the most appropriate lesions are anterior communicating aneurysm and anterior cerebral artery aneurysm (A1).

Another debate is the cosmetic problem. Eyebrow incision seems to have a more immediate postoperative cosmetic problem than the standard pterional incision. But after a period of time, the scar will fade away. A watertight dural closure, skull repositioning, and meticulous skin closure are important factors to attain a good cosmetic result. Surgeons must be preoperatively clear with the patients about the possible postoperative scar. From the authors' experience, the wrinkles in senile patients can conceal the scar very well. To avoid this supraorbital scar, one can combine the standard pterional skin incision with the minicraniotomy. However, the question still exists. What extent of the degree of minimally invasive neurosurgery should be adequate? If a certain lesion is treated inappropriately through a small, atraumatic approach, this procedure cannot be considered minimally invasive due to its lack of efficacy. Yet it may be the road to perdition. Remember that any surgical procedure with a small, atraumatic approach leaving a patient with an inadequately treated lesion should be called maximally invasive rather than minimally invasive. This is very true in cases of specific lesions which could have been treated completely and effectively through a somewhat larger; tailored approach. The golden decision is "a surgical approach should be as large as necessary and as small as possible"[9].

Finally, the authors still recommend that those who want to practice this technique should begin with the conventional skin incision for the pterional approach with a small bone flap first. So that if anything goes wrong, then the bone flap can be enlarged without disaster.

Conclusion

The keyhole approach has proven itself to be one of the standard neurosurgical approaches but it can not replace the pterional approach. It has many advantages: a less time consuming operation, cranial base operation with minimum brain retraction, and it can reduce the length of hospital stay. However, disadvantages still persist. For surgeons with less experience, the familiarity with neuroanatomy must be concerned. The varieties of the working angle are much more in a conventional craniotomy than in a keyhole craniotomy. In cases of tight brain despite removal of the cerebrospinal fluid, this supraorbital keyhole approach is not the choice. So both two approaches can not replace each other. The surgeons must keep in mind not to attempt acrobatics with a stake in gambling of the patient's life. If they feel unsure about which approach to use, the conventional approach may be more appropriate without risking the patients' life.

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เปรียบเทียบการผ่าตัดแบบดั้งเดิมและแบบรูกุญแจ: ข้อดี-ข้อเสีย

เมธี วงศ์ศิริสุวรรณ, อนันต์ อนันทนันดร, ประวิทย์ ประชาศิลป์ชัย

การผ่าตัดทางจุลศัลยกรรมระบบประสาทได้มีการพัฒนามาอย่างต่อเนื่อง โดยเฉพาะอย่างยิ่งด้านเครื่องมือผ่าตัด และวิธีการผ่าตัด เพื่อให้เข้าถึงส่วนลึกของสมองได้มากที่สุดแต่ในขณะเดียวกันก็หลีกเลี่ยงการการทำอันตรายต่อเนื้อเยื่อต่าง ๆ น้อยที่สุด Yasargil ได้รับการยอมรับว่าเป็นผู้ที่ได้วางแนวทางการผ่าตัดแบบ pterion หรือ frontotemporal ซึ่งในปัจจุบันก็ยังใช้กันเป็นวิธีมาตราฐานในการเข้าถึงส่วนลึกของสมอง ด้วยวิธีการผ่าตัดดังกล่าวทำให้ประสาทศัลยกรรมมีความก้าวหน้าเป็นอย่างมาก อย่างไรก็ตามในปัจจุบันก็ได้มีการพัฒนาวิธีการผ่าตัดโดยการเปิดแผลขนาดเล็กบริเวณคิ้วและกะโหลกศีรษะ โดยยังสามารถเห็นส่วนลึกของสมองได้เหมือนการเปิดแผลขนาดใหญ่ วิธีดังกล่าวนี้เรียกว่า การผ่าตัดแบบรูกุญแจ ประสาทศัลยแพทย์หลายท่านมีความเห็นทั้งในเชิงสนับสนุนและคัดค้านการผ่าตัดแบบใหม่นี้ วัตถุประสงค์ของรายงานนี้เพื่อ เปรียบเทียบข้อดีและข้อเสียของวิธีทั้งสอง