



Original Article

Suprafascial dissection for pterional craniotomy to preserve the frontotemporal branch of the facial nerve with less temporal hollowing

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ABSTRACT

Background: To protect the frontotemporal branch of the facial nerve (FTFN) when performing pterional craniotomy, several reports suggest the subfascial or interfascial dissection technique. However, the reports of postoperative frontalis paralysis and temporal hollowing, which are common complications, were relatively limited. This study reports the incidence of postoperative frontalis paralysis and temporal hollowing after pterional craniotomy using the suprafascial and interfascial techniques.

Methods: Patients who underwent pterional craniotomy, using the suprafascial technique (leaving the muscle cuff and not leaving the muscle cuff) and the interfascial technique, between November 2015 and September 2018 were retrospectively evaluated for postoperative frontalis paralysis and temporal hollowing using Chi-squared/Fisher exact test.

Results: Seventy-two patients underwent pterional craniotomy, using the suprafascial technique in 54 patients (leaving the muscle cuff in 21 patients and not leaving the muscle cuff in 33 patients) and the interfascial technique in 18 patients. Eleven patients (20.4%) in the suprafascial group and 1 patient (5.6%) in the interfascial group developed transient frontalis paralysis ($P = 0.272$). No permanent frontalis paralysis was observed. Obvious temporal hollowing occurred in 18.2% of patients in the suprafascial group without the muscle cuff, in 64.3% of patients in the suprafascial group with the muscle cuff, and in 72.7% of patients in the interfascial group ($P = 0.003$).

Conclusion: The suprafascial dissection technique does not cause permanent injury of the FTFN, and this approach results in a significantly lower incidence of postoperative temporal hollowing than interfascial dissection, especially without leaving a temporalis muscle cuff.

Keywords: Facial nerve preservation, Frontalis paralysis, Pterional craniotomy, Suprafascial dissection, Temporal hollowing

INTRODUCTION

The two-layer technique of scalp flap creation for pterional craniotomy gives better exposure of the pterion and sphenoid rim compared with the one-layer technique (myocutaneous flap) wherein the muscle bulge blocks the visualization of these area.^[26] However, many studies reported that the two-layer technique carried the risk of injury to the frontotemporal branch of the facial nerve (FTFN), which runs just beneath the galea aponeurotica and above the temporal fascia, which

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separates into superficial and deep layers with the interfascial fat pad at the anteroinferior part [Figure 1].^[3,6,7,17,26]

Therefore, many researchers advise against dissection in the plane between the galea aponeurotica and the temporal fascia, known as suprafascial (subgaleal) dissection. Subsequently, several techniques were developed to protect the FTFN during pterional craniotomy such as interfascial and subfascial dissection techniques [Figure 1].^[5,6,10,17,18,20,26] The frontal ramus, which is a branch of the FTFN, innervates the frontalis muscle. Injury to the nerve can cause facial asymmetry and the inability to elevate the ipsilateral eyebrow.^[3]

In 1998, Salas *et al.* studied the anatomy of the FTFN in cadavers and suggested that when only the zygomatic process of the frontal bone needs to be exposed (pterional craniotomy), it is not necessary to perform interfascial dissection and that interfascial dissection is indicated when the zygomatic bone or zygomatic process of the temporal bone needs to be exposed (zygomatic arch osteotomy or orbitozygomatic osteotomy). However, the clinical results were not reported.^[18]

Postoperative frontalis paralysis and temporal hollowing are also common complications after pterional craniotomy. Temporal hollowing is reported to occur after 87–100% of temporal craniotomies.^[12,16,19,24,25] In plastic (facial bone) surgery, the incidence of temporal hollowing is lowest when the suprafascial (subgaleal) plane was used (called suprafascial dissection by the authors) for the creation of the bicoronal flap without the risk of postoperative frontalis

paralysis [Figure 1].^[14,25] When the authors harvested the frontal branch of the superficial temporal artery from the inner side of the scalp flap for double-barrel superficial temporal artery–middle cerebral artery bypass, the suprafascial plane was routinely dissected before harvest. The authors found that a minority of patients developed postoperative frontalis paralysis, which resolved completely within 3 to 4 months. In addition, the authors followed the approaches of Salas *et al.*,^[18] Vaca *et al.*,^[25] Matic and Kim,^[14] Takeuchi *et al.*,^[23] Matsukawa *et al.*,^[15] and Katsuno *et al.*^[11] and routinely performed the pterional craniotomy using the suprafascial dissection technique for vascular and tumor surgery.

This study aims to show the incidence of postoperative frontalis paralysis and temporal hollowing after pterional craniotomy using the suprafascial and interfascial dissection techniques.

MATERIALS AND METHODS

Between November 2015 and September 2018, we retrospectively reviewed patients who underwent pterional craniotomy using suprafascial and interfascial dissection techniques for cerebrovascular or tumor surgery.

Exclusion criterion was (1) Bilateral pterional craniotomy; (2) Previous ipsilateral facial weakness; (3) Orbitozygomatic osteotomy; (4) Ipsilateral re-craniotomy; (5) Extensive removal of lateral orbital wall; (6) Indirect bypass using temporalis muscle; (7) Muscle patch graft or fascia taken from the ipsilateral temporalis muscle; and (8) Patients loss to follow-up from the outpatient clinic within 9 months after surgery. Most procedures were performed with suprafascial dissection. The indication for interfascial dissection was to teach residents this widely used technique.

Surgical techniques for suprafascial dissection

Scalp incision with superficial temporal artery preservation was performed just above the root of the zygoma [Figure 2a]. The scalp flap was created just above the temporal fascia (using sharp dissection or gauze dissection) and through the loose areolar tissue plane with the preservation of pericranium. Just above the temporal fascia, the loose areolar tissue and subgaleal (suprafascial) fat pad were dissected together with the scalp flap without separation (dissection just beneath the suprafascial fat pad) until the frontozygomatic process was reached (identified by palpation) [Figure 2b]. The meticulous dissection of the suprafascial fat pad and the loose areolar tissue together with the scalp flap is the key to suprafascial dissection. The fibro-fatty tissue, which is located above the anteroinferior one-third area of the temporalis muscle, should not be violated. In this step, the temporal fascia was not incised (as performed in the interfascial and subfascial techniques),

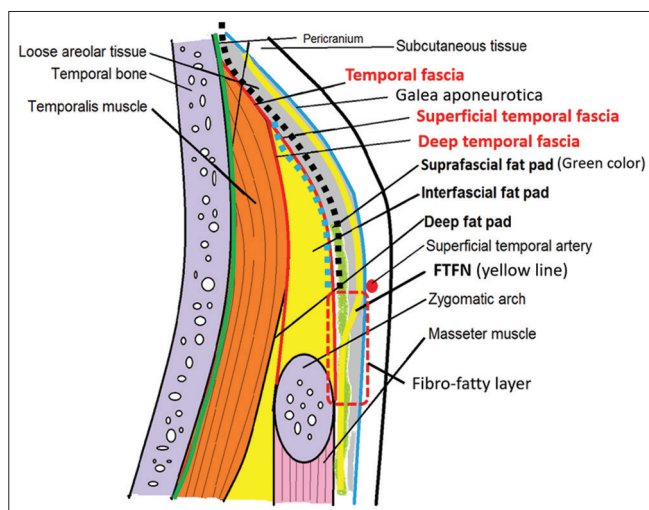


Figure 1: Schematic depiction of the anatomy of the temporal area in the coronal section and course of frontotemporal branch of the facial nerve. The area of the fibro-fatty layer is shown in the red dashed box. The planes of suprafascial dissection and interfascial dissection are indicated by the black dotted line and blue dotted line, respectively.

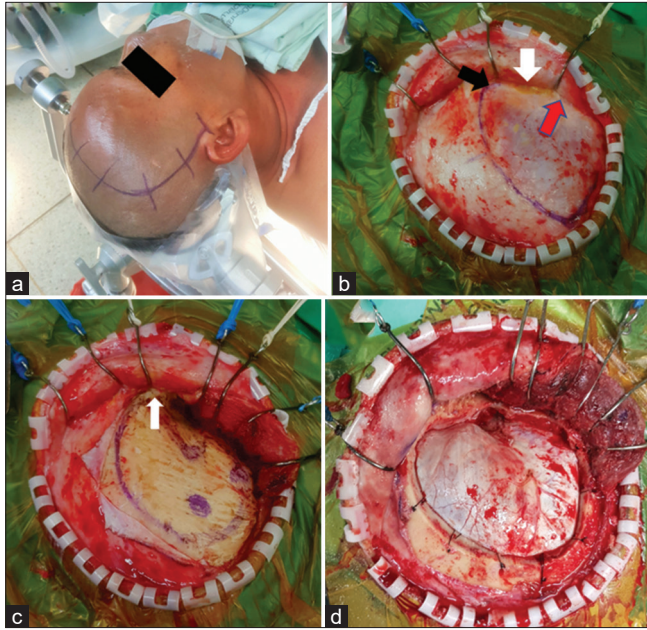


Figure 2: The suprafascial dissection without muscle cuff for right pterional craniotomy. (a) Skin incision. (b) Scalp flap was elevated through the suprafascial plane. Suprafascial fat pad (white arrow) was elevated together with scalp flap until the frontozygomatic process (black arrow) was reached without violation to the fibrofatty adhesion (red arrow). The temporal line was marked with marker pen. (c) The temporalis muscle was elevated from the skull without a muscle cuff. The temporal fascia was cut along the frontozygomatic process (white arrow). (d) Frontotemporal craniotomy was performed.

and the interfascial fat pad was not exposed (as performed in the interfascial techniques). The superior half of the posterior aspect of the temporalis muscle was cut and extended along the temporal line. Two techniques were used with and without leaving a cuff of temporalis muscle [Figure 2c and 2d]. With leaving the cuff [Figure 3], a 1-cm width of the temporal fascia lateral to the temporal line was left to the skull.^[20] The temporalis muscle was then elevated from the skull posteroinferiorly to maximally expose the pterion. The temporal fascia was cut along the frontozygomatic process to facilitate the posterior mobilization of the temporalis muscle, and the frontotemporal craniotomy was performed [Figure 2d and 3]. After the operation, the skull flap was placed and fixed to the craniotomy site with skull plates. The temporalis muscle was reattached to the muscle cuff (in case with leaving the muscle cuff) or pericranium (in case without leaving the muscle cuff). The temporal fascia also reattached to itself along the frontozygomatic process. The scalp flap was closed in the standard manner.

Surgical techniques for interfascial dissection

The technical steps were same as for the suprafascial dissection, without leaving the muscle cuff [Figure 4a],

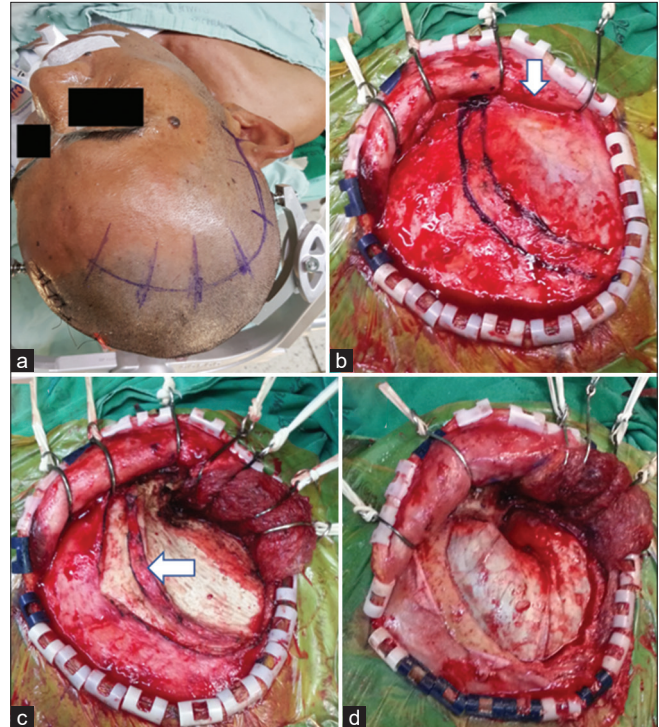


Figure 3: The suprafascial dissection with the muscle cuff for right pterional craniotomy. (a) Skin incision. (b) Scalp flap was elevated through the suprafascial plane. Suprafascial fat pad (arrow) was elevated together with the scalp flap. The temporal line and temporal muscle cuff were marked with marker pen. (c) The temporalis muscle was elevated from the skull, leaving the muscle cuff (arrow) to the skull. (d) Frontotemporal craniotomy was performed.

except for elevation of the scalp flap. Just above the temporal fascia, the galea aponeurosis and the loose areolar tissue were dissected together with the scalp flap until the interfascial fat pad was seen through the superficial temporal fascia without exposure of the subgaleal (suprafascial) fat pad [Figure 4b]. An incision was made along the superficial temporal fascia and pericranium. The superficial temporal fascia and pericranium were elevated from interfascial fat pad and skull, respectively, until the frontozygomatic process was reached [Figure 4c]. The middle temporal veins within the interfascial fat pad were preserved as much as possible. The temporalis muscle was cut and elevated from the skull without leaving the muscle cuff [Figure 4d-f].^[16] After the operation, the skull flap was fixed to the craniotomy site with skull plates. The incised superficial temporal fascia was reattached together, and the temporalis muscle was reattached to the pericranium.

Outcome assessment

The function of the FTFN was assessed by the action of the frontalis muscle immediately or within 1 month after the operation and at the outpatient clinic. Postoperative temporal hollowing was evaluated 6–9 months after surgery. Degrees

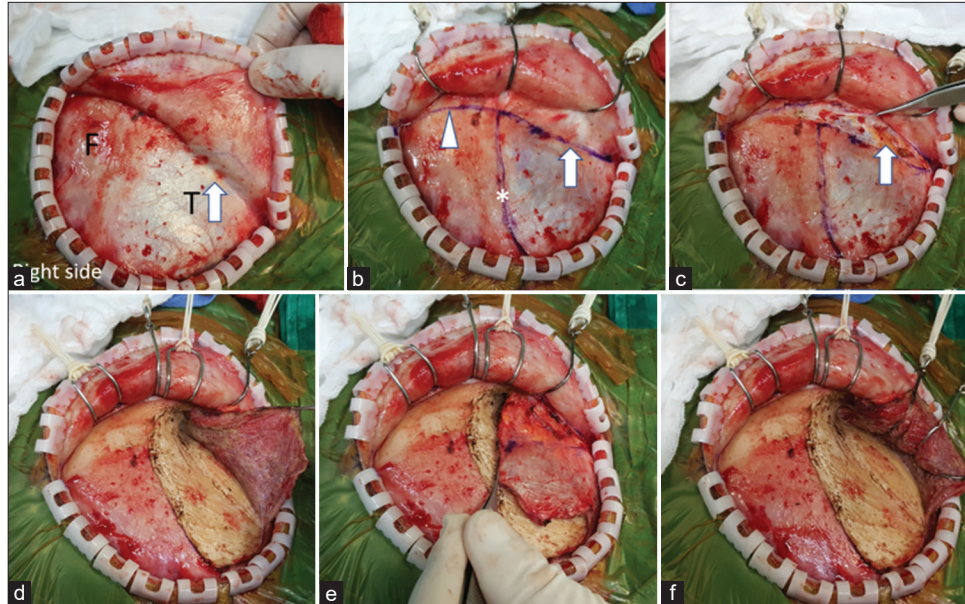


Figure 4: The interfascial dissection for right pterional craniotomy. (a) The scalp flap was elevated through the suprafascial plane until the interfascial fat pad (arrow) was seen through the superficial temporal fascia. (b) The planned fascia (arrow) and pericranial incision (arrow head) were marked with marker pen. The temporal line (asterisk) was also marked. (c) The superficial temporal fascia (grasped with forceps) and pericranium were incised to expose the interfascial fat pad (arrow). (d) The temporalis muscle was incised along the temporal line. (e) The temporalis muscle was elevated from the skull without the muscle cuff. (f) The temporalis muscle was retracted posteroinferiorly with scalp hooks. F: Frontal, T: Temporal.

of temporal hollowing were classified as mild, moderate, and severe by comparison to the nonoperative side in the same patient. Temporal hollowing, which is only observed by closed inspection, was defined as mild. The temporal asymmetry detected at 1 and 2-m from the patient was defined as moderate and severe hollowing, respectively. Obvious hollowing was defined for moderate and severe.

Statistical analysis

Correlations between the postoperative frontalis paralysis, temporal hollowing, and surgical techniques were analyzed. Statistical analysis was performed with SPSS software version 22 for Windows. Study results for categorical measurements and univariate analysis are presented as a percentage (%). Chi-squared/Fisher exact test was used to compare the significance of the study parameters on the categorical scale between the two study groups. Fisher exact test was used when more than 20% of cells had expected frequencies <5. A $P < 0.05$ was considered statistically significant.

RESULTS

A total of 72 patients were included in this study. Fifty-four patients (75%) underwent pterional craniotomy using the suprafascial technique. In this group, the temporalis muscle cuff was left in 21 patients (29.2%) and not left in 33 patients

(45.8%). The interfascial technique without muscle cuff was used in 18 patients (25%) [Figure 1]. No statistical difference was observed in the demographic data between the suprafascial dissection group and interfascial dissection group [Table 1] or between the two suprafascial dissection subgroups [Table 2].

Postoperative frontalis paralysis

Ipsilateral frontalis muscles were evaluated in all patients immediately or within 1 month after the operation. In the suprafascial group, frontalis paralysis was not detected in 43 patients (79.6%) [Figure 5]; however, 11 patients (20.4%) developed frontalis paralysis [Table 3]. All of these patients completely recovered within 6 months [Table 4] [Figure 6]. No permanent frontalis paralysis was observed in this group. In the interfascial group, frontalis paralysis was detected in 1 patient (5.6%), which resolved completely within 2 months. No statistical difference in postoperative frontalis paralysis was observed between the suprafascial and interfascial groups ($P = 0.272$) [Table 3].

In the suprafascial group, all postoperative frontalis paralysis was transient. The possible times of recovery from paralysis ranged from 1 month to 6 months after surgery. The majority of the paralytic patients (7 in 11 cases; 63.6%) seem to improve within 4 months after the operation [Table 4].

Table 1: Demographic data.

Demographic data	Suprafascial dissection	Interfascial dissection	P-value
Age (years) (%)			0.056
<40	4 (50.0)	4 (50.0)	
41–60	40 (83.3)	8 (16.7)	
>60	10 (62.5)	6 (37.5)	
Gender			
Female: Male	38:16	12:6	0.768
Surgical side			
Right: Left	29:25	10:8	0.891
Diagnosis			
Vascular: Tumor	42:12	15:3	0.746
Total	54	18	

Table 2: Demographic data for the suprafascial dissection group.

Demographic data	Suprafascial dissection		P-value
	Not leaving a muscle cuff	Leaving a muscle cuff	
Age (years) (%)			
<40	3 (9.1)	1 (4.8)	0.645
41–60	23 (69.7)	17 (80.9)	
>60	7 (21.2)	3 (14.3)	
Gender			
Female: Male	24:9	14:7	0.634
Surgical side			
Right: Left	16:17	13:8	0.335
Diagnosis			
Vascular: Tumor	27:6	15:6	0.371
Total	33	21	

Table 3: Number of patients with postoperative frontalis paralysis.

	Dissection technique		P-value
	Suprafascial technique (n=54)	Interfascial technique (n=18)	
Postoperative frontalis paralysis	11 (20.4%)	1 (5.6%)	0.272

Postoperative temporal hollowing

Among 54 patients who underwent the suprafascial dissection technique, 36 patients (66.7%) were also monitored for postoperative temporal hollowing at 6–9 months after the operation. In this group, 14 patients (66.7%) in the muscle cuff-on subgroup and 22 patients (66.7%) in the muscle cuff-off subgroup met the follow-up criteria [Figure 7]. Postoperative suprafascial dissection cases with a range from no temporal hollowing to severe temporal hollowing were photographed as shown in [Figures 8-11]: no hollowing [Figure 8], mild [Figure 9], moderate [Figure 10]

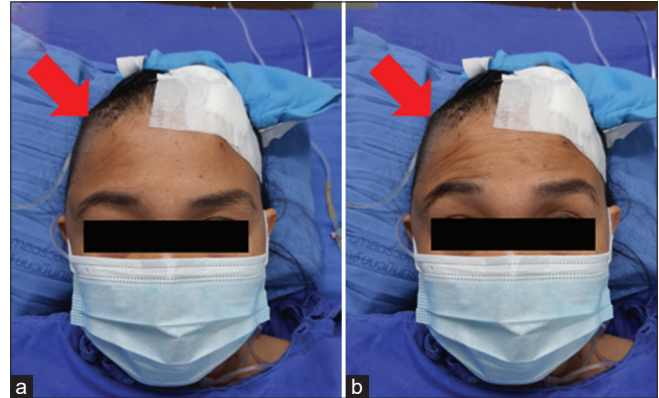


Figure 5: Suprafascial dissection was performed for right pterional craniotomy. Postoperative frontalis paralysis was not detected within 7 days after surgery: (a) at rest; (b) bilateral eyebrow elevation.

and severe [Figure 11]. Obvious (moderate and severe) temporal hollowing occurred in patients with temporalis muscle elevation with the muscle cuff-off (18.2%), with the muscle cuff-on (64.3%), and overall (36.1%) [Table 5]. Among 18 patients in the interfascial group, 11 patients (61.1%) were monitored for postoperative temporal hollowing at 6–9 months postoperatively [Figure 7]. Obvious temporal hollowing occurred in 8 patients (72.7%) [Table 5] [Figure 12].

Statistical difference was demonstrated between the suprafascial and interfascial groups ($P = 0.03$) [Table 6]. Suprafascial dissection resulted in significantly less incidence of obvious temporal hollowing compared with interfascial dissection. In the suprafascial group, statistical difference was demonstrated between the two muscle cuff subgroups: cuff-on and cuff-off ($P = 0.005$) [Table 7]. Therefore, retaining the muscle cuff (cuff-on) resulted in a significantly higher incidence of obvious temporal hollowing compared with the cuff-off dissection.

DISCUSSION

Anatomy of the FTFN

The facial nerve exits the stylomastoid foramen, crosses the mandible at approximately 2.5 cm below the zygomatic arch, and enters the parotid gland where it divides into the frontal (temporal or frontotemporal), zygomatic, buccal, marginal mandibular, and cervical branches. The FTFN exits the parotid gland and runs anterosuperiorly to cross the zygomatic arch at approximately 2 cm from the tragus and gives three main rami: the auricularis (posterior rami), frontalis (middle rami, also known as the frontal branch), and orbicularis (anterior rami). The frontal (middle) rami innervate the frontalis muscle, which elevates the ipsilateral eyebrow.^[6,22]

Table 4: Postoperative timelines for the 11 patients with postoperative frontalis paralysis in the suprafascial group.

Case No.	Frontalis paralysis after operation					
	Immediate or <1 month	2 months	3 months	4 months	5 months	6 months
1	Y	–	Y	–	N	–
5	Y	–	Y	–	–	N
11	Y	N	–	N	–	N
12	Y	–	N	–	–	–
17	Y	N	–	–	N	–
29	Y	–	–	N	–	–
31	Y	–	–	–	N	–
46	Y	–	N	–	–	–
48	Y	–	–	N	–	–
52	Y	N	–	–	–	–
54	Y	–	Y	–	–	N

–: not follow up; N: No; Y: Yes

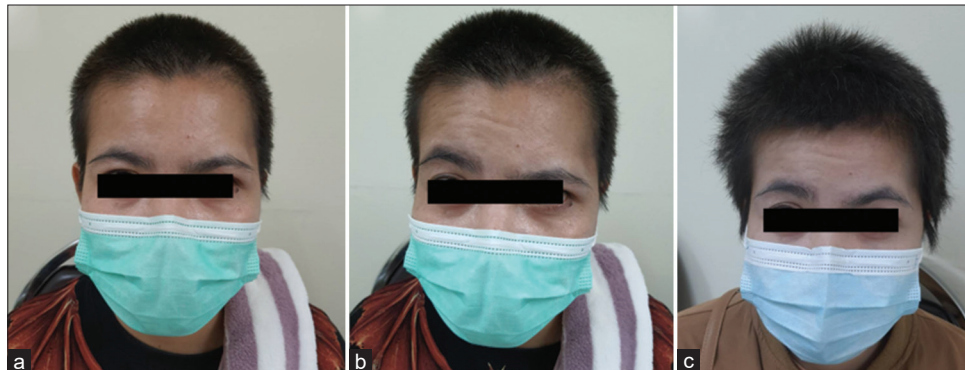


Figure 6: Suprafascial dissection caused transient left frontalis paralysis: (a) at rest and (b) bilateral eyebrow elevation; (c) complete recovery was detected within 2 months after surgery.

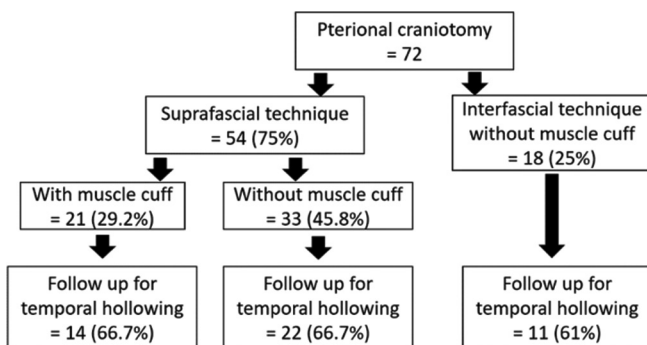


Figure 7: Groups of study patients underwent pterional craniotomy with suprafascial and interfascial techniques.

At the level of the zygomatic arch, the FTFN crosses in the fibro-fatty layer underneath the galea aponeurotica (also called temporoparietal fascia). The fibro-fatty layer, which is the fibrous adhesion of the galea, suprafascial (subgaleal) fat pad, loose areolar tissue and superficial temporal fascia, is located above the anteroinferior one-third of the temporalis muscle (3 cm posterior to the frontozygomatic process and 2.3 cm above the root of zygoma). This fibrous adhesion

between the galea and superficial temporal fascia makes the separation of the two layers difficult and results in high risk of injury to the FTFN. Therefore, the elevation of the galea and skin from the superficial temporal fascia in this area should be avoided to minimize the risk to the FTFN [Figure 1].^[7,18]

Superior to the fibro-fatty layer, the FTFN runs just underneath the galea aponeurotica, courses superficially to the loose areolar tissue and suprafascial (subgaleal) fat pad, and runs anterosuperiorly to innervate the frontalis muscle. In this area, the plane between the galea and superficial temporal fascia is separated by loose areolar tissue without adhesion, which makes the elevation of the galea and the loose areolar tissue from the superficial temporal fascia easy with minimal risk of FTFN injury.^[7,17,18] The FTFN runs parallel and within 1 cm caudal to the frontal branch of the superficial temporal artery [Figure 1].^[6]

Many tissue layers and cleavage planes exist beneath the FTFN. From the superficial to deep layer in the area superior to the fibro-fatty tissue, the loose areolar tissue, subgaleal (suprafascial) fat pad, superficial temporal fascia, interfascial (intrafascial) fat pad, deep temporal fascia, subfascial (deep) fat pad, and temporalis muscle are arranged subsequently

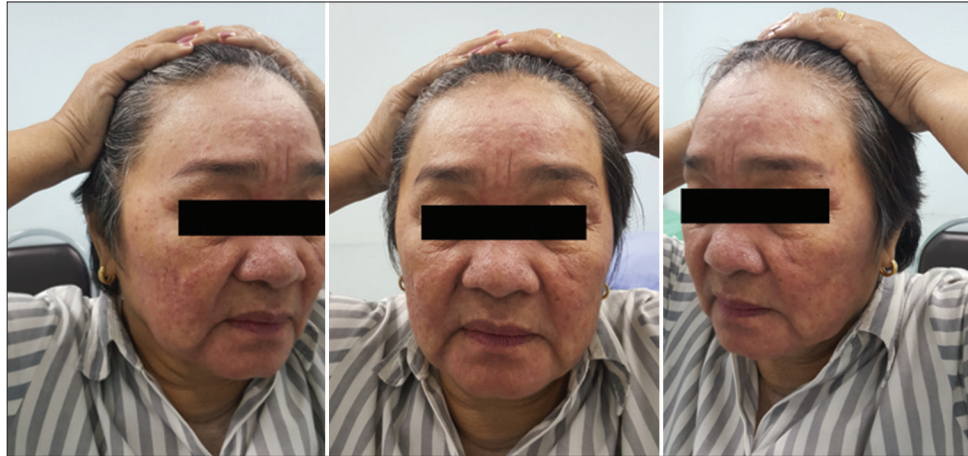


Figure 8: Suprafascial dissection without the temporal muscle cuff was performed for right pterional craniotomy. No temporal hollowing was detected at 6 months after the operation.



Figure 9: Suprafascial dissection without the temporal muscle cuff was performed for left pterional craniotomy. Mild temporal hollowing at the left was detected at 9 months after the operation.



Figure 10: Suprafascial dissection without the temporal muscle cuff was performed for left pterional craniotomy. Moderate temporal hollowing at the left was detected at 6 months after the operation.

above the skull. Many techniques for scalp flap elevation, such as subfascial, interfascial, and suprafascial (subgaleal)

dissection, have been proposed to protect the FTFN [Figure 1].^[7]



Figure 11: Suprafascial dissection with the temporal muscle cuff was performed for right pterional craniotomy. Severe temporal hollowing at the right was detected at 6 months after the operation.



Figure 12: Interfascial dissection without the temporal muscle cuff was performed for right pterional craniotomy. Severe temporal hollowing at the right was detected at 8 months after the operation.

Table 5: Postoperative temporal hollowing at 6–9 months after surgery.

Techniques	Temporal hollowing (patients) (%)		
	No	Mild	Obvious
Suprafascial technique			
Leaving a muscle cuff (<i>n</i> =14)	1 (7.1)	4 (28.6)	9 (64.3)
Not leaving a muscle cuff (<i>n</i> =22)	5 (22.7)	13 (59.1)	4 (18.2)
Overall (<i>n</i> =36)	6 (16.7)	17 (47.2)	13 (36.1)
Interfascial technique			
Not leaving a muscle cuff (<i>N</i> =11)	2 (18.2)	1 (9.1)	8 (72.7)

Table 6: Obvious temporal hollowing after suprafascial and interfascial dissections.

	Dissection techniques (%)		<i>P</i> -value
	Suprafascial technique (<i>n</i> =36)	Interfascial technique (<i>n</i> =11)	
Obvious temporal hollowing	13 (36.1)	8 (72.7)	0.03

The interfascial and subfascial dissection technique

To maximize the exposure of the pterional area, the two-layer technique of scalp flap creation was needed, but the

risk of FTFN injury remained a concern. In 1987, Yasargil *et al.* first proposed the interfascial technique to protect the FTFN during pterional craniotomy.^[26] Minor modifications to this technique were subsequently developed.^[3-5,17,21,22] However, no clinical outcomes about postoperative frontalis paralysis and temporal hollowing were reported. In 1993, Ammirati *et al.* reported the twigs of the FTFN in the subgaleal space and interfascial space. They suggest that the

Table 7: Obvious temporal hollowing after suprafascial dissections with and without retaining a muscle cuff.

	Suprafascial dissection techniques		P-value
	Leaving a muscle cuff (n=14)	Not leaving a muscle cuff (n=22)	
Obvious temporal hollowing	9 (64.3%)	4 (18.2%)	0.005

subfascial dissection technique provide better protection of the FTFN than the interfascial technique.^[1] Horimoto *et al.*^[10] and Coscarella *et al.*^[6] reported the subfascial dissection technique to protect the FTFN.

The suprafascial dissection technique

Although suprafascial (subgaleal) dissection of the skin flap results in a 30% incidence of ipsilateral frontalis nerve paralysis according to the technical article of Yasargil *et al.*, no clinical data for this technique were provided.^[26] To our knowledge, no clinical study of this technique was found in the neurosurgical field.

In the field of plastic and reconstructive surgery, suprafascial dissection was frequently used for access to the anterior and lateral facial skeleton. In 2008, Matic and Kim performed the prospective randomized controlled trial for postoperative temporal hollowing after bicoronal incision for facial bone surgery. The results were (1) the suprafascial dissection resulted in no postoperative frontalis paralysis and significantly less temporal hollowing (45%) than interfascial dissection (76% for dissection above the interfascial fat pad and 71% for dissection within the interfascial fat pad) at 6 months after surgery, and (2) decreased volumes of interfascial fat pad were negatively correlated with an increase in temporal hollowing severity.^[14] In 2009, Baek *et al.* reported that suprafascial dissection for facial bone surgery results in 2.7% of transient frontalis paralysis without temporal hollowing.^[2] In the field of neurosurgery, the suprafascial dissection was routinely used by some Japanese neurosurgeons for pterional craniotomy but no cosmetic results were reported.^[11,15,23]

Postoperative transient frontalis paralysis

Both postoperative frontalis paralysis, which has an unclear incidence, and temporal hollowing are common complications after pterional craniotomy. In this study, the incidences of frontalis paralysis were 20.4% and 5.6% in suprafascial dissection and interfascial dissection, respectively. The incidence of postoperative frontalis paralysis tended to be higher with the suprafascial technique

than interfascial technique, but no statistically significant difference was observed, which may be due to the small sample size. The natural history of frontalis paralysis was transient and spontaneously resolved within 6 months after the operation. No permanent frontalis paralysis was found after using both dissection techniques. No previous report of postoperative frontalis paralysis after pterional craniotomy was found. The incidence of frontalis paralysis in the suprafascial group of this study (20.4%) was higher than that reported by Matic and Kim^[14] (0%) and Baek *et al.*^[2] (2.7%) which performed facial surgery via the bicoronal flap with the same dissection technique. This may result from differences in surgical procedures and because stronger retraction of the scalp flap was needed in neurosurgical procedures.

With suprafascial and interfascial dissection, postoperative frontalis paralysis was transient. Therefore, the possible mechanism of paralysis is temporary nerve dysfunction (neurapraxia) caused by tissue manipulation during the dissection process and the retraction force of the scalp hooks. In this study, the incidence of frontalis paralysis in the suprafascial group (20.4%), which more than that in the interfascial group (5.6%), may be due to the dissection in the suprafascial plane, which is closer to the FTFN than dissection in the interfascial plane.

Postoperative temporal hollowing

In this study, the incidence of obvious temporal hollowing was significantly high in the interfascial group (72.7%) and the suprafascial group with muscle cuff (64.3%), compared with the suprafascial group without muscle cuff (18.2%). The analysis was separated into two subgroups. In the first subgroup analysis of no muscle cuff-the cuff-off suprafascial group compared with the cuff-off interfascial group-the incidence of temporal hollowing was significantly high in the interfascial group. This indicates that interfascial dissection is the risk factor for temporal hollowing. In the second subgroup analysis of the suprafascial technique-retaining the muscle cuff (cuff-on) compared with not retaining the muscle cuff (cuff-off)-the incidence of temporal hollowing was significantly higher in the cuff-on group. This indicates that retaining the muscle cuff is the other risk factor for temporal hollowing, which corresponds to a previous report by Thiensri *et al.*^[24] These results suggest that the important factors for temporal hollowing are the exposure of the interfascial fat pad (interfascial dissection) and cutting of the anterosuperior part of the temporalis muscle to leave the muscle cuff. The primary cause of temporal hollowing is the atrophy of the interfascial fat pad located at the anteroinferior one-third of the temporalis muscle. Fat pad atrophy can occur by disruption of the suspensory system of the fat pad, which is adherent superficially.^[2,13,14] In this study, dissection beneath the superficial temporal muscle (interfascial dissection) and

cutting the anterosuperior part of the temporalis muscle to leave the muscle cuff (suprafascial dissection with leaving the muscle cuff) usually injure the fat pad and result in a higher incidence of temporal hollowing than suprafascial dissection without leaving the muscle cuff, which preserve the temporal fascia and fat pad.

In this study, suprafascial dissection without leaving the muscle cuff, which does not expose and cut the interfascial fat pad, caused an 18.2% incidence of temporal hollowing. This suggests that the atrophy of the temporalis muscle^[12,16,19,24,25] and suprafascial fat pad also plays a role in temporal hollowing. The incidence of temporal hollowing in this group was lower than rates reported by Matic and Kim^[14] This may result from differences in surgical procedures and the definition of temporal hollowing.

For the interfascial dissection technique for pterional craniotomy, previous reports demonstrated 62–78% incidence of moderate and severe temporal hollowing at 3–6 months after operation which is comparable to this study (72.7%).^[8,12,16] No clinical study of the suprafascial technique for pterional craniotomy was previously reported.

Gonçalves *et al.* performed systematic review and meta-analysis regarding the postoperative frontalis paralysis and temporal hollowing after pterional craniotomy with various modified techniques such as minipterional craniotomy, supraorbital craniotomy, lateral mini-orbitotomy, osteoplastic craniotomy, and subgaleal/myocutaneous dissection. Although these techniques seemed to minimize the postoperative complications, but reduced the size of craniotomy and exposure and required operative time. The suprafascial technique and the role of muscle cuff leaving were not included in this review.^[9]

The indications for the interfascial dissection

Salas *et al.* discovered the fibro-fatty layer located just above the anteroinferior one-third of deep temporal fascia and proposed the appropriate indication for interfascial dissection. When exposure of the zygomatic bone or zygomatic arch is required (zygomatic arch osteotomy or orbitozygomatic osteotomy), interfascial dissection should be performed to protect the FTFN. When exposure of only the frontozygomatic process is required (frontal or pterional approach), interfascial dissection is not necessary, and the suprafascial technique can be performed.^[18] The results of this study confirmed the later suggestion.

Limitations

Relatively high percentage of the transient frontalis paralysis (20.4%) and the incidence of postoperative temporal hollowing (18.2% in the cuff-off group) were the limitations of the suprafascial dissection technique compared to

the interfascial and the one-layer (myocutaneous flap) technique respectively. The exposure of the zygomatic arch for orbitozygomatic osteotomy was another limitation of the suprafascial technique.^[18]

The limitations of this study are its retrospective design, the small number of patients, and the relatively small percentage of patients (61–66.7%) who were followed long term to monitor temporal hollowing. Because most neurosurgeons in our hospital routinely use the one-layer submuscular dissection technique to perform the pterional craniotomy, the number of patients available for this study was small. Many patients in our tertiary center hospital were transferred from another distant hospital, which resulted in the high rate of patients lost to follow-up. Another limitation is that the esthetic outcomes from the patient's opinion was not evaluated in this study.

CONCLUSION

The suprafascial dissection technique does not cause the permanent injury of the FTFN and results in a significantly lower incidence of postoperative temporal hollowing than the interfascial dissection, especially without leaving a temporalis muscle cuff.

Declaration of patient consent

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

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Conflicts of interest

There are no conflicts of interest.

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