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A cadaveric study of a combined trans-mandibular and trans-zygomatic approach to the infratemporal fossa

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Abstract The infratemporal fossa (ITF) is a deep retromaxillary space corresponding to the inferior aspect of the middle cranial fossa. There are numerous surgical approaches, indicating the difficulty of access, accentuated by the communications with the neighboring regions. The aim of this anatomical study was the optimization and photographic demonstration of the pre-auricular infra-temporal trans-zygomatic approach combined with a trans-mandibular approach allowing access to the different regions of the ITF. Six human heads preserved in formalin were dissected under the operating microscope (magnification between ×6 and ×4). Intra-arterial injection of colored silicone had been done in advance. A plastinated hemi-head was conserved as a teaching and training specimen using the S10 silicone technique. After a pre-auricular temporo-cervical incision, skin flaps, the superficial temporalis fascia and the temporal fascia were elevated. The facial nerve and its branches were preserved and the temporal and zygomatic branches were protected by the superficial temporalis fascia. The division of the temporal muscle and osteotomy of the zygomatic arch opened the superior part of the ITF. Osteotomy of the mandibular ramus preserving the division of the mandibular nerve opened the inferior part of the ITF. This was thus perfectly exposed and access was not impeded by the trunk of the facial nerve and its branches. The place of this complex approach is discussed among the principal exocranial surgical approaches to the ITF.

Abord combiné trans-mandibulaire et trans-zygomatique de la fosse infratemporale. Etude cadavérique

Résumé La fosse infra-temporale (FIT) est un espace rétro-maxillaire profond répondant à la face inférieure de la fosse crânienne moyenne. Ses voies d'abord sont nombreuses, ce qui traduit sa difficulté d'accès, accentuée par ses communications avec les régions de voisinage. Le but de ce travail anatomique était l'optimisation et la démonstration photographique de la voie pré-auriculaire infra-temporale trans-zygomatique combinée à un abord trans-mandibulaire permettant le contrôle des différentes sous-régions de la FIT. Six pièces anatomiques céphaliques humaines entières formolées ont été disséquées sous microscope opératoire (grossissement variable de ×6 à ×40). Une injection intra-artérielle de silicone coloré a été préalablement réalisée. Une hémi-tête plastinée a été conservée comme matériel pédagogique et d'entraînement, en utilisant la technique S10 au silicone. Après l'incision pré-auriculaire temporo-cervicale, la dissection séparait le lambeau cutané, le fascia temporalis superficialis et le fascia temporal. Le nerf facial et ses rameaux étaient préservés et les rameaux temporaux et zygomatiques étaient protégés par le fascia superficialis temporalis. La section du muscle temporal et l'ostéotomie de l'arcade zygomatique ouvrait la partie supérieure de la FIT; l'ostéotomie du ramus mandibulaire préservant la division du nerf mandibulaire ouvrait la partie inférieure de la FIT. Celle-ci était ainsi parfaitement exposée et l'accès n'était barré que par le tronc du nerf facial et ses rameaux. La place de cet abord complexe est discutée parmi les principales voies d'abord exo-crâniennes de la FIT.

Keywords Infra-temporal fossa · Zygomatic arch · Mandibular ramus · Facial nerve

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Introduction

The infratemporal fossa is a deep quadrangular space corresponding to the inferior aspect of the middle cranial fossa. It limits are represented anteriorly by the maxillary tuberosity and the maxillary sinus, above by the greater wing of the sphenoid bone and a part of the plate of the temporal bone, medially by the lateral blade of the pterygoid process and the lateral wall of the pharynx, laterally by the temporalis and the mandibular ramus, and below by a horizontal plane passing through the inferior border of the angle of the mandible [10, 17, 19, 21]. The surgical approach to this region requires a precise anatomical knowledge of its contents, its limits and its relationships. Current surgical techniques, notably for the extirpation of voluminous tumors of the base of the skull, have benefited not only from progress in imaging but also from the successive anatomical surgical works of Conley for the trans-mandibular approach [4, 5], Barbosa [1] and Samii [24] for the trans-zygomatic approach and finally, most recently, Fisch [7] for the postero-lateral infra-temporal approaches. Taking inspiration from the surgical techniques of craniomaxillofacial traumatology, in particular those of Obwegeser [18], Sekhar has described a pre-auricular antero-lateral infra-temporal approach [25]. In fact the lateral approach offers a large exposure of the whole of the infra-temporal fossa which is essential for satisfactory extirpation of a tumor but also for reduced functional and cosmetic consequences [23, 26, 29].

The aim of this anatomical study was the optimization and photographic demonstration of the pre-auricular infra-temporal trans-zygomatic approach combined with a trans-mandibular approach, allowing access to the different subregions of the infra-temporal fossa potentially invaded by tumor [21].

Materials and methods

Six anatomical specimens from the University Anatomy Laboratory were studied. The cephalic extremity was sectioned at the level of C6/7 and fixed by immersion in a 5% aqueous formalin for at least 15 days. The common carotid arteries were manually injected with silicone (Biodur, Germany) S10 + S3 (1%) + S2 (3%) + S6 (3%) with red dye AC50 Biodur. Polymerization occurred in 24 h. Twenty cubic centimeters was injected into each carotid artery. No venous injections were done in order not to spoil the field of dissection during sacrifice of veins, particularly during the trans-mandibular approach. A Wild Leitz operating microscope with magnification from ×6 to ×4 aided the dissection. Twelve infra-temporal fossae were thus explored. The principle is demonstrated in Fig. 1. One hemi-head was plastinated and conserved as teaching and training material using the S10 silicone technique [20].

For each specimen, a lateral approach to the infra-temporal fossa was done via a pre-auricular incision extended inferiorly to circumscribe the angle of the mandible and upwards into the temporal frontal region as far as the middle of the superior border of the orbital rim. Photographs were taken with a Nikon AF camera with a 60 mm of objective micro 1:2.8 and the Wild Leitz operating microscope.

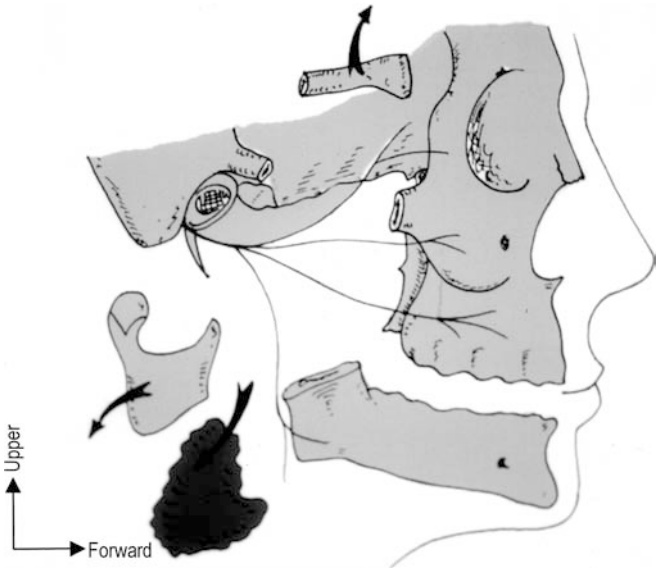

Fig. 1 Principle of the pre-auricular infra-temporal route combining the trans-zygomatic and mandibular approaches

Results

After the pre-auricular incision, the plane of dissection for the cervical facial flap was immediately sub-cutaneous allowing it to be retracted forwards, exposing the superficial temporalis fascia (Fig. 2). From the stylo-mastoid foramen, the trunk of the facial nerve was visualized and its principal branches dissected in their proximal segment. The superficial arteries and veins were also identified. The superficial temporalis fascia was then separated from the subjacent temporal fascia and retracted forwards in its turn. During this maneuver, the temporal and zygomatic branches of the facial nerve, which became superficial, were accurately identified (Fig. 3). The dissection and retraction forwards of the superficial temporalis fascia allowed effective protection of these branches of the facial nerve during the surgical technique.

After elevating the masseteric insertions, the zygomatic arch was divided with a circular saw from its anterior zygomatic extremity as far as its posterior extremity at the height of the articular tubercle. The bony fragment was preserved. The anterior osteotomy could include a segment of the orbital margin in order to increase even more the superior access to the intra temporal fossa.

The tendon of the temporalis muscle was divided horizontally at the height of the mandibular notch and reflected upwards (Fig. 4). The deep temporal branches of the maxillary artery running to the temporalis muscle were identified. The superior part of the infra-temporal fossa was thus perfectly seen: in front the sphenopalatine artery and other anterior branches of the maxillary artery were dissected as far as the maxillary tuberosity after removing the cellulo-fatty tissue of the buccal fat

Fig. 2 Right pre-auricular temporo-cervical incision. Dissection of the superficial temporalis fascia and fascia of the temporal muscle itself (*filled arrowhead*)

Fig. 3 Dissection of the facial nerve and protection of the temporal branch (*filled arrowheads*). Osteotomy and retraction of the zygomatic arch (*open arrowhead*) (right side from the operating position)

pad. Medially, the pterygomaxillary fissure was located. Immediately behind the buccal fat pad, the two heads of the lateral pterygoid muscle were identified and divided. On the lateral aspect of the medial pterygoid, the mandibular nerve divided just after its exit through the oval foramen into voluminous branches: the lingual nerve in front and medially, the inferior alveolar nerve behind and laterally. This was followed as far as the mandibular foramen marked by the mandibular lingula (Spix's spine), which was easily palpated. The maxillary artery ran horizontally at a variable height on the lateral aspect of the neural division of the mandibular nerve (Fig. 5). Below the auriculotemporal nerve lay in a trajectory which was schematically parallel to the artery while the buccal nerve was more anterior and vertical, crossing the lateral aspect of the artery. This latter was therefore held within neural forceps represented medially by the alveolar and lingual nerves and laterally by the buccal nerve. Reaming the temporal plate as far as the oval foramen exposed the temporal dura mater (Fig. 6), opening even more the upper part of the infratemporal fossa.

Above the mandibular foramen, a horizontal osteotomy was done with the circular saw allowing the mandibular ramus with the condyle and coronoid process to be separated. The angle of the mandible itself was preserved. Nevertheless, this may be done if required for surgical extirpation (Fig. 7). Mandibular osteotomy allowed wide exposure of the inferior part of the infratemporal fossa and its submandibular opening in front

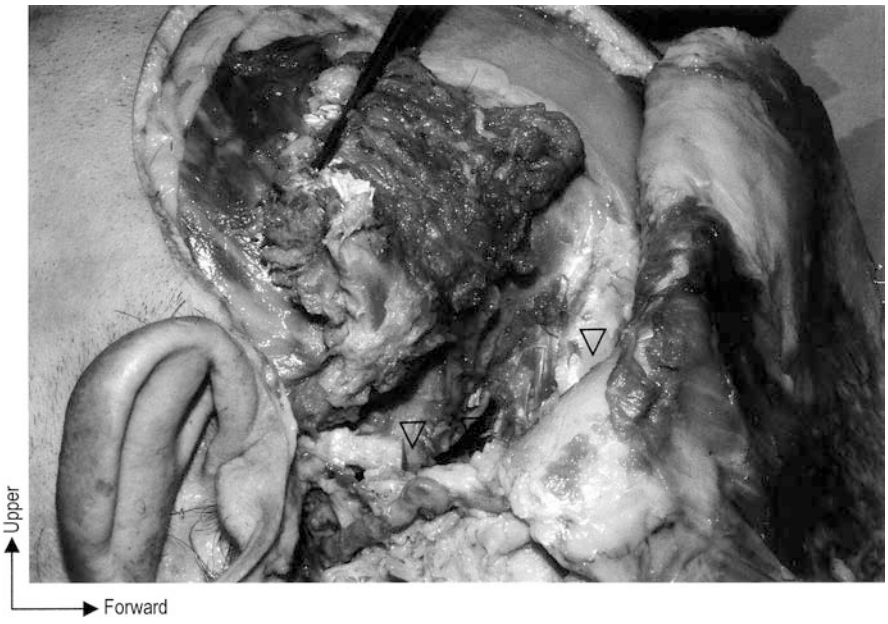

Fig. 4 Division of the tendon of the temporalis and cranial retraction of the muscle: opening the superior part of the infra temporal fossa (right side from the operating position)

Fig. 5 Location of the division of the mandibular nerve and laterally the maxillary artery (*filled square*) (right side)

and jugulo-carotid opening behind and below after division of the medial pterygoid muscle.

Thus the combined lateral trans-zygomatic and trans-mandibular approach allows complete exposure of the infra temporal fossa, access to which is not blocked by the trunk of the facial nerve and its branches (Fig. 6). The complex succession of the different stages of dissection may be repeated on the preserved plastinated specimen.

Discussion

The precise bony limits of the infra temporal fossa [10, 17, 19] do not allow one to ignore two anatomical surgical peculiarities of this retro-maxillary region: its irregularity, which is the origin of hidden zones—a source of local tumor recurrence—and its wide "openings", which are responsible for local tumor extension. On the other hand, its bony limits, but also the muscular ligamentous ones, notably the styloid muscle fascia, the rhino-pharyngeal wall and the auditory tube, are only relative barriers, vis-à-vis tumor invasion requiring extended surgical extirpation [6, 16, 32]. In fact primary, benign or malignant tumors of the infra temporal fossa are rare compared with tumors originating in neighboring spaces [15, 29], such as nasopharyngeal angiofibromata reaching the intra- and/or extracranial structures [9, 24, 32] but also meningiomas, haemangiopericytomas, chemodectomas

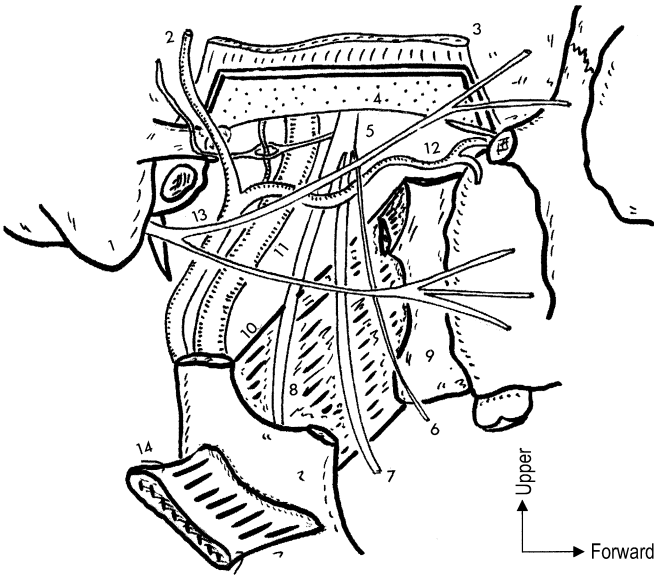

Fig. 6 Infra-temporal extra-dural exposure of the trans-mandibular trans-zygomatic approach (right side) *1*, Mastoid process; *2*, superficial temporal artery; *3*, temporal muscle; *4*, temporal dura mater; *5*, mandibular nerve (V3) at the foramen ovale; *6*, buccal nerve; *7*, lingual nerve; *8*, inferior alveolar nerve; *9*, pterygoid process; *10*, medial pterygoid muscle; *11*, internal carotid artery; *12*, maxillary artery; *13*, facial nerve (VII); *14*, masseter muscle

and cystic or epidermoid carcinomas of the adenoids [14, 15, 27].

Medially, the lateral pterygoid plate corresponds in front and above to the narrow and irregular breach of the pterygomaxillary fissure [31], a zone of communication with the pterygopalatine fossa which contains the maxillary nerve, the inferior orbital fissure to the round foramen and the ending of the maxillary artery [21, 28, 29]. This zone, which is rich in fissures, opens the infra temporal fossa towards to the orbit and nasal cavity but also towards the cranial cavity by the round foramen. The buccal fat pad which occupies the retro-maxillo-zygomatic region is in a more inferior and lateral plane [10, 21]. This fatty zone opens the infra temporal fossa towards the jugular and masseteric regions (Fig. 8).

Immediately behind the buccal fat pad, the pterygoid and temporal muscular region corresponds to the mandibular ramus and condyle, the mandibular notch and the coronoid process but also to the curve of the zygomatic arch. These bony elements must be exposed to give a wide lateral exposure to the superior and inferior infra temporal fossa [11, 25, 32]. This muscular part of the infra temporal fossa [21] contains the exit of the mandibular nerve, which leaves the oval foramen vertically, its division being blocked laterally at a variable height by the sinuous maxillary artery [30]. The mandibular nerve at the oval foramen is between 33 and 36 mm from the zygomatic arch [30]. It presents an important anatomico-surgical landmark. The spinous foramen is postero-lateral by several millimeters [29]. The mandibular nerve is related medially to the lateral aspect of the tensor veli palatini and the auditory tube. This muscular zone opens the infra temporal fossa above towards the temporal region, in front towards the sub mandibular region, behind towards the parotid region, and below towards the neck, partially divided by the medial pterygoid [21, 28]. In front and outside the posterior edge of the medial pterygoid, the infra temporal fossa opens towards the lateral pharyngeal space and the extension of the parotid gland [26].

Because of the anatomico-surgical characteristics of the infra temporal fossa, numerous surgical approaches have been proposed allowing partial or complete

Fig. 7 Disarticulation of the mandibular ramus (right side) opening the inferior part of the infra temporal fossa. The facial nerve is preserved (*filled arrowheads*)

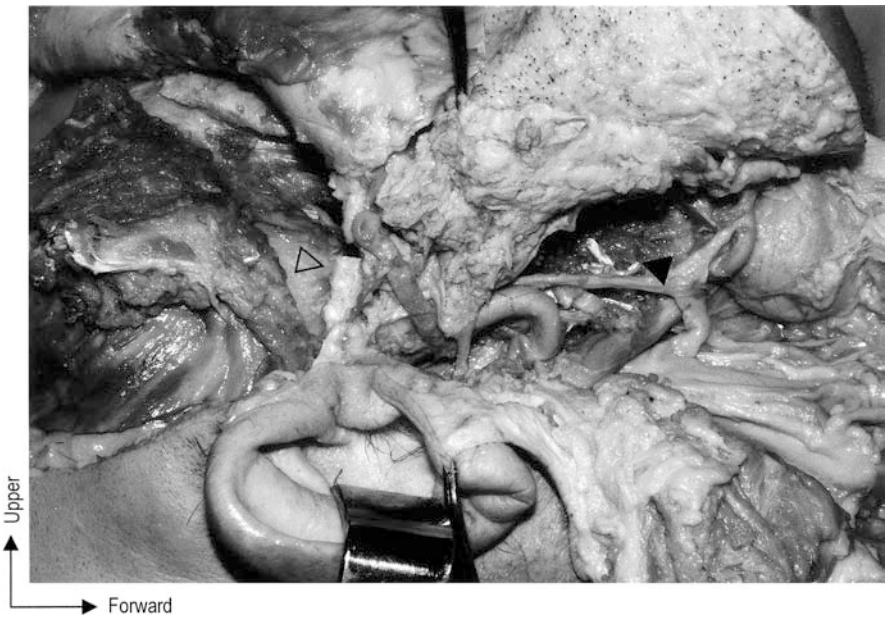

Fig. 8 General review of the right side in the operating position of the combined trans-zygomatic and trans-mandibular approach to the infra temporal fossa

exposure of this region. Partial exposure of the infra temporal fossa may be gained particularly by a superior trans-zygomatic approach, enlarged as required towards the orbital region in front [2, 8, 13, 24] or behind towards the mastoid process as in Fish's B or C approaches [7]. An anterior trans-maxillary approach [16, 22] allows limited access to the anterior infra temporal sub-regions. It may be combined with maxillectomy and anterior labio-mandibulotomy [16]. The isolated lateral trans-mandibular approach [15, 17] allows access to the pterygoid and inferior temporal muscular region but permits only limited access to the base of the skull itself. A minimal lateral access by the endoscopic route has even been proposed to approach the extra-cranial foramen ovale [12].

Simple dislocation of the mandibular condyle has been described by Sekhar [25] and by Fisch [7] who, thanks to his personal retractor, displaces the mandible forwards without resecting it. This dislocation is completely satisfactory to expose the upper part of the infra temporal fossa during extirpation of a limited naso-pharyngeal angiofibroma. Experience of oncological surgery, however, has shown that mandibular conservation at any price or bony reconstruction was paradoxically the cause of severe trismus because extirpation of the masticator muscles is routinely necessary and is often associated with complementary radiotherapy causing major fibrosis. On the other hand, sacrificing the mandibular ramus above the angle with temporo-mandibular disarticulation allows a wide approach to the

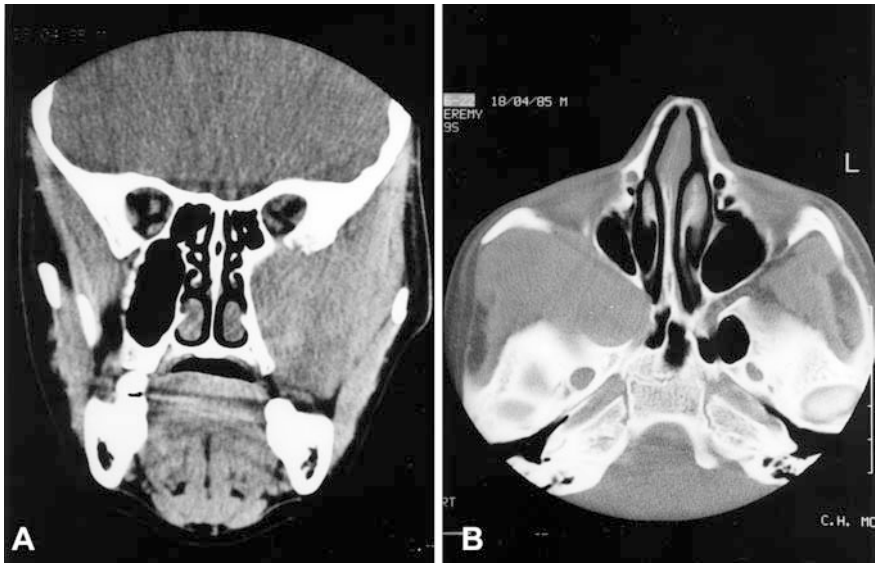

Fig. 9 Axial (**A**) and coronal (**B**) CT scans of an angiofibroma of the right infratemporal fossa operated on by a pre-auricular infratemporal route in a child of 10 years

lower part of the infra temporal fossa. This bony sacrifice leads to neither incapacitating trismus nor major cosmetic sequelae. It is responsible for a certain lateral deviation of the mandible with pain in the opposite temporo-mandibular joint.

Complete exposure of the infra temporal fossa is allowed by the Fisch B and C approaches [3, 7] and Sekhar's pre-auricular approach [25, 32]. The former are better for postero-lateral lesions (sphenoid, clivus, bony petrous, jugular foramen and pontocerebellar angle). The latter are preferable for antero-lateral lesions (sphenoid, clivus, nasopharynx and nasal sinuses), being able to preserve the external, middle and internal ear [3, 7, 25]. Combined approaches most often offer the best solution to tumors with multiple extensions [29]. The infra temporal pre-auricular route has been described to remove primary exocranial extradural tumors at the base of the skull such as angiofibroma (Fig. 9) with possible intracranial extension towards the median line [8, 25].

As a function of tumor requirements, the pre-auricular route allows access to the petrous part of the internal carotid artery [3, 8, 25] with minimal retraction of the temporal lobe if resection of the superior wall of the infratemporal fossa is done with neurosurgical collaboration. The whole of the inferior bony wall of the middle cerebral fossa may be reamed as far as the canal of the hypoglossal nerve if required. Access to the ventral aspect of the brainstem in front of the plane of the facial, glossopharyngeal, vagus and accessory nerves (VII, IX, X, XI) is also possible [8]. Preservation of the facial nerve, particularly the superior branches, is the rule [23, 25, 32].

Thus, while hearing may be preserved, the transzygomatic pre-auricular route combined with a transmandibular route allows, in a variable fashion, access to all the sub-regions of the infra temporal fossa as shown as by the anatomical dissections, and results in minimal functional and cosmetic deficit [6, 26].

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