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Maxillary-fronto-temporal approach for removal of recurrent malignant infratemporal fossa tumors: Anatomical and clinical study

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A B S T R A C T

Purpose: For recurrent malignant tumors occurring in the infratemporal fossa, it is difficult to select a proper surgical approach. We explore the efficiency of a new approach for removal of recurrent malignant tumors involving the infratemporal fossa based on the measurement on three-dimension CT, observation of six cadaveric specimens, and our surgical experience.
Materials and methods: The distances between the surgical landmarks in the infratemporal fossa were measured using CT data to determine the safe distance. And anatomy observation was examined on 6 formalin-fixed cadaveric specimens. Data from seven patients with recurrent malignant infratemporal fossa tumors were retrospectively analyzed.
Results: The mean distance of the medial pterygoid plate from the zygoma was 52.12 mm. The maxillary artery can be found between the deep surface of the condyle and the sphenomandibular ligament, with mean distance of 8.25 ± 3.22 mm to the inferior border of the capsule of the temporomandibular joint. All tumors got gross resection using the maxillary-fronto-temporal approach with minor complication.
Conclusions: The advantages of the new approach include adequate protection of facial nerve with extended operation field; the exposed temporal muscle could be used to fill the dead space. This technique is especially useful to remove recurrent malignant infratemporal tumors safely.

1. Introduction

Malignant tumors in the infratemporal fossa (ITF) close to the carotid artery and IX–XII cranial nerves, are difficult to remove en bloc (Bilsky et al., 2005; Fisch, 1982; Koutsimpelas et al., 2010). Several approaches have been described to resect tumors transgressing the ITF, including the Fisch C and subtemporal-preauricular ITF, transmandibular, Weber-Fergusson and facial degloving approach (Anand, 1999; Bilsky et al., 2005; Fisch, 1982; Hirano et al., 1996; Jian et al., 1998; Shahinian et al., 1999). In recurrent malignant cases, scars often obscure the border between the tumor and normal tissue. The altered anatomical structures increase the risk of damaging the important structures (carotid artery & IX–XII cranial nerves) during the operation (Aktas et al., 2013; Chatni et al., 2009). It is difficult to control the depth to ensure the safety of the operation because of the obstacle of the changed structure. In this paper, we describe a new approach to ITF based on the measurement on three-dimension CT, observation of six cadaveric specimens, and our experience of recurrent ITF tumor resections using this approach.

2. Materials and methods

In recurrent tumors of the ITF, the medial side of the fossa cannot be visualized directly and the difficulty in controlling depth of the operation becomes the major surgical obstacle.

A natural plane exists between the medial pterygoid muscle and the superior constrictor muscle. The natural cleavage forms the

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medial boundary for the resection for malignant ITF tumors. The distance of the zygomatic arch from the medial pterygoid plate indicates the distance of the lateral wall of the nasopharynx from the zygoma, which is the safe depth of operation.

2.1. Measurement of distances between the important anatomic landmarks in the ITF

Three-dimensional CT scan data of 30 adults without skull base lesions were used to measure the distances between the surgical landmarks in the ITF (Tiwari 1998; Yu et al., 1998). Since the zygomatic arch was the most superficial bony landmark and was almost always exposed in the surgery of the infratemporal fossa, we used it as the fixed point to measure distances to get the data for safe operation depth, measuring outer border of zygomatic arch to the medial pterygoid plate (Fig. 1).

2.2. Observation of the contents of ITF on cadaveric specimens

As part of the preparation for undergraduate anatomy teaching, dissections using the designed approach (MFT) were performed on six sides of six formalin-fixed cadavers in order to observe the ITF contents. The skin incisions followed the Weber-Fergusson approach and curved superiorly at the lateral canthus, and posteriorly along the supratemporal line to the temporal scalp. The skin flap was elevated deep to the superficial layer of the deep temporal fascia, to protect the zygomatic/temporal branch of the facial nerve. In order to expose the infratemporal fossa, the zygomatic arch was transected with the masseter muscle reflected downward. The coronoid process was resected with the temporalis muscle retracted superiorly (Fig. 2). At this stage, the medial and lateral pterygoid muscles, the maxillary artery, the pterygoid venous plexus and the mandibular nerve could be observed (Fig. 3).

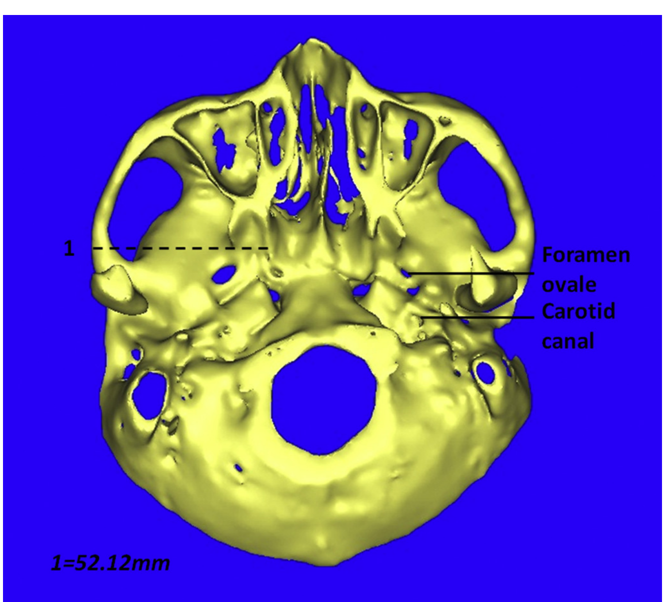

Fig. 1. View of skull base of three-dimensional CT, showing measurements made and their relationship to important landmarks. The picture shows distance of medial pterygoid plate from the zygomatic arch in millimeters.

2.3. Patient population

Between 2003 and 2011, the senior author performed recurrent malignant ITF tumor resection on 7 patients (4 males, 3 females) using the MFT approach. The presenting symptoms most commonly included facial swelling, trismus, and pain or anesthesia arising from the maxillary division of the trigeminal nerve. The epicenter of tumor site, as judged radiographically, was the maxillary sinus ($n = 1$) and ITF ($n = 6$). Computed tomographic (CT) scans were obtained in all patients, and magnetic imaging scans were obtained in three patients. The median tumor diameter, as measured via preoperative imaging and intraoperative observation, was 5 cm (range, 3–6 cm).

2.4. Surgical technique

The anterior approach (transmandibular) and the lateral approach (subtemporal-preauricular ITF) were the most frequently used approaches for the primary ITF tumor resection in this series. However, the resection of recurrent tumors could not be performed readily using the previous operative approaches as the previous surgery had destroyed the normal structures. The recurrent tumor was usually too high and deep (close to orbital apex and pterygopalatine fossa). We extended the Weber-Fergusson incision to the temporal area to design the maxilla-front-temporal (MFT) approach.

2.5. Incision

As noted above, a Weber-Ferguson incision was used, and the incision was curved superiorly at the lateral canthus, and posteriorly along the supratemporal line to the temporal scalp (Fig. 2). The mucosal incision was then extended intraorally along the upper gingivolabial sulcus to the maxillary tubercle. The skin flap was elevated deep to the superficial layer of the deep temporal fascia to protect the zygomatic/temporal branch of the facial nerve.

2.6. Osteotomy & exposure of the ITF

The osteotomised zygomatic arch with the masseter muscle was reflected inferiorly (Fig. 2). Before the osteotomies, titanium microplates were precontoured and predrilled for precise anatomical restoration later. The coronoid process of the mandible was resected and retracted superiorly with the temporalis muscle attached to expose the ITF (Fig. 2). If the tumor occupied the anterior part of ITF, the pterygopalatine fossa, and the orbital floor, the osteotomy consisted of the entire zygomatic complex (Fig. 4). To avoid exposure of the maxillary sinus, the inferior osteotomy of the zygoma was placed as laterally as possible.

If the malignant tumor originated from the maxillary sinus, a subtotal or total maxillectomy was performed.

3. Results

3.1. The measurement from three-dimensional CT data of 30 normal adults

The mean distance of the medial pterygoid plate from the zygoma that indicates the distance of the lateral wall of the nasopharynx from the zygoma in this group of patients was 52.12 mm. The measurements taken from the three-dimensional CT scans of these 30 adults are shown in Table 1.

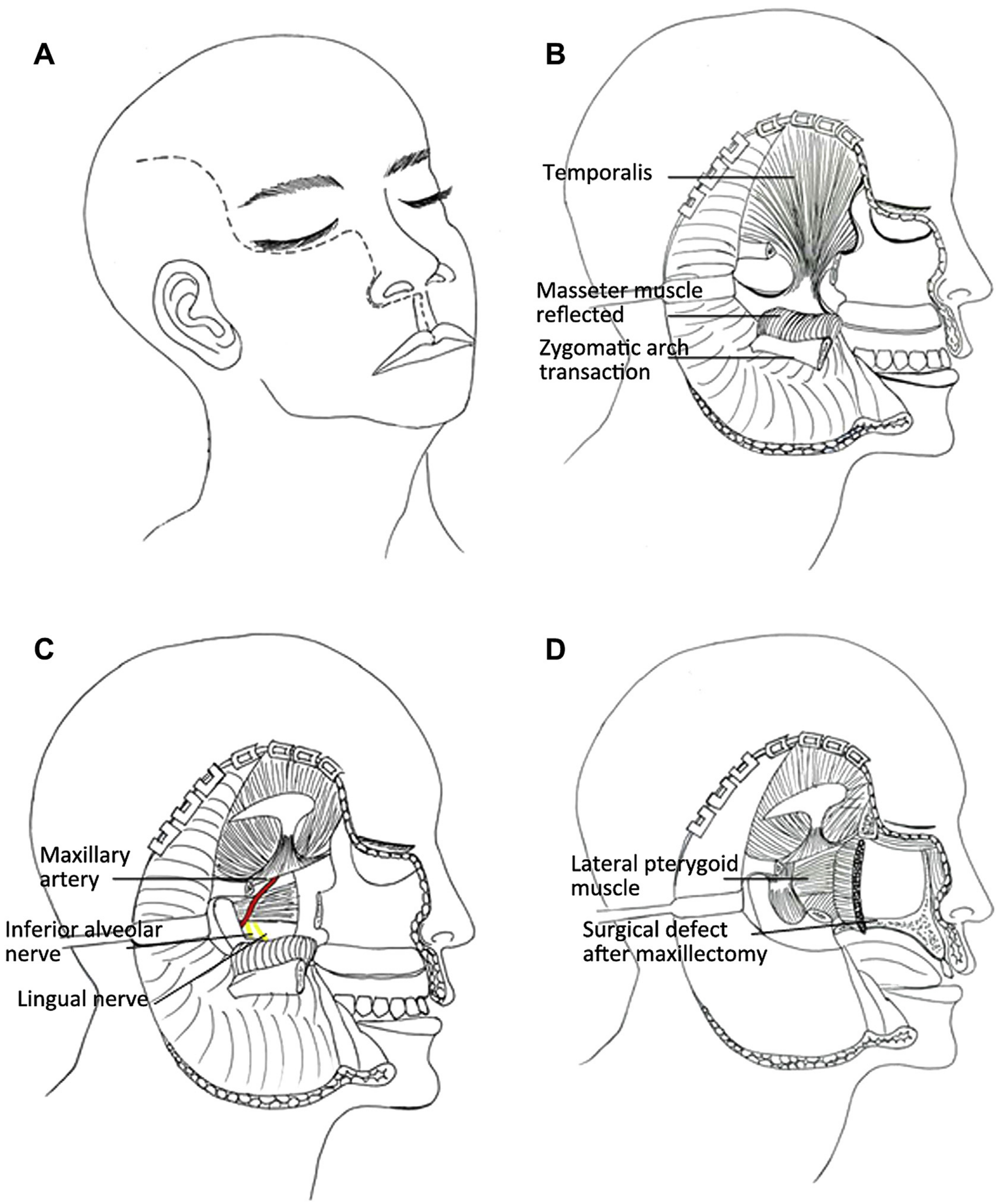

Fig. 2. (A) Design of the operation approach. (B) Zygomatic arch osteotomized with the masseter muscle reflection inferiorly. (C) Coronoidotomy with the attached temporalis muscle retracted superiorly, thus exposing ITF contents. (D) Illustration of the zygomatic arch transaction, coronoid process resection and maxillectomy.

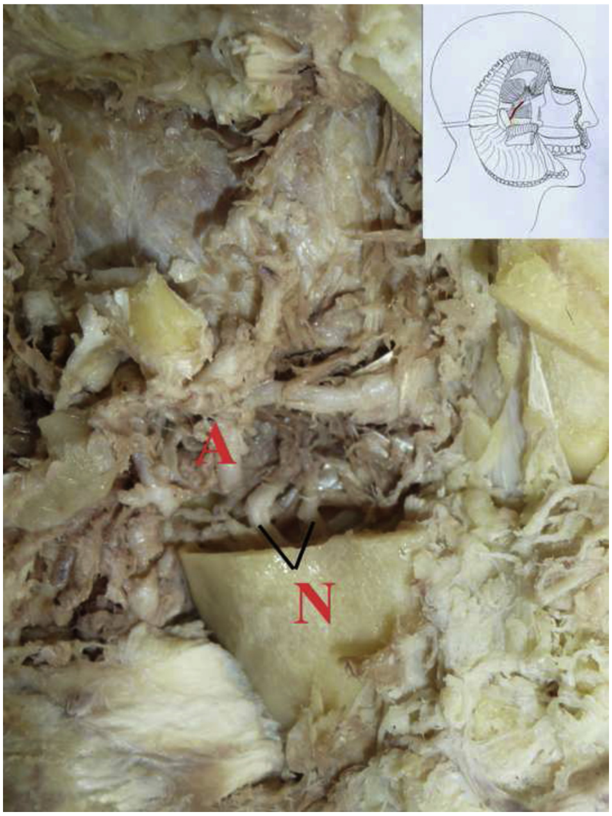

Fig. 3. Observation of ITF on cadaveric specimen shows the maxillary artery, inferior alveolar nerve and lingual nerve.

3.2. The contents of infratemporal fossa

The major structures that occupy the infratemporal fossa are: the lateral and medial pterygoid muscles, the mandiblular division of the trigeminal nerve, the maxillary artery and its branches, and the pterygoid venous plexus. Upon the exposure of ITF as described, the maxillary artery was found between the deep surface of the condyle and the sphenomandibular ligament (mean distance of 8.25 $\pm$ 3.22 mm to the inferior border of the capsule of the temporomandibular joint). It is often difficult to locate the pterygoid venous plexus, which is usually situated around and within the lateral pterygoid muscle in the cadaver. When the mandibular branch of the trigeminal nerve exits the foramen ovale, the middle meningeal artery usually lies 5.17 $\pm$ 2.56 mm postero-laterally. The natural plane between the medial pterygoid muscle and the superior constrictor muscle is separated by a layer of loose areolar tissue – an extension of the buccal fat pad. The natural cleavage forms the medial boundary of the resection for malignant ITF tumors. When surgery extends beyond this boundary, the pharyngeal wall can be easily damaged. The difficulty of reconstruction of such a pharyngeal wall defect can leave the patient confronted with a serious complication.

3.3. Clinical results

Two cases had positive margins, and other 5 patients had complete resection. The osteotomy pattern and the reconstruction of defects are shown in Table 2 and Table 3. The median amount of bleeding was less than 450 ml/operation in this series. Clinical follow-up was performed on all patients at regular intervals, including radiographic scan at 3- to 6-month intervals or as clinically indicated.

Three patients received postoperative radiation (in other hospitals), and the median radiation dose was 65 Gy (60–70 Gy).

Chewing problems, consisting of TMJ pain and reduced mouth opening, were found in three patients. Moderate cosmetic disfigurement was observed in all 6 cases with temporal muscle flap reconstruction. Postoperative temporal hollowing could be covered with the grown hair (Fig. 4). All patients had weakness of the affected frontal muscle, but at immediate and long-term (mean time $>$ 3 years) follow-up no patients in our series were found to have lower eyelid retraction, ectropion, or corneal ulceration. No patient died during the perioperative period.

4. Discussion

Malignant tumors originating from the skull base region have the lowest survival rates because there is not enough space for extensive resection (Schalch et al., 2010; Sekhar et al., 1987). The majority of patients with skull base sarcoma will succumb to local recurrence to vital structures, such as the carotid arteries, cavernous sinus, and brain (Gil et al., 2007). The anterior approach (transmandibular) and the lateral approach (subtemporal-preauricular ITF) were the most frequently used approaches for resecting primary ITF tumors in our unit. In this series, recurrent tumors were usually found at the anterior segment of the ITF, next to the skull base. The altered anatomical structures make it difficult for the operator to control the operation depth and carries the risk of neurovascular injury.

The extended incision allowed exposure of the entire ITF and easily ligation the maxillary artery without causing major bleeding. From our observation, the maxillary artery can be found between the deep surface of the condyle and the sphenomandibular ligament, with mean distance of 8.25 $\pm$ 3.22 mm to the inferior border of the capsule of the temporomandibular joint.

The outer border of the root of the zygomatic arch is a fixed landmark, invariably exposed in almost all surgical procedures in the ITF area, and is also easily palpable (Tiwari, 1998). With the anatomical distortion present with recurrent malignant tumor patients, it was difficult for the surgeon to control the operation depth, especially when the tumor had destroyed the pterygoid plates. Blind manipulation could easily include the nasopharyngeal wall in the resection by mistake, which is difficult to repair (Aktas et al., 2013; Moxham and Berkovitz, 2003). The communication between the nasopharyngeal space and the skull base could easily contaminate the operation field, which could cause serious infection in the intercranial communication tumor case. Thus understanding the safe distance for surgical manipulation is very important (Bao et al., 2006).

The superior constrictor muscle of the pharynx and the fibrous raphe forming the lateral layers of the wall of the nasopharynx have attachments to the medial pterygoid plate (Sabit et al., 2002). Therefore, the distance of the medial pterygoid plate from the zygoma indicates the distance of the lateral wall of the nasopharynx from the zygoma, whose mean distance was 52.12 mm according to our measurement. The natural plane between the medial pterygoid muscle and the superior constrictor muscle forms the medial boundary of the resection for malignant ITF tumors.

In our series, there was one maxilla malignant tumor with extension into the ITF, which required resecting of the maxilla

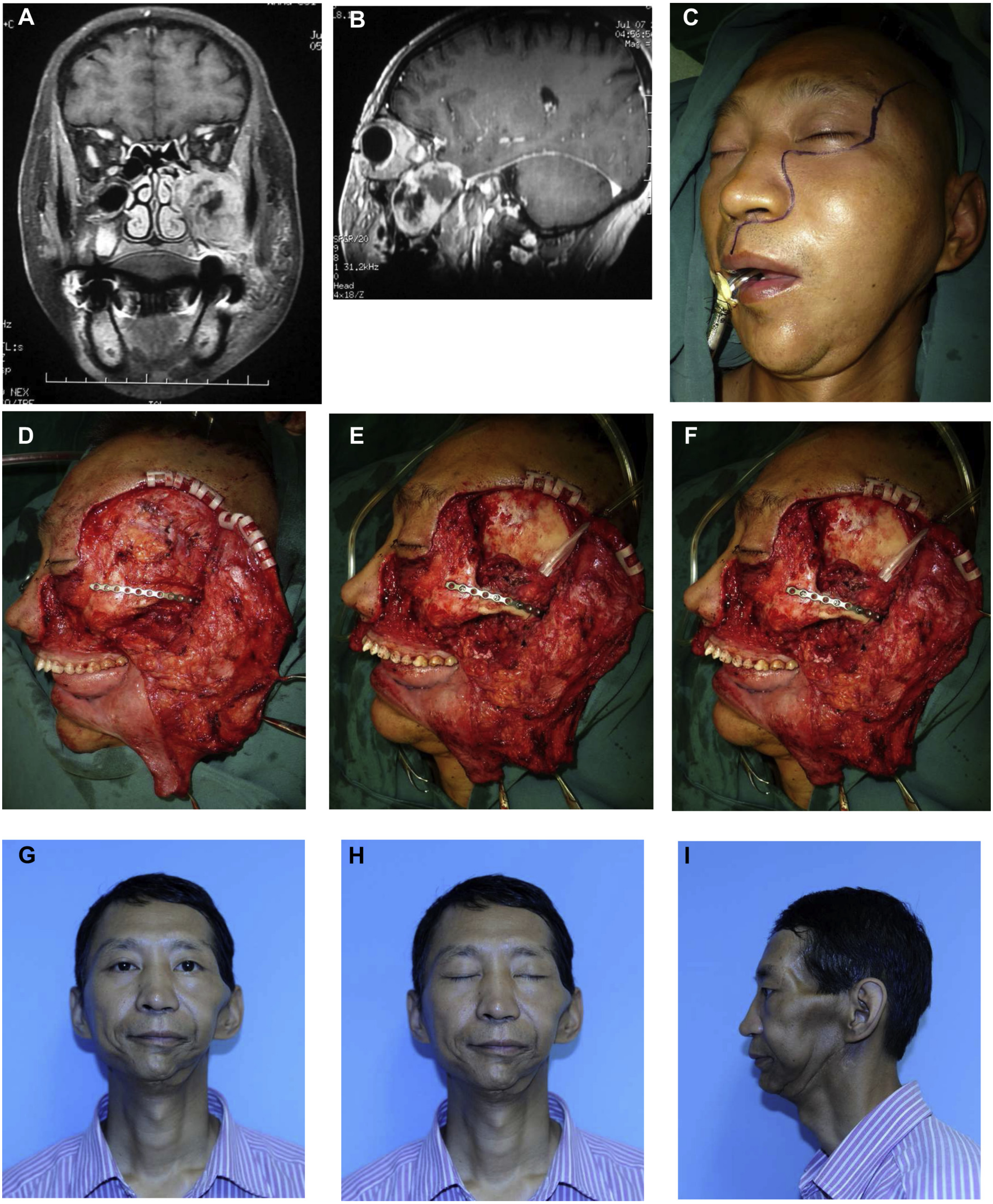

Fig. 4. Case5: A 43-year-old male with recurrence of primary mandible ameoblastoma, and last operation had removed the tumor with the pathology report of ameloblastic carcinoma. (A and B) Coronal image of magnetic resonance demonstrated that the tumor had involved the entire ITF space adjacent to orbital apex. (C) Design of the operation approach. (D) Precontoured fixation of zygomatic arch. (E) Temporalis myofascial flap is used to fill dead space. (F) Restoration of zygomatic arch and dead space pack with temporalis myofascial flap. (G–I) The close eyes function and the facial appearance after 1 year of operation.

Table 1
Measurement results of distances in the ITF in 30 adult human skulls of three-dimensional CT (mm).

Skull specimen	Distance between zygoma and LPP	Distance between zygoma and MPP	Distance between LPP and MPP
1	41.90	48.95	11.05
2	42.47	52.34	11.87
3	43.17	54.81	12.39
4	43.8	54.97	13.26
5	41.32	51.68	13.10
6	41.52	50.10	8.67
7	46.38	58.17	12.93
8	39.73	49.49	12.22
9	45.14	56.26	12.31
10	38.27	48.66	10.89
11	46.59	55.04	9.04
12	42.49	50.91	8.66
13	41.69	51.79	12.14
14	40.12	51.12	12.19
15	40.56	50.58	15.88
16	43.71	52.17	9.19
17	42.67	50.06	7.42
18	49.14	61.42	15.37
19	39.91	47.47	9.44
20	40.10	51.84	12.76
21	41.25	48.47	9.77
22	38.46	48.58	10.73
23	39.91	51.32	12.81
24	41.47	51.69	13.22
25	41.33	48.98	7.83
26	43.54	54.61	12.51
27	44.34	54.15	10.86
28	41.28	52.57	12.10
29	42.40	52.16	9.84
30	42.59	53.34	12.23
Maximum distance	46.38	61.42	15.88
Minimum distance	38.27	47.47	7.42
Mean distance	42.24	52.12	11.42

LPP, lateral pterygoid plate; MPP, medial pterygoid plate.

and also pterygoid plates. The maxillary bone hindered the direct visualization of the posterior border of the tumor, which usually led to incomplete removal of the diseased tissue. Using the MFT approach, the extended temporal incision with the osteotomy of the zygomatic arch and coronoid osteotomy can help identify the maxillary artery, allowing ligation to reduce bleeding. The clear exposure of ITF can help the surgeon remove the pterygoid plates and maxilla together safely (Fig. 2). Some authors introduced modification of Weber-Fergusson approach to extend the incision to the auricle from the lateral canthus. The horizontal extension can help enlarge the operation field, but the incision can easily damage more branches of facial nerve with an obvious scar and removal of option to use temporalis myofascial flap.

There are many potential complications which are common to any ITF approach. An international collaborative study from 17 institutions involving 1193 patients with malignant tumors of the skull base reported an overall complication rate of 36.3% (Ganly et al., 2005). During surgical resection of skull base pathology, it is important not to remove too much soft tissue exposing bare bone. Without enough tissue protection, postoperative adjuvant radiotherapy can lead to serious osteoradionecrosis of the skull base (Wei and Ng, 2007). The maxillectomy defect could be reconstructe by a rectus abdominis muscle flap and forearm flap. The temporal muscle flap can be used to repair the defect in cases without maxillectomy (Michaelidis and Hatzistefanou, 2011). Most skull base surgeons worry that the extended incision would injure the facial nerve, causing serious complication affecting the eye function. The protection of the zygomatic/temporal branch can be achieved by careful dissection deep to the superficial layer of the deep temporal fascia (Hwang, 2010; May, 2000).

Table 2
Summary of patients data.

Patient	Previous surgery times	Previous adjuvant treatment		X-ray findings				Histological findings
No./age(y)/sex		Radiotherapy	Chemotherapy	ITF	Maxilla	PPF	IC	
1/31/male	2	No	Yes	●			●	Leiomyosarcoma
2/42/male	4	Yes (60 Gy)	Yes	●				Malignant schwannoma
3/56/female	1	No	No	●		●	●	Malignant fibrous histiocytoma
4/66/female	1	No	No	●	●	●		Squamous cell carcinoma
5/43/male	1	No	No	●				Ameloblastic carcinoma
6/50/female	4	No	Yes	●				Osteosarcoma
7/50/male	5	No	Yes	●			●	Osteosarcoma

IC indicates Intercranial communication.

Table 3
Surgical and follow-up results.

Patient	Secondary operation data	Osteotomy pattern	Reconstruction	Complication	Adjuvant treatment		Follow-up	Data of death
no./age(y)/sex					Radiotherapy	Chemotherapy		
1/31/male	Feb-2004	MCO	TMF & RAF	Salivary fistula	No	No	DOD	May-2006
2/42/male	Jun-2003	TM, MCO	TMF	None	No	No	DOD	Jau-2005
3/56/female	Mar-2010	ZAT	TMF	None	Yes (70 Gy)	No	DOD	Sep-2011
4/66/female	Agu-2010	MCO, CPO	RAF	Trismus	Yes (60 Gy)	No	NED	Alive
5/43/male	Agu-2011	ZAT	TMF	None	Yes (65 Gy)	No	NED	Alive
6/50/female	Oct-2011	MCO	TMF	None	No	No	NED	Alive
7/50/male	Nov-2011	ZAT	TMF	None	No	No	NED	Alive

MCO, malar complex osteotomy; TMF, temporalis muscle flap; RAF, rectus abdominis flap; FF, forearm flap; DOD, dead of disease; TM, total maxillectomy; ZAT, zygomatic arch transaction; NED, no evidence of disease; CPO, coronoid process osteotomy.

5. Conclusions

The safe distance (the distance of the lateral wall of the nasopharynx from the zygoma) for surgical manipulation in ITF was 52.12 mm according to our measurement. The advantages of the MFT approach include adequate protection of facial nerve with extended operation field and use of the exposed temporal muscle to fill the dead space.

In conclusion, adequate visualization greatly facilitates complete and safe resection of the ITF tumors.

Conflict of interest

None.

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References

Aktas U, Yilmazlar S, Ugras N: Anatomical restrictions in the transsphenoidal, transclival approach to the upper clival region: a cadaveric, anatomic study. J Craniomaxillofac Surg 41: 457–467, 2013
Bao S, Ni S, Zhang J, Li L, Mo D, Guo C, et al: Treatment of lesions involving both the infratemporal fossa and middle skull base. Surg Neurol 66(Suppl. 1): S10–S17, 2006
Bilsky MH, Bentz B, Vitaz T, Shah J, Kraus D: Craniofacial resection for cranial base malignancies involving the infratemporal fossa. Neurosurgery 57: 339–347, 2005
Chatni SS, Sharan R, Patel D, Iyer S, Tiwari RM, Kuriakose MA: Transmandibular approach for excision of maxillary sinus tumors extending to pterygopalatine and infratemporal fossae. Oral Oncol 45: 720–726, 2009
Fisch U: Infratemporal fossa approach for glomus tumors of the temporal bone. Ann Otol Rhinol Laryngol 91: 474–479, 1982
Ganly I, Patel SG, Singh B, Kraus DH, Bridger PG, Cantu G, et al: Complications of craniofacial resection for malignant tumors of the skull base: report of an International Collaborative Study. Head Neck 27: 445–451, 2005
Gil Z, Patel SG, Singh B, Cantu G, Fliss DM, Kowalski LP, et al: Analysis of prognostic factors in 146 patients with anterior skull base sarcoma: an international collaborative study. Cancer 110: 1033–1041, 2007
Hirano A, Arakaki M, Nishida H, Hamada Y, Fujii T: Hemifacial degloving approach to tumours in the infratemporal and pterygopalatine fossae: a preliminary report. J Craniomaxillofac Surg 24: 285–288, 1996
Hwang K: Surgical anatomy of the lower eyelid relating to lower blepharoplasty. Anat Cell Biol 43: 15–24, 2010
Jian XC, Chen XQ, Wang CX: A surgical approach to extensive tumors in the pterygopalatine fossa extending into the maxillary sinus. J Oral Maxillofac Surg 56: 578–584, 1998
Koutsimpelas D, Mueller-Forell W, Stoeter P, Hey O, Mann WJ: Arachnoid cyst with extraordinary extracranial extension in the skull base as a result of an iatrogenic defect of the middle cranial fossa floor: case report and literature review. J Craniomaxillofac Surg 38: 284–287, 2010
May M: Anatomy for the clinician. In: The facial nerve, 2nd edn. New York: Thieme, 19–56, 2000
Michaelidis IG, Hatzistefanou IM: Functional and aesthetic reconstruction of extensive oral ablative defects using temporalis muscle flap: a case report and a sort review. J Craniomaxillofac Surg 39: 200–205, 2011
Moxham BJ, Berkovitz BKB: Regional and sectional anatomy infratemporal fossa. In: Langdon JD, Berkovitz BKB, Moxham BJ (eds), Surgical anatomy of the infratemporal fossa. Martin Dunitz: Distributed in the USA by Taylor & Francis, 1–27, 2003
Sabit I, Schaefer SD, Couldwell WT: Modified infratemporal fossa approach via lateral transantral maxillotomy: a microsurgical model. Surg Neurol 58: 21–31, 2002
Sekhar LN, Schramm VJ, Jones NF: Subtemporal-preauricular infratemporal fossa approach to large lateral and posterior cranial base neoplasms. J Neurosurg 67: 488–499, 1987
Shahinian HK, Suh RH, Jarrahy R: Combined infratemporal fossa and transfacial approach to excising massive tumors. Ear Nose Throat J 78: 350–356, 1999
Tiwari R: Surgical landmarks of the infratemporal fossa. J Craniomaxillofac Surg 26: 84–86, 1998
Wei WI, Ng RW: Complications of resection of malignant tumours of the skull base: outcome and solution. Eur Arch Otorhinolaryngol 264: 733–739, 2007
Yu Q, Wang P, Shi H, Luo J, Sun D: The lesions of the pterygopalatine and infratemporal spaces: computed tomography evaluation. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 85: 742–751, 1998