Percutaneous biopsy through the foramen ovale for parasellar lesions: surgical anatomy, method, and indications

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Abstract

Knowledge of the pathological diagnosis before deciding the best strategy for treating parasellar lesions is of prime importance, due to the relative high morbidity and side-effects of open direct approaches to this region, known to be rich in important vasculo-nervous structures. When imaging is not evocative enough to ascertain an accurate pathological diagnosis, a percutaneous biopsy through the transjugal-transoval route (of Hartel) may be performed to guide the therapeutic decision.

The chapter is based on the authors' experience in 50 patients who underwent the procedure over the ten past years. There was no mortality and only little (mostly transient) morbidity. Pathological diagnosis accuracy of the method revealed good, with a sensitivity of 0.83 and a specificity of 1.

In the chapter the authors first recall the surgical anatomy background from personal laboratory dissections. They then describe the technical procedure, as well as the tissue harvesting method. Finally they define indications together with the decision-making process.

Due to the constraint trajectory of the biopsy needle inserted through the Foramen Ovale, accessible lesions are only those located in the Meckel trigeminal Cave, the posterior sector of the cavernous sinus compartment, and the upper part of the petroclival region.

The authors advise to perform this percutaneous biopsy method when imaging does not provide sufficient evidence of the pathological nature of the lesion, for therapeutic decision. Goal is to avoid unnecessary open surgery or radiosurgery, also inappropriate chemo-/radio-therapy.

Keywords: Cavernous sinus; neurosurgical procedures; parasellar region; percutaneous biopsy; oncology; petro-clival region; skull base tumors; trigeminal cave.

Introduction

Despite advances in microsurgical and endoscopic techniques, surgery of lesions arising from, or invading, the parasellar space and surroundings – a region rich in highly important vasculo-nervous structures (Fig. 1) – are associated with a significant rate of morbidity and side-effects. Knowing the variability of the lesions in this area, to have the pathological diagnosis before establishing the most efficient therapeutical strategy is of importance. Goal is to avoid unnecessary open surgery or radiosurgery, also inappropriate chemo-/radio-therapy. As a matter of fact, number of the neoplasms there are "non-surgical" lesions, some others pseudo-tumors from inflammatory origin.

In around one-fourth of the patients, current imaging is not evocative enough to ascertain an accurate pathological diagnosis. In those cases a percutaneous biopsy through the transjugal-transoval route may be performed to guide therapeutic decision.

The transjugal-transoval route was first described by Hartel in 1912 [7] (Fig. 2), for alcohol injection at level of the gasserian ganglion to treat trigeminal neuralgia. Then this route was extensively used with the same indication for performing percutaneous destructive procedures of the trigeminal system, by

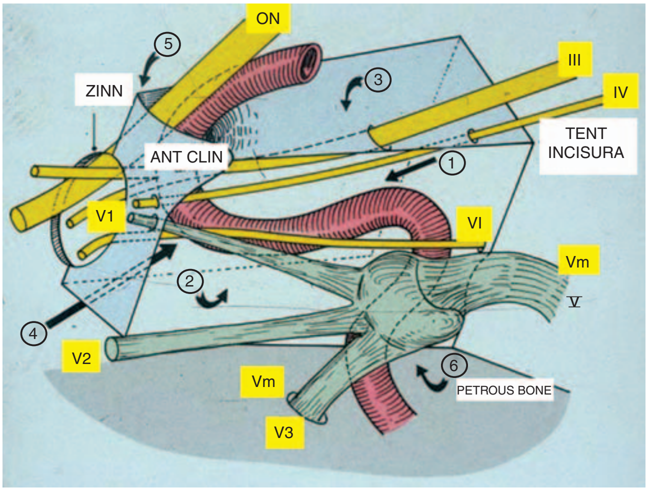

Fig. 1. Schematic drawing (by senior author M.S.) of the parasellar lodge (*left side*), showing location of the crossing cranial nerves (N), namely: the trigeminal N. and its three branches: ophthalmic (V1) maxillary (V2) and mandibulary (V3) together with the motor (masticatory) branch (V^m); the oculomotor N. (III); the trochlear N. (IV); the abducens N. (VI). The illustration also indicates the various microsurgical windows to the parasellar region: (1) the Parkinson triangle (between V1 and IVth N.) via a fronto-pteriono-temporal craniotomy; (2) the Mullan triangle (between V1 and V2) via a subtemporal approach; (3) the roof of the cavernous sinus, along the third nerve (Dolenc and Hakuba) or through the carotid ring (Perneczky) via pterional approach; (4) the infero-medial wall by transphenoidal approach (Laws); (5) the supero-medial wall via a contralateral sub-frontal approach (Sano); (6) beneath the Meckel Cave via a preauricular infratemporal approach (Sekhar)

thermocoagulation [8, 15], balloon compression [10] or glycerol injection [6]. This route was also used for inserting EEG electrodes to explore patients affected with refractory temporo-mesial epilepsy with the purpose of resective surgery.

To our knowledge the first attempts of percutaneous biopsy to the middle fossa region were by Stechison and Bernstein in 1989 [14], then by Dresel et al. in 1991 [5]. Given our favourable experience of the Hartel's approach for treating trigeminal neuralgias with the thermorhizotomy procedure, in 3800 patients, in terms of accuracy and inocuity [13], we decided to apply this percutaneous route for biopsies in the parasellar region and surroundings [12].

The present chapter is based on the personal experience of the senior author (MS) with endocranial surgery of central skull base in a series of 306 tumors operated on between 1991 and 2010. Fifty patients met the inclusion criteria for percutaneous biopsy, namely those with masses with atypical

Fig. 2. Transjugal-transoval Hartel' s route for percutaneous biopsy in the parasellar region: *Left:* On the patient's face the external landmarks for the percutaneous Hartel' s route are drawn. The entry point is at ± 30 mm from the labial commissure (60 mm from the middle of the intercommissural line). The foramen ovale is targeted by aiming: 1) in lateral view, at 35 mm anterior to the anterior wall of the external auditory meatus (=tragus), 2) in frontal view, the medial border of the pupilla. The depth is guided by X-ray. *Right:* Exocranial view of the needle trajectory, successively transjugal, through pterygomaxillary fossa, up to foramen ovale. Note that trajectory passes laterally to the lateral pterygoid process

features; there were 18 meningiomas, 3 schwannomas, 2 epidermoid cysts, 3 pituitary adenomas, 5 inflammatory pseudo-tumors, 4 low grade chondrosarcomas, 4 lymphomas and 11 carcinomas. Accessible lesions are those located in the Meckel Cave, the posterior sector of the cavernous sinus, and the upper part of the petroclival region.

Surgical anatomy

Review of the numerous literature series in which Hartel's route was used shows a rather acceptable rate of complications, most of them being mild and transient [1]. Analysis of the (few) articles reporting percutaneous biopsy through the Foramen Ovale (FO) did not find any major complications with the technique [3–5, 14, 18]. Although considered a relatively reliable approach, precise knowledge of the anatomy of the transjugal-transoval trajectory offers the best warranty for a reliable surgery. A detailed anatomical study of this region has been addressed in recently published articles [1] (Figs. 3 and 4). The main features can be summarized as follows.

The anatomical region crossed by the biopsy needle may be considered an inverted, three-sided, pyramidal volume, with its apex at a cheek cutaneous point, 3 cm lateral to the labial commissure (Fig. 5 left). Its triangular base, located at skull base, is delineated by the three following landmarks. The *supero-lateral* one is a cutaneous point on the orbito-meatal line along the

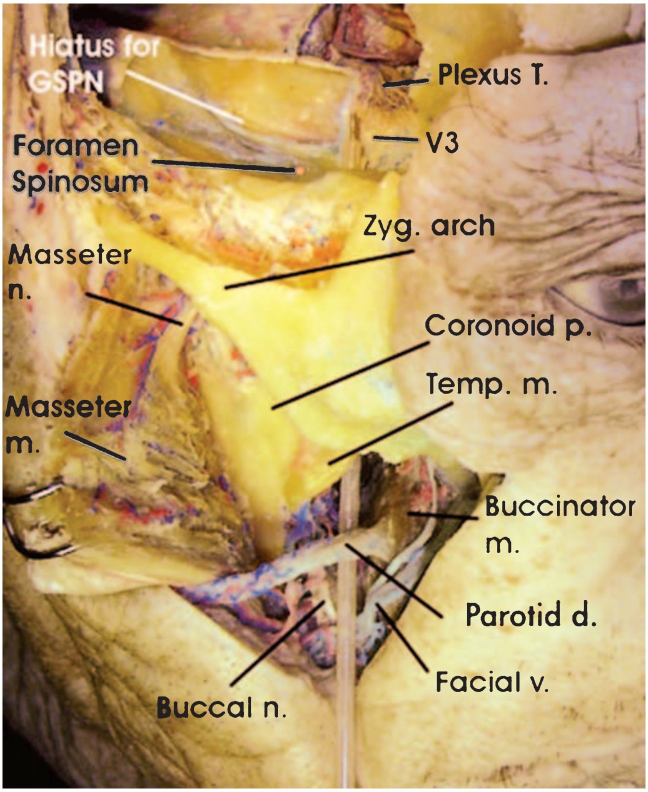

Fig. 3. Anatomical dissection of the transjugal-transoval route (*lower part*). Anatomical dissection of Hartel's trajectory (right side of the face). Cadaveric microsurgical dissection after placement of the needle according to the Hartel's landmarks. The needle has entered cheek at a point 2.5–3 cm lateral to the labial commissure and targeted the Foramen Ovale (FO), situated at the 90° intersection of the ipsilateral pupilla with a point 3 cm anterior to the tragus. The masseter muscle has been detached from its zygomatic insertion. A pterional –subtemporal craniotomy and removal of the dura covering the Meckel cave and the cavernous sinus have been performed in order to expose the Gasser ganglion and the retrogasserian plexus triangularis (Plexus T). Buccal n. buccal nerve, Buccinator m. buccinator muscle, Coronoid p. coronoid process, Facial v. facial vein, Foramen spinosum, Hiatus for GSPN hiatus for great superior petrosal nerve, Masseter m. masseter muscle, Parotid d. parotid duct, Plexus T. plexus triangularis, Temp. m. temporalis muscle, V3 mandibular branch of the trigeminal nerve, Zyg. Arch zygomatic arch. Dissection by J. Alvernia, from Laboratory of Anatomy (Head: Prof. P. Mertens) [1]

inferior border of the zygoma, 3 cm anterior to the tragus. *The supero-mesial* one corresponds to the pupilla. The *deep-seated* one is the Foramen Ovale (FO) itself.

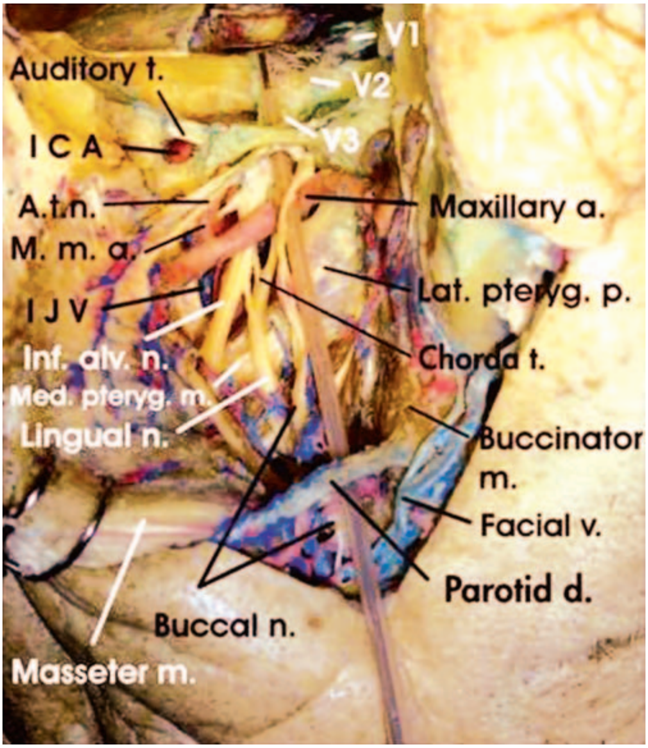

Fig. 4. Anatomical dissection of the transjugal-transoval route (*upper part*). Anatomical dissection of Hartel's trajectory (right side of the face), the zygomatic arch has been removed, the ascending branch of the mandible bone cut and the lateral aspect of the middle fossa floor drilled off. In addition a partial drilling of the petrous bone has been performed in order to show the auditory portion of the internal carotid artery (ICA) as well as the chorda tympani, Buccal n. buccal nerve, Buccinator m. buccinator muscle, Facial v. facial vein, IJV internal jugular vein, Inf. Alv. n. inferior alveolar nerve, Lat. Pteryg. p. lateral pterygoid process, Lingual n. lingual nerve, Masseter m. masseter muscle, Maxillary a. maxillary artery, Med. Pteryg. m. medial pterygoid muscle, M.m.a. Middle meningeal artery, Parotid d. parotid duct, V3 mandibular branch of the trigeminal nerve, V2 maxillary branch of the trigeminal nerve, V1 ophtalmic branch of the trigeminal nerve. Dissection by J. Alvernia, from Laboratory of Anatomy (Head: Prof. P. Mertens) [1]

This inverted pyramid can be subdivided into three segments (Fig. 5 right). An *inferior segment* (of 13 mm long on average), it comprises the portion from the apex of the pyramid where the probe enters the cheek, to the point where the probe contacts the parotid duct (PD). A *middle segment* (of 29 mm long on average) it consists of the portion from the parotid duct to the lateral pterygoid muscle (LPM), is filled with fatty tissue and contains the lingual, the chorda-tympani, the buccal and the inferior alveolar nerves. In this portion, the needle

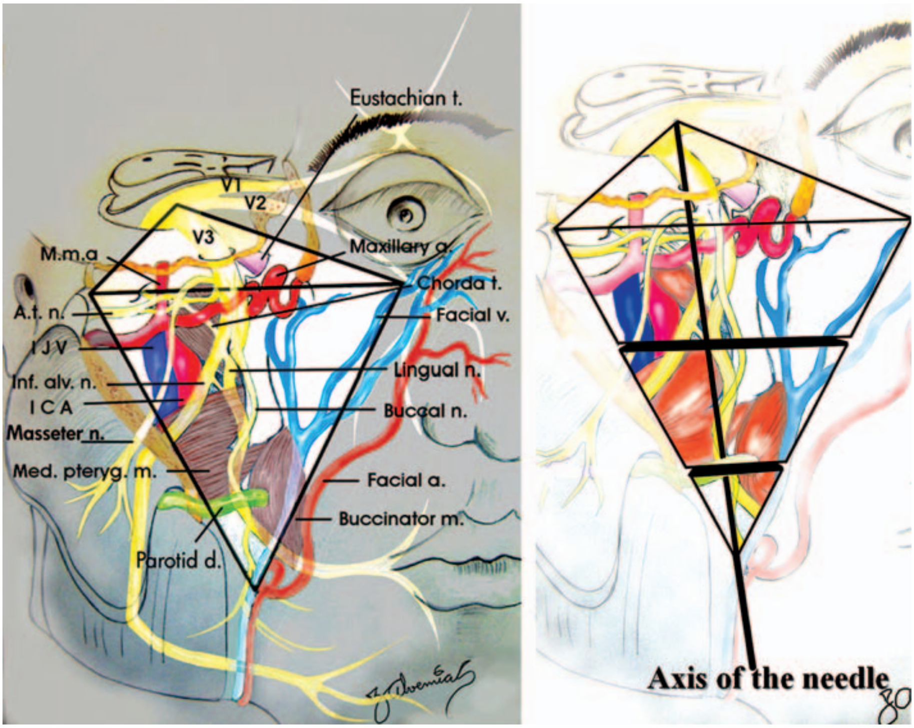

Fig. 5. Drawing (by J. Alvernia), through an oblique anterior view, depicting the anatomical structures surrounding Hartel's trajectory. *Left:* Note the pyramid that may be imagined according to the anatomical landmarks. A.t.n. auriculotemporal nerve, Buccal n. buccal nerve, Buccinator m. buccinator muscle, Chorda T. chorda tympani, Eustachian t. Eustachian tube, Facial a. facial artery, Facial v. facial vein, Inf. Alv. n. inferior alveolar nerve, ICA internal carotid artery, IJV internal jugular vein, Lingual n. lingual nerve, Masseter n. masseter nerve, Maxillary a. maxillary artery, Med. Pteryg. M. medial pterygoid muscle, M.m.a. middle meningeal artery, Parotid d. parotid duct, V1 ophtalmic branch of the trigeminal nerve, V2 maxillary branch of the trigeminal nerve, V3 mandibular branch of the trigeminal nerve, Zyg. n. zygomatic nerve. *Right:* Subdivision of the inverted pyramid into three segments. The danger in the inferior compartment is the parotid duct. The middle compartment mainly contains the branches of the mandibular nerve. The superior compartment is crossed by the internal maxillary artery and its branches, as well as the auditory tube. At the base of the pyramid, carotid artery may be injured, especially if the needle would penetrate into the foramen lacerum

may encounter branches of the maxillary artery (MA) or its trunk if tortuous. A *superior segment,* it starts from the LPM and ends at the FO. Within this portion, the MA runs posterior to the LPM, and may be in contact with the inserted needle. Also pterygoid venous plexuses may be penetrated.

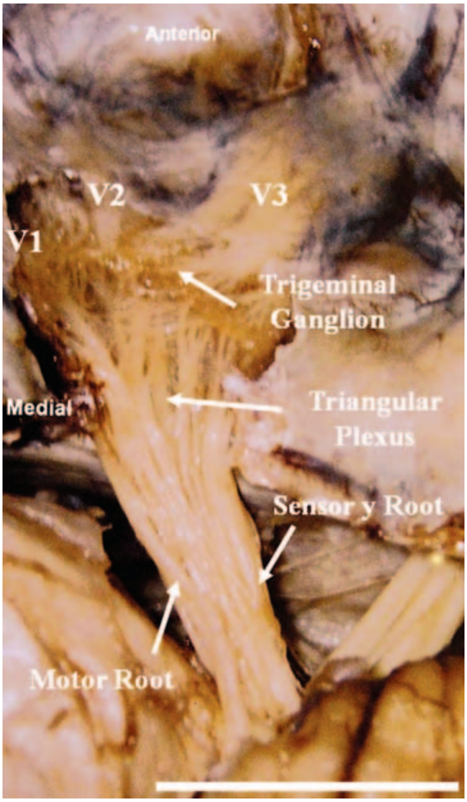

Fig. 6. Anatomical dissection of the trigeminal nerve after opening the dural roof of the Meckel's trigeminal cave (superior view, right side). The Gasser ganglion is recognizable by its semilunar aspect. Posterior to the trigeminal ganglion the rootlets have a fascicular organization (with somatotopy according to V_3, V_2 and V_1 divisions). The retrogasserian rootlets form the triangular plexus where many anastomoses of nerve fibers can be seen, before gathering to form the trigeminal root. Dissection by E. Wydh, from Laboratory of Anatomy (Head: Prof. P. Mertens) Bar: 2 cm [2]

After passing through the Foramen Ovale, the needle enters the Trigeminal Cave and is in relation with the trigeminal system [2] (Fig. 6).

At skull base, i.e., at the base of the pyramid, the following structures might be endangered: the internal jugular vein located 27 mm postero-laterally to the needle trajectory, the internal carotid artery at its entry into the petrous carotid canal (25 mm posterior to the needle axis), again the internal carotid artery at Foramen Lacerum if trajectory would be deviated of 10° medially from its correct pathway, and also the membranous portion of the Auditory tube if trajectory would be deviated of a 9° angle in the anteromedial direction. The inferior, then the superior, orbital fissure(s), and consequently the optic nerve,

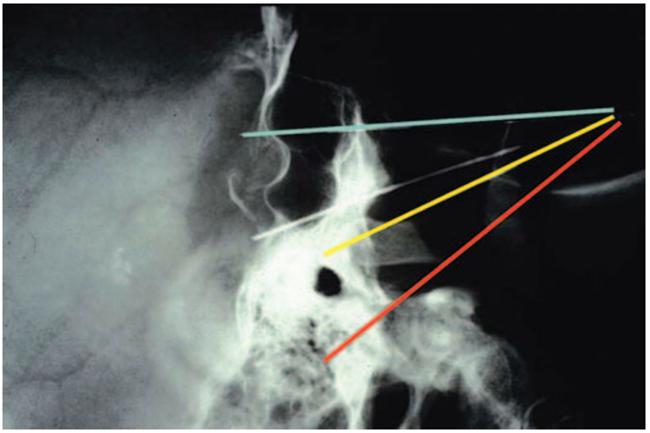

Fig. 7. Wrong (i.e., dangerous) trajectories. An excessive postero-lateral direction (red trajectory) could puncture the internal jugular vein at jugular foramen or the internal carotid artery at entrance into the petrous carotid canal. An excessive medial direction could enter the foramen lacerum and injure the internal carotid artery at its C5 segment (yellow trajectory). An excessive anterior direction could penetrate the orbital apex through the inferior fissure and injure the optic nerve (green). Appropriate trajectory is white

might be attained if needle would be placed 17° too anteriorly from its correct trajectory [1] (Fig. 7).

Method

Selection of patients and preoperative evaluation

Because of the constraint trajectory of the biopsy needle, the method can only be considered for the patients who present with central skull base lesions located in the Meckel cave, the posterior portion of the cavernous sinus, or the upper part of the petroclival region. Only the patients in whom imaging does not afford sufficient assurance for a reliable pathological diagnosis are candidates to percutaneous biopsy.

Candidates should undergo Magnetic Resonance Imaging (MRI), fine Computed Tomography Scanning (CT-scan) with bone-window, and if possible intracranial Selective Digital Substraction Angiography (DSA) by femoral arterial catherization. MRI with T2 weighted images, and T1 with and without contrast enhancement – in sagittal, coronal and axial planes – gives appraisal of the mass extent and its relationships with the neurovascular structures, especially the internal carotid artery (ICA). CT-scan with 3D recontruction provides information regarding central skull base and middle fossa bony structures, especially on the intregity and diameter of the Foramen Ovale. Selective DSA aims to detail tumor vascularization, its feeders and its relationships with the ICA.

Preoperative evaluation also includes neuro-otological and ophtalmological examinations.

Operative procedure

Surgical technique

Patients are placed in supine position, the head under lateral fluoroscopic control (Fig. 8). For commodity reason, submental X-ray trajectory for accessing skull base would only be used if FO could not be reached with the sole lateral control. Surgery is performed under light and short-lasting general anesthesia with IV propofol (Diprivan, Zeneca Pharma, Cergy, France) without the need of laryngeal tube. A local anesthesia with 10 cc of 1% Xylocaine is performed at the site of the skin puncture of the cheek up to the pterygomaxillary fossa. Then the (specially designed) biopsy needle [Sindou Biopsy Needle N° ACS-976 DIXI microtechniques SAS, 4 chemin de Palente – BP 889, 25025 Besançon, Cedex, France] (Fig. 9) is pushed along the Hartel's route, through the pterygomaxillary fossa up to the Foramen Ovale, using the same current technique as the one to perform the trigeminal percutaneous lesioning procedures [6, 8, 10]. The needle tip location is checked with a lateral X-Ray [17] (Fig. 10 Right). Then the needle is connected to a 20 mL syringe

Fig. 8. Surgery under fluoroscopic control. The tip of needle should target ± the intersection between the clivus line and the upper petrous ridge

Fig. 9. Photography showing the biopsy needle (ref Sindou Biopsy Needle N° ACS-976 DIXI microtechniques SAS, 4 chemin de Palente – BP 889, 25025 Besançon, Cedex, France). *Upper:* outer needle; *middle:* inner solid needle for puncturing; *lower:* inner needle to aspirate tissue samples. After the outer needle (together with the inner solid needle) has been introduced and reached the targeted region, the inner solid needle is withdrawn. Then the inner needle to aspirate is placed inside the outer needle, and connected to a 20 ml syringe. Tissue samples are aspirated with a strong negative pressure applied to the syringe

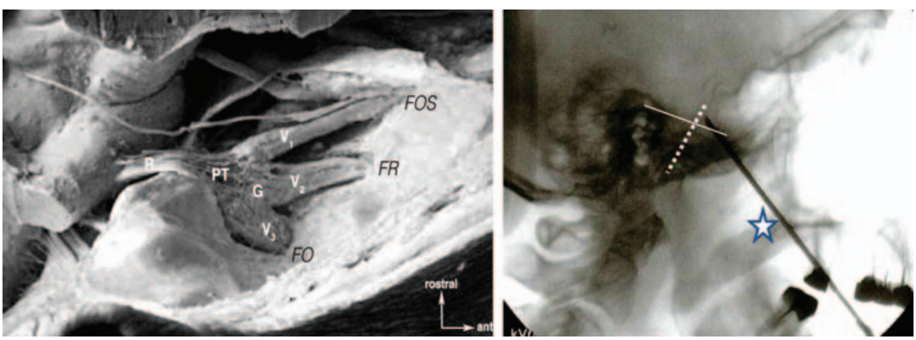

Fig. 10. *Left*: Dissection of the trigeminal system at levels of the Meckel Cave and the lateral wall of the Cavernous Sinus, by Kingler (Courtesy of the Museum of Anatomy in Bale). Note the relationships of the trigeminal branches: ophthalmic (V1), maxillary (V2) and mandibulary (V3) to their corresponding foramina, respectively: superior orbital fissure (FOS), foramen rotundum (FR) and foramen ovale (FO). Note also the relationships of the semilunar Gasserian ganglion (G) and the retrogasserian plexus triangularis (PT) with the clivus and the upper ridge of the petrous bone. *Right:* Lateral X-ray control of (correct) location of the biopsy needle, at upper part of petroclival region). The tip of the needle should be approximately ± 1 cm in front of the intersection between the clivus (dotted line) and the upper petrous ridge (continuous line). $\star$ Landmark on lateral view for a good trajectory of the needle, when entering the pterygo-maxillary fossa

through which negative pressure is manually applied until tissue for cytological and histological examination is obtained.

Tissue harvesting

As soon as tissue is aspirated at the defined target, approximately the center of the lesional volume, a small amount of material is sent to the pathologist, for extemporaneous examination, in order to check the validity of the harvesting and orientate the biopsy process. Staining used is May-Grunwald or Toluidine blue. Biopsy is stopped after the pathologist has given confirmation of a workable pathological tissue, and after a sufficient quantity has been harvested for the "definitive" pathological examination.

Extemporaneous pathological examination may also give an orientation toward benign or malignant features, and sometimes on the histological type.

Pathological examination

The cytological specimens are studied using the May-Grunwald staining technique, either directly or after centrifugation. When samples are big enough, conventional histological techniques are used, and when possible search with immunological markers is added.

A recently published study of a consecutive series of 50 patients who underwent percutaneous biopsy of lesions located in the parasellar region, demonstrated the validity of the method. As a matter of fact, sensitivity was 0.83 and specificity 1, with a Kappa coefficient of 0.89 [9]. When biopsy is "productive", such a worthwhile diagnostic accuracy authorizes therapeutic decision-making, that is, to choose the most appropriate treatment among resective surgery, radiosurgery, chemo-/radio-therapy, corticosteroids, or simply watching-waiting.

How to avoid complications

In our series of 50 patients, two complications occurred: face cellulitis in one case and cheek hematoma in the other, that recovered without any sequelae. In two-thirds of the patients, the procedure was followed by some degree of masticatory weakness and hypoesthesia with paresthesiae in the V3 territory. These side-effects, due to the needle penetration of the Foramen Ovale, were mostly transient; only 3 patients retained permanent disturbances. Further, literature review did not find any mortality or severe morbidity in the similar published cases [16].

Knowledge of surgical anatomy is of considerable help to understand the potential risks of the percutaneous biopsy (see supra). A wrong trajectory might lead to vital complications especially if puncturing the internal carotid artery. Even with a correct trajectory, the needle may encounter the parotid duct, the

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