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Original Article

Extradural minipterional approach: Evolving indications of the minipterional craniotomy

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ABSTRACT

Background: In this paper, we report a clinical series of skull base lesions operated on trough the MiniPT, extending its application to skull base lesions, either using the classical minipterional or a variant, we call extradural minipterional approach (MiniPTEx).

Methods: We describe our surgical technique of operating on complex skull base lesions using a minipterional extradural approach. Anterior clinoidectomy, middle fossa peeling, transcavernous, and Kawase approaches were performed as needed. In total, we carried out 24 surgeries: three skull base tumors, 1 Moyamoya case, and 20 giant/complex intracranial aneurysms. All the patients present good neurological result (mRs < 3). Only two patients had paralysis of any cranial nerve and only one patient had a mild hemiparesis.

Results: This surgery series there are 24 cases, 10 patients were treated with exclusive MiniPT. MiniPT extradural approach was made in 14 patients. Twelve were treated using pure MiniPTEx approach, 1 patient using transcavernous approach, and in 1 patient, the anterior clinoid was resected with the combination of a MiniPT, a medium fossa peeling, and the Kawase anterior petrosectomy for skull base surgery.

Conclusion: We further advance the indications of the MiniPT by extending it to operate on the cranial base tumors or complex vascular lesions without additional morbidity. MiniPT approach may be safely associated with skull base techniques, including anterior and posterior clinoidectomies, peeling of the middle fossa, transcavernous approach, and anterior petrosectomy. The versatility of the MiniPT craniotomy and the feasibility of performing skull base surgery through the MiniPT technique have been demonstrated in this paper.

Keywords: Aneurysm, Craniotomy, Extradural minipterional approach, Minimally invasive neurosurgery, Minipterional, Pterional, Skull base, Vascular

INTRODUCTION

The pterional approach (PT) or frontotemporal approach is the most used technique in cranial neurosurgery.[1-9] It was described by Gazi Yasargil in 1975 to access the anterior and middle fossa, anterior circulation aneurysms, distal basilar artery, and tumors of the sellar, parasellar, and subfrontal regions.[9,10] There are a large number of variations of this approach that has been described that expand the access to provide "better" exposure of the intracranial anatomical structures, such as transzygomatic and orbitozygomatic approach.[11]

However, these approaches, including the classic PT, present some disadvantages that include extensive soft-tissue retraction, skin healing problems, temporal muscle atrophy, and postoperative chewing pain. Frontal sinus opening may also lead to complications such as cerebrospinal fluid leakage and meningitis. To circumvent these drawbacks, technical modifications have been proposed, including minipterional approach (MiniPT).[3,7] MiniPT as described by Figueiredo *et al.* has gained increasing acceptance among neurosurgeons; however, it has not been used to approach skull base lesions thus far.[3,7]

We have used the MiniPT approach associated with skull base techniques, such as extradural clinoidectomy, middle fossa peeling, anterior Kawase petrosectomy, and/or transcavernous approach, to operate on skull base lesions. We call these technical refinements extradural minipterional approach (MiniPTEx). It has expanded the indications of the MiniPT while preserving its advantages. In this paper, we describe its surgical technique and present its clinical application.

MATERIALS AND METHODS

Positioning

The patient was placed in supine deflected position with the head fixed with a head holder. The rotation varied between 30° and 45° depending on the lesion to be treated. When necessary, the cervical carotid artery was exposed for proximal control, mainly when operating on paraclinoid aneurysms [Figure 1].

Technique

We performed the MiniPT as previously described.[3,7] The skin incision and subcutaneous tissue were performed more anterior in comparison to the standard pterional approach. It began 2 cm above the superior edge of the zygomatic arch. The incision line followed the anterior insertion of the hair in the scalp to the hemi-pupil line ([Figure 2], interfascial dissection was performed immediately after the fat cushion plane has been reached).

Subperiosteal dissection of the temporal muscle was performed with Penfield's #1 dissector to preserve the deep temporal artery. Three points of traction were made in the temporal muscle: the first in its upper border, then another in the base, and finally another in the anterior part, reflecting

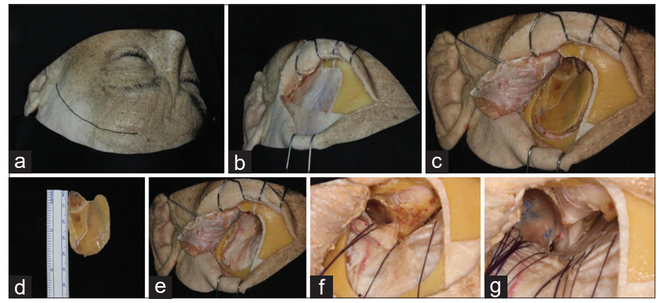

Figure 1: Cadaveric anatomic dissection: (a) MiniPT approach incision and variants in cadaver; (b) interfacial dissection, fronto-orbital suture exposure, and zygomatic arc; (c) exposure of the temporal muscle and mini-pterional craniotomy; (d) bone flap from 3.5 to 4 at its largest diameter; (e) dura mater exposure after the craniotomy; (f) sectional meningo-orbital band, mini-pelling of the middle fossa, and partial resection of the lateral wall of the orbit. (g) Resection of the lateral wall, orbit rim, and optic pillar with extradural anterior clinoidectomy.

Figure 2: Positioning of the patient for modified MiniPTEx. Note that the incision does not reach the midline.

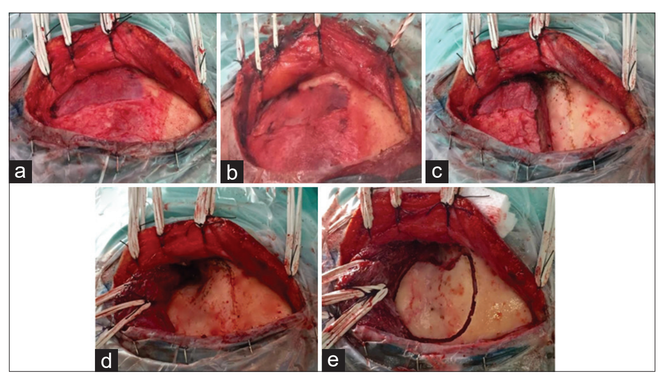

Figure 3: (a) Interfacial dissection in the left mini-pterional approach; (b) exposure of the orbital rim and malar arch in the interfacial dissection; (c) temporary muscle disinserted from the upper temporal line and its anterior border; (d) exposure of the bone plane, after reflecting the temporal muscle toward its base; (e) mini-pterional approach craniotomy.

it on its base and exposing the temporal bone and part of the sphenoid wing [Figure 3].

A single and small bone groove was made to allow space for the osteotomies. This resulted into minimum bone defect and was performed 0.5 cm below the superior temporal line, behind the zygomatic process of the frontal bone. The craniotomy had its upper limit in the superior temporal line. The interfascial dissection allowed us to perform the craniotomy with an anterior limit immediately behind the lateral orbital rim. This exposure cannot be obtained without interfascial dissection and it is an essential step for the extradural approach. The orbitomeningeal band was cut when necessary if the middle meningeal artery did not give rise to the ophthalmic artery and the sphenoidal wing was drilled.

When indicated, an extradural removal of the anterior clinoid process was carried out. The upper orbital fissure was identified, the lateral wall was dissected and a small part of the orbital roof was removed to open the optic channel.

The meningo-orbital fold was sectioned entirely using *Kamiyama* microscissors (*Takayama Instruments*, model 20–30), following the lateral edge of the clinoid until to its tip. A peeling of the middle fossa was performed accessing the inferior surface of the clinoid and thus dissecting the optic strut. Finally, the optic strut was drilled disconnecting the anterior clinoid process of its three points of support, the sphenoid, the optical component, and the roof of the optical channel. This step was performed with 1 mm Kerrison and with straight gauges of different sizes 0.5-0.75-1-1.3 mm (*Sontec Instruments, Mini Neuro Rongeurs*).

Then, the dura was opened over the optic nerve since to avoid injury to the carotid artery or a premature aneurysm rupture. The distal dural ring was opened, either wholly or partially depending on the lesion. The internal carotid artery was always exposed in its clinoid segment. Microsurgical steps of the procedure were performed as usual [Figure 4].

RESULTS

Clinical examples

Cases were performed prospectively with simple MiniPT approach and MiniPtEx. During this period, MiniPT as described by Figueiredo *et al*. was performed in 24 patients [Table 1]. Ten patients underwent a pure MiniPT craniotomy. In another nine patients, anterior clinoidectomy was performed, and in two cases, a transcavernous approach was carried out, with posterior clinoidectomy. In two patients, peeling of the middle fossa was carried out. In addition, MiniPT with a middle fossa peeling and Kawase petrosectomy were performed in one case of trigeminal schwannoma [Figure 5]. No mortality or additional morbidity has been reported in this series [Table 2].

CASE EXAMPLES

Case 1

A 56-year-old female patient presented with a history of 3 weeks ictal onset of a headache. She was conscious and oriented, without any deficit. CT scan displayed a

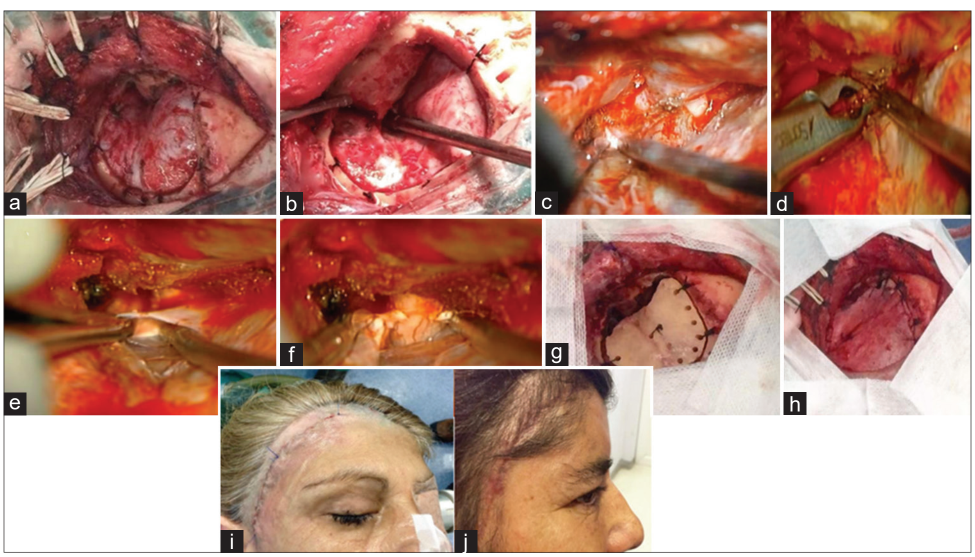

Figure 4: (a) Dura mater exposed with dural lifting points, the sphenoid wing has been milled, (b) left craniotomy. Milled sphenoidal wing, orbitomeningeal band is shown, (c) left craniotomy, the resection of the lateral and minimal wall of the roof of the orbit is observed and middle fossa mini-peeling, (d) left mini-pterional craniotomy with anterior extradural clinoidectomy, (e) dural linear opening, on front temporal side, (f) dura opening over the optic nerve, (g) cranioplasty with minimal osseous defect, (h) the temporal muscle is fixed to the upper temporal line, (i) skin closure with intradermal suture, (j) surgery wound month control.

Table 1: Total patients. MiniPT, MiniPTEx, transcavernous, peeling of middle fossa, and Kawase. In the total of 24 patients, the majority (71%) were women, with an average age of 46 years. Of the patients, 21 corresponded to vascular pathology, and of these, six cases correspond to subarachnoid hemorrhages, 14 to unruptured aneurysms, 5 to paraclinoid aneurysms, and 1 to Moyamoya disease. In two instances of aneurysms of the posterior communicating segment of the internal carotid artery, it was necessary to perform a MiniPTEx approach for an adequate clipping.

Number	Patient	Age	Gender	Diagnosis	Approach	Surgery
1	WTP	45	M	Left ruptured ACM aneurysm	Left MiniPT	Clipping
2	YBV	48	F	Right ruptured ACM aneurysm	Right MiniPT	Clipping
3	SSR	18	M	Moyamoya	Left MiniPT	EDAS
4	TTP	56	F	Right ruptured transitional ICA aneurysm	Right MiniPTEx (peeling of the middle fossa and anterior clinoidectomy)	Clipping
5	PMR	33	F	Right ruptured transitional ICA aneurysm	Right MiniPTEx (peeling of the middle fossa and anterior clinoidectomy)	Clipping
6	ELG	38	F	Right ruptured transitional ICA aneurysm	Right MiniPTEx (peeling of the middle fossa and anterior clinoidectomy)	Clipping
7	FAL	65	F	Right ruptured ACM aneurysm	Right MiniPT	Clipping
8	MMM	41	F	Right ruptured paraclinoid aneurysm	Right MiniPTEx (peeling of the middle fossa and anterior clinoidectomy)	Clipping
9	SVR	41	F	Right ruptured ICA aneurysm	Right MiniPTEx (peeling of the middle fossa and anterior clinoidectomy)	Clipping
10	MCR	47	F	Left V nerve schwannoma	Left MiniPTEx (peeling of the middle fossa)	Total removal
11	AOE	19	M	Interpeduncular pilocytic astrocytoma	Left MiniPTEx (transcavernous approach)	Total removal
12	IFA	63	F	Right cavernous, sellar and suprasellar hemangiopericytoma	Right MiniPTEx (peeling of the middle fossa and transcavernous approach)	Total Removal
13	GMA	58	F	Right ruptured ICA transitional aneurysm	Right MiniPTEx (peeling of the middle fossa and anterior clinoidectomy)	Clipping
14	ACM	27	F	Ruptured AComA aneurysm	Left MiniPT	Clipping
15	MVM	43	F	Left ruptured transitional ICA aneurysm	MiniPTEx (peeling of the middle fossa and anterior clinoidectomy)	Clipping
16	AML	77	F	Right ruptured ACM and PcomA aneurysm	MiniPTEx (peeling of the middle fossa and anterior clinoidectomy)	Clipping
17	LVJ	62	F	Ruptured paraclinoid aneurysm	MiniPTEx (peeling of the middle fossa and anterior clinoidectomy)	Clipping
18	DGZ	19	F	Right ACA aneurysm	MiniPT	Clipping
19	JSA	63	M	Ruptured AcoA aneurysm	Right MiniPT	Clipping
20	FMR	34	M	Rupture left Pcom aneurysm	Left MiniPT	Clipping
21	CMV	41	M	Right ruptured transitional ICA	MiniPTEx (peeling of the middle fossa and anterior clinoidectomy)	Clipping

(*Contd...*)

Table 1: (*Continued*)

Number	Patient	Age	Gender	Diagnosis	Approach	Surgery
22	DUR	70	F	Ruptured left PcomA aneurysm	MiniPTEx (peeling of the middle fossa and anterior clinoidectomy)	Clipping
23	LCS	53	F	Left ruptured choroidal artery aneurysm	Left MiniPT	Clipping
24	WNS	49	M	Right carotid artery bifurcation aneurysm	Right Mini-PT	Clipping

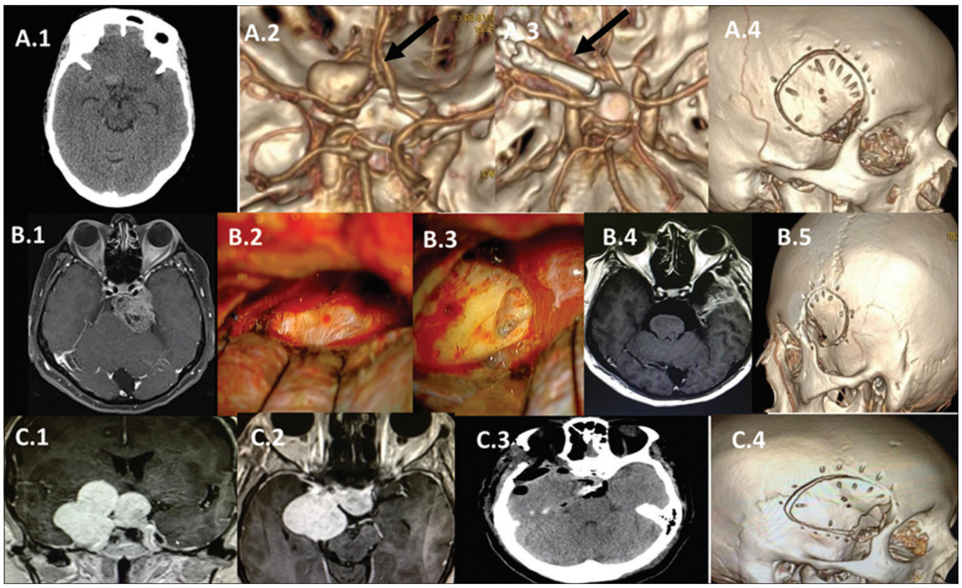

Figure 5: (A) Case 1: (A.1) CT without contrast with hyperdense right paraclinoid image and hydrocephalus; (A.2) CT angiotomography (AGT) shows right transitional aneurysm; (A.3) control AGT with complete elimination of the aneurysm; (A.4) 3D AGT, showing MiniPTEx craniotomy. (B) Case 2: (B.1) left schwannoma V nerve; (B.2) fossa media peeling of V left nerve schwannoma; (B.3) previous initial Kawase petrosectomy; (B.4) MR T1 with gadolinium in the immediate postoperative period. A muscular tissue is observed occupying sealing space and extradural space; (B.5) posterior surgical 3D cranial CT. MiniPT craniotomy is observed. (C) Case 3: (C.1) brain MR in T1 weighting with gadolinium, with coronal cortex with extensive expansive skull base process that enhances with contrast; (C.2) axial MR with axial section showing extensive expansive process of the base of the skull; (C.3) postsurgical CT without contrast; (C.4) right MiniPT craniotomy.

subarachnoid hemorrhage with modified Fisher's Grade I and hydrocephalus. A ruptured right internal carotid transitional aneurysm was diagnosed. A right MiniPTEx approach and aneurysm clipping were performed. Postoperative angiogram depicted complete exclusion of an aneurysm. The patient was discharged uneventfully [Figure 5A].

Case 2

A 46-year-old male patient presented with a headache and hypesthesia in the left V1 territory. MRI displayed a lesion suggestive of schwannoma of the left V nerve. A left MiniPT craniotomy, middle fossa peeling, and anterior Kawase petrosectomy were performed (MiniPTEx). Complete removal was achieved as demonstrated by postoperative MR. The patient remained with the right trigeminal neuralgia in territory V2 and V3 and peripheral facial palsy with House-Brackmann IV after 1 month of follow-up [Figure 5B].

Case 3

A 63-year-old female patient complained of visual impairment. MRI showed an extensive skull base lesion that involved the right cavernous sinus, sellar, and suprasellar regions. A right MiniPTEx approach (peeling of the middle fossa and a transcavernous approach) was carried out. Complete resection was achieved. Definitive diagnosis was hemangiopericytoma. Postoperative outcome was satisfactory and the patient remained in excellent condition, with only a paresis of the III and VI right nerve after 1 month of follow-up [Figure 5C].

Table 2: Outcomes of patients operated on through MiniPT and MiniPtEx craniotomies.

Number	Patient	Diagnosis	Approach	Surgery	Outcome
1	WTP	Left ruptured ACM aneurysm	Left MiniPT	Clipping	mRs 0
2	YBV	Right ruptured ACM aneurysm	Right MiniPT	Clipping	mRs 0
3	SSR	Moyamoya	Left MiniPT	EDAS	mRs 0
4	TTP	Right ruptured transitional ICA aneurysm	Right MiniPTEx (peeling of the middle fossa and anterior clinoidectomy)	Clipping	mRs 0
5	PMR	Right ruptured transitional ICA aneurysm	Right MiniPTEx (peeling of the middle fossa and anterior clinoidectomy)	Clipping	mRs 0
6	ELG	Right ruptured transitional ICA aneurysm	Right MiniPTEx (peeling of the middle fossa and anterior clinoidectomy)	Clipping	mRs 0
7	FAL	Right ruptured ACM aneurysm	Right MiniPT	Clipping	mRs 0
8	MMM	Right ruptured paraclinoid aneurysm	Right MiniPTEx (peeling of the middle fossa and anterior clinoidectomy)	Clipping	mRs 0
9	SVR	Right ruptured ICA aneurysm	Right MiniPTEx (peeling of the middle fossa and anterior clinoidectomy)	Clipping	mRs 0
10	MCR	Left V nerve schwannoma	Left MiniPTEx (peeling of the middle fossa)	Total removal	mRs 1, VII palsy nerve
11	AOE	Interpeduncular pilocytic astrocytoma	Left MiniPTEx (transcavernous approach)	Total removal	mRs 2, mild left hemiparesis
12	IFA	Right cavernous, sellar and suprasellar hemangiopericytoma	Right MiniPTEx (peeling of the middle fossa and transcavernous approach)	Total Removal	mRs 0, paresis III and VI nerve
13	GMA	Right ruptured ICA transitional aneurysm	Right MiniPTEx (peeling of the middle fossa and anterior clinoidectomy)	Clipping	mRs 0
14	ACM	Ruptured AComA aneurysm	Left MiniPT	Clipping	mRs 0
15	MVM	Left ruptured transitional ICA aneurysm	MiniPTEx (peeling of the middle fossa and anterior clinoidectomy)	Clipping	mRs 0
16	AML	Right ruptured ACM and PcomA aneurysm	MiniPTEx (peeling of the middle fossa and anterior clinoidectomy)	Clipping	mRs 0
17	LVJ	Ruptured paraclinoid aneurysm	MiniPTEx (peeling of the middle fossa and anterior clinoidectomy)	Clipping	mRs 0
18	DGZ	Right ACA aneurysm	MiniPT	Clipping	mRs 0
19	JSA	Ruptured AcoA aneurysm	Right MiniPT	Clipping	mRs 0
20	FMR	Rupture left Pcom aneurysm	Left MiniPT	Clipping	mRs 0
21	CMV	Right ruptured transitional ICA	MiniPTEx (peeling of the middle fossa and anterior clinoidectomy)	Clipping	mRs 0
22	DUR	Ruptured left PcomA aneurysm	MiniPTEx (peeling of the middle fossa and anterior clinoidectomy)	Clipping	mRs 0
23	LCS	Left ruptured choroidal artery aneurysm	Left MiniPT	Clipping	mRs 0
24	WNS	Right carotid artery bifurcation aneurysm	Right Mini-PT	Clipping	mRs 0

Outcomes of patients operated on through MiniPT and MiniPtEx craniotomies

All the patients present good neurological result (mRs <3). Only two patients had paralysis of any cranial nerve and only one patient had a mild hemiparesis (Table 2).

DISCUSSION

MiniPT approach with an interfascial flap, despite being a smaller craniotomy than the traditional PT, offers all of its advantages of the PT technique and its variations. These advantages include the ability to approach the anterior, middle fossa and anterior circulation lesions.[3]

Since May of 2016, our group began to combine the MiniPT with an anterior extradural clinoidectomy, transcavernous approach, middle fossa peeling, and Kawase anterior petrosectomy, to operate on vascular and tumor lesions located in previously considered inaccessible areas by "minimally invasive" craniotomies.[4,5] This extradural variant of MiniPT approach has not been described thus far. In addition, this maneuver allowed complex paraclinoid lesions to be surgically treated. Alternatively, the middle fossa pelling, the Kawase anterior petrosectomy, and the transcavernous approach methods may be employed as needed. These refinements allow surgeons to operate on more complex vascular and tumoral neurosurgical pathologies using a less invasive technique. In addition, it changes the paradigm of only operating on skull base or complex vascular lesions through large openings. This new approach allows us to treat complex vascular and tumor pathologies, with less exposure of brain tissue which protects it and at the same time provides the versatility offered by the classical pterional approach and its variants.[3,5]

MiniPT interfascial approach, unlike others "keyhole" techniques, allows the craniotomy to be performed with a more anterior edge since there is no bulging of the temporal muscle that is minimized due to the interfascial dissection. An essential advantage of the MiniPT approach, since the upper temporal line limits its anterior extension, is that the frontal sinus is not exposed, avoiding complications, mainly wound infections, cerebrospinal leakage, and meningitis.[1-3]

On the other hand, the skin incision offers versatility since it allows us to expand the approach when necessary. The anterior and middle fossa exposure provides the possibility to obtain soft tissues such as muscle and temporal fascia to repair dural defects. This is not properly provided by the lateral or superciliary supraorbital approach which is the most used "keyhole" approaches.[1,4,6,7,8]

Another essential advantage of the MiniPT is the higher grade of satisfaction of the patients in the postoperative period. This method considerably reduces the pain when chewing since the dissection of the temporal muscle is minimal compared to the standard pterional approach. At the same time, any incisions before the midline of the skin have fewer complications and heal faster, with less atrophy of the temporalis, as demonstrated by Welling *et al*.[1,2,4,6,8]

Extending minimally invasive techniques to approach skull base lesions is challenging, mainly when peeling of the middle fossa, transcavernous route, or anterior petrosectomy are required. In this scenario, MiniPT represents a valuable and natural option since it provides access to the anterior clinoid process, cavernous sinus, middle fossa, and petrous apex. Therefore, MiniPT technique is more anatomically appropriate to operate lesions in these regions, than other minimally invasive alternatives.

However, the fundamental difference between MiniPT approach and the other so-called "keyhole" craniotomies is conceptual. The rationale of the MiniPT technique is to preserve the exposure provided by the standard PT, while minimizing its extension. Therefore, the MiniPT represents the optimal balance between the resulting exposure and size of the craniotomies. "*Keyhole*" approaches concept is different and has no objective of preserving the exposure provided by conventional and long tested craniotomies. It is focused on the size of craniotomy and not on the microsurgical exposure, unlike the MiniPT craniotomy. In addition, some variants such as supraorbital, presents anatomical limitations in approaching the middle fossa, and some procedures described herein, such as, transcavernous or Kawase techniques, may not be performed using other "minimally invasive" techniques. We believe that this is the reason for the high versatility of the MiniPT craniotomy, as it has been demonstrated in this paper.

CONCLUSION

In this paper, we further advance the indications of the MiniPT by extending it to operate on the cranial base tumors or complex vascular lesions. MiniPT approach may be safely associated with skull base techniques, including anterior and posterior clinoidectomies, peeling of the middle fossa, transcavernous approach, and anterior petrosectomy. We called these variants the extradural minipterional approach (MiniPTEx). The versatility of the MiniPT craniotomy and the feasibility of performing skull base surgery through the MiniPT technique have been demonstrated in this paper.

Declaration of patient consent

Institutional Review Board (IRB) permission obtained for the study.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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