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THE SUBCRANIAL EXTENDED ANTERIOR APPROACH: FOR CRANIOFACIAL RESECTION OF CARCINOMA INVOLVING THE MIDLINE ANTERIOR SKULL BASE

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ABSTRACT

The extended anterior subcranial approach, for craniofacial resection of carcinoma involving anterior midline skull base, involves an osteotomy of the fronto-naso-orbital external skeletal frame, so as to provide optimum anterior access to the orbital and sphenoethmoid planes, the nasal and paranasal cavities. A clear advantage is the avoidance of frontal lobe retraction, leading to early postoperative recovery.

KEYWORDS: Subcranial Extended Anterior Approach.

The "Subcranial Extended Anterior Approach" was developed in the field of cranio-maxillofacial Surgery, by Raveh et al, who initially described the technique in 1978 for treatment of skull base trauma[1,2,3] and certain craniofacial anomalies.[4,5] Later, the authors expanded the indications of this approach for application to various skull base tumours,[6,7,8] both benign and malignant.

In the sense of evolution, the subcranial approach differs a lot from other traditional approaches utilised by cranio-maxillofacial surgeons, otolaryngologic surgeons and neurosurgeons,[9-13] and also from more recently reported modifications of these techniques.[14-17] The difference lies not in the location of frontal and naso-orbital osteotomies, because most of the bone flap variations that allow transfrontal access are now well known,[18-21] but in the surgical exposure and direction of operative approach. The subcranial extended anterior approach provides broad anterior and inferior exposure of all the planes, including the anterior ethmoid roof up to the clivus, along with both orbital roofs towards temporal bone. This facilitates precise intradural and extradural tumour resection. The approach enables adequate visualization of tumour borders towards the dura as well as along the nasal and maxillary sinus extensions. The resulting simultaneous exposure of cranial as well as caudal aspects of the tumour, enables radical resection of tumour, while preserving the optic nerve, optic chiasm and carotid arteries, when these structures are not directly involved.

The tumours affecting this region mostly arise from the ethmoid sinus, the frontal sinus or the upper part of nasal cavity. The malignant lesions[8] afflicting these anatomical areas may be enlisted as – adenocarcinoma, adenoid cystic carcinoma, squamous cell carcinoma, esthesioneuroblastoma, melanoma, sarcoma, basal cell carcinoma, clear cell carcinoma and Non-Hodgkin's lymphoma. The benign tumours[8] include angiofibroma, inverted papilloma, adenoma, angioma, meningioma, neurofibroma, fibrous dysplasia, giant cell tumour and osteoma.

The extended anterior subcranial approach involves an osteotomy of the fronto-naso-orbital external skeletal frame (Fig. 1), so as to provide optimum anterior access to the orbital and sphenoethmoid planes (Fig. 2), the nasal and paranasal cavities. A clear advantage is the avoidance of frontal lobe retraction, leading to early postoperative recovery. The following discussion will involve a description of the original surgical technique as stated by Raveh et al.[6,7,8]

Preoperative evaluation

The location, extent and size of the lesion are evaluated with the help of CT and MRI. Apart from these, neuroangiography may be carried out, followed by preoperative embolization or carotid occlusion (depending on cerebral blood flow measurements), when required.

Surgical Technique[6,7,8]

General anaesthesia is induced and maintained through either oral endotracheal tube or a tracheostomy tube. The advantage of tracheostomy lies in the fact, that it eliminates the nuisance posed by the tube in the mouth, can contribute to a cleaner operative field and is an excellent prophylaxis against the development of tension

pneumocephalus.[22] The head may be supported on a Mayfield headrest.

The incision is marked as for a bicoronal flap. Thenceforth, the bicoronal flap is raised in a subperiosteal plane, preserving the pericranium for possible use during reconstruction. The flap is then dissected down to the frontozygomatic sutures bilaterally, and to the rhinion and piriform apertures in the midline. Subsequently, the periorbita is dissected from the superior, medial and lateral walls of the orbit, back to the apex of orbit on either side. The anterior ethmoid arteries are ligated. Careful dissection prevents damage to the optic nerve and orbital contents. Next, the outline of nasofrontal segments is planned, depending on the size and extent of both the lesion and frontal sinus. Before beginning osteotomy, the miniplates for subsequent bone fixation are adapted and drilled. The osteotomy line of the bone flap can be extended cranially and laterally (Fig. 1), as required by the extent of tumour. The osteotomy begins with drilling of bur holes, with a dissector protecting the frontal lobe dura at all times. The osteotomy lines are made across the frontal bone, down to and along the orbital roofs, down the medial orbital wall, and along the nasomaxillary grooves just anterior to the lacrimal duct. Subsequently, a vertical osteotomy performed anterior to the crista galli, allows detachment of the frontonasal segment, avoiding damage to the sagittal sinus or dural tears. In accordance with the location of tumour, two types of osteotomies are distinguished (Fig. 3), as follows:-

Type I: The first type involves an osteotomy of the frontonasal segment, leaving the posterior wall of frontal sinus intact, so as to be removed in a second step. The procedure is indicated in cases where the tumour involves the posterior wall. It allows the removal of external skeletal frame, after dissection of posterior wall under direct vision, safely and far enough from tumour borders (Fig. 4).

Type II: This procedure involves single stage removal of the frontonasal segment, including the posterior wall of frontal sinus. The procedure is indicated for tumours not involving the posterior wall, or for tumours having major intracranial extension, thus making necessary a broad access. The borders of osteotomy can be extended cranially and laterally.

Dissectors should be inserted along orbital roofs and along the conjunction of posterior wall of frontal sinus with roof of ethmoid, so as not to injure the dura. By using the tumour borders as guides, the dura is now divided circumferentially, around the olfactory groove and the involved portion of dura, followed by sectioning of olfactory filaments. In case of unilateral tumours, it is an advantage to preserve contralateral olfactory filaments. In case there is no intracranial extension, the olfactory filaments and dura are dissected upwards and backwards, subcranially, from the crista galli anteriorly to the planum sphenoidale posteriorly, while avoiding excessive manipulation of frontal lobe. The bone from orbital and ethmoid roofs should be removed to facilitate this dissection. This anterior step-by-step exposure, gives clear definition of tumour borders, and provides exposure of vital structures such as the optic nerve, carotid arteries, optic chiasm and lateral sphenoid walls. The above procedures provide optimal assessment of the clivus, nasal lumen, palate and maxillary sinuses, thus allowing radical resection of tumour. With the dura protected by a slim dissector, osteotomy of the planum sphenoidale is simple and easy. The medial wall of the optic nerve canal is unroofed by this access, and the optic chiasm and nerves can be exposed bilaterally.

In case of carcinoma extending to frontal lobes,[22] the latter are gently retracted, and a margin of 3 to 5 mm. is taken around the tumour and checked with frozen section. The dense connective tissue comprising the dura mater, offers a strong barrier to spread of tumour. Also, the arachnoid layer, with its thin filamentous composition, offers significant resistance to the spread of tumour, especially towards brain. The involvement of superior sagittal sinus can be safely resected upto the level of coronal suture. A biopsy of frontal lobe tissue, adjacent to the areas of dural penetration, must be done to determine whether there is intracerebral invasion. A generous cuff of frontal lobe must be resected surrounding any such site of involvement. Most of the patients tolerate this quite well.[22]

Reconstruction and closure[6,7,8]

The smaller dural defects may be sutured, but the larger defects resulting from intradural tumour involvement are patched with fascia lata. Temporalis fascia may be used instead of fascia lata, as it is readily available through the coronal incision. A second large fascia lata flap is applied using fibrin glue, so as to seal the entire skull base defect, which extends from the exposed frontal lobes upto the clival area. The lateral borders of the fascia must be adapted between the dura and the lateral resection borders of the orbital roof and sphenoid plane, to avoid herniation and provide a water tight seal to the subcranial compartment.

The osteotomy bone flap is placed back and fixed with miniplates, using previously drilled holes as guides for accurate approximation. The medial canthal ligaments must be fixed back. This is achieved by placing a non-absorbable suture through the ligament and then guiding the suture under the nasofrontal segment to the contralateral anterior frontal sinus wall. Bilateral tightening of the suture results in medial, downward and inward pull, thus achieving correct positioning of the medial canthal ligaments along the vertical, horizontal and sagittal planes. Alternatively, the ligaments may be fixed to holes drilled through nasal bones.[23]

Osteomyocutaneous flaps, free or pedicled, are used in cases of very extensive resections of the skull base frame

or frontal lobe defects. Polyethylene tubes are inserted bilaterally into the subcranial compartment and externalized through the nasal lumen. The tubes are left in place for about eight months, so as to allow frontal drainage, to avoid development of orbital apex syndrome or later mucus retention. These tubings also help to prevent late infectious sequelae such as chronic sinusitis, mucocoele or brain abscess. In cases where total removal of medial orbital walls was necessary or the periosteum had to be resected, the medial walls are reconstructed with cartilage grafts.

Extensions of the Surgical Tehnique

In cases of extension of cancer to the orbit, orbital exenteration may be required. The decision to carry out orbital exenteration is very critical and requires knowledge and judgement. It is important that such a critical judgement be based on well established criteria. A remarkable study, in this regard, was presented by Iannetti et al.[24] The authors have classified orbital invasion into three grades:

- **Grade I:** involves the erosion or destruction of bony wall of orbit.
- **Grade II:** involves extraconal invasion of the periorbital fat.
- **Grade III:** involves invasion of the rectus muscle, the optic nerve, ocular bulb, or the skin overlying the orbit.

The authors concluded that only the cases with grade III invasion should be treated by orbital exenteration. However, in a study by Tiwari et al,[25] the author stated the importance of periorbital fascia lining the orbital fat in preserving the orbit. As an inference, orbital exenteration is not required in the absence of invasion of orbital fat.

For tumours extending to the nasal cavity or maxillary sinus, an extended surgery may be required, including nasal exenteration, Transfacial approach,[26] medial maxillectomy, partial maxillectomy or total maxillectomy, with or without orbital exenteration. Involvement of the lateral infratemporal fossa, pterygopalatine fossa or the sphenoid sinus, requires an additional lateral surgical approach.[27] Combinations of transcranial and transfacial approaches were initially reported by Smith et al,[28] Ketcham et al[29] and Van Buren et al.[30]

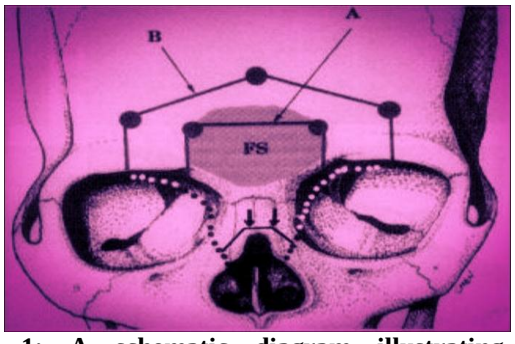

Fig. 1: A schematic diagram illustrating the frontonasal segment osteotomies.

Fig. 2: A schematic diagram illustrating the extent of exposure afforded by this approach.

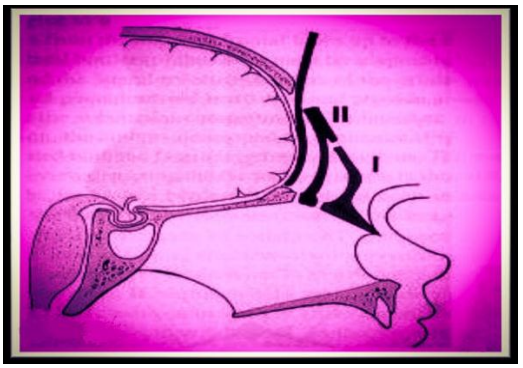

Fig. 3: A schematic diagram illustrating the two types of osteotomies.

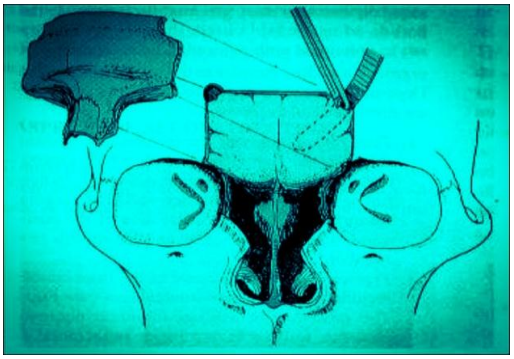

Fig. 4: Type I osteotomy with dura detached.

DISCUSSION

The subcranial extended anterior approach, provides an adequate access to anterior skull base and sphenoclival region, and to nasal and paranasal cavities. This approach provides accurate identification of tumour margins and dural excision. The major advantages of this approach may be stated as:

- Adequate exposure of tumour borders, from anterior to posterior, as well as from cranial to distal (and vice versa) directions;
- Accurate visualization of the optic nerves along the optic canal and optic chiasm;
- Identification of the carotid arteries;
- Prevention of unnecessary damage.

A possible disadvantage to the approach may be stated as osteomyelitis or osteoradionecrosis of the osteotomised

bone flap[31] in regions of nasal bone, glabella and medial orbital rim, when the approach is used in cases of malignant tumours. This problem can be avoided by wrapping the bone flap in galeopericranial flap.[23]

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interests that could influence this work.

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