Quantitative Evaluation of Transtemporal and Facial Translocation Approaches to Infratemporal Fossa

Moni A. Kuriakose, M.D.,¹ Alex Sorin, M.D.,² Rajeev Sharan, M.D.,¹
Andrew J. Fishman, M.D.,³ Ramesh Babu, M.D.,³ and Mark D. DeLacure, M.D.²

ABSTRACT

Objective: To compare the extent of exposure and surgical maneuverability provided by facial translocation and transtemporal approaches for access to the infratemporal fossa and anterolateral skull base. **Materials and Methods:** Surgical procedures were performed on five fresh frozen adult cadavers (ten sides) with no known pathology. Facial transfacial approaches with and without a mandibulotomy and transtemporal approaches were evaluated. Objective measures were (1) the distance from the surgical plane to designated anatomic landmarks and (2) the surgical angle of exposure. **Results:** Distances from the surgical plane to the anatomic reference points were comparable for most of the access procedures (3 to 6 cm). The extended midfacial translocation and bilateral facial translocation approaches did, however, provide a shorter operative distance (1 to 3 cm) for access to the infratemporal fossa and contralateral structures, respectively. The transtemporal approaches facilitate a better angle of exposure (74 to 84 degrees) to the petrottemporal region, while the transfacial approaches were superior for access to the infratemporal structures. **Conclusions:** Based on the results, we propose a clinical algorithm for selecting a surgical approach based on the position and extent of an infratemporal or petrottemporal lesion.

KEYWORDS: Infratemporal fossa, anterior skull base, lateral skull base, Fisch Type C, facial translocation, transzygomatic approach

The inherently compact anatomy of the infratemporal fossa demands surgical approaches that enable maneuvering within an anatomically crowded region, while facilitating a means to an-

ticipate and recognize vital neurovascular structures. This objective is accomplished principally by transtemporal or facial translocation approaches. These two well-described surgical alternatives facilitate

¹Head and Neck Institute, Amrita Institute of Medical Sciences, Kerala, India; ²Department of Otolaryngology–Head and Neck Surgery, ³Department of Otolaryngology and Neurotology, New York University School of Medicine, New York, New York.

Address for correspondence and reprint requests: Moni A. Kuriakose, M.D., Chairman, Head and Neck Institute, Amrita Institute of Medical Sciences, Elamakkara, Cochin, Kerala

682026, India (e-mail: mak12@nyu.edu).

Skull Base 2008;18:17–28. Copyright © 2008 by Thieme Medical Publishers, Inc., 333 Seventh Avenue, New York, NY 10001, USA. Tel: +1(212) 584-4662.

Received: May 28, 2007. Accepted: August 6, 2007. Published online: November 13, 2007.

DOI 10.1055/s-2007-992765. ISSN 1531-5010.

exposure to the anterolateral skull base and the infratemporal fossa, with distinct morbidity profiles.

The Type C infratemporal fossa approach, described by Fisch,¹ is used for access to lesions at the infratemporal and pterygopalatine fossae, parasellar region, and the nasopharynx. Potential complications associated with this approach include permanent conductive hearing loss, ascending infection from nasopharynx, facial nerve paralysis, mandibular dysfunction, and anesthesia in the distribution of trigeminal nerves V2 and V3. Conversely, facial translocation approaches, popularized by Janeka,^{2,3} entail modular disassembly of the face for exposure to the anterior and anterolateral skull base. Morbidities associated with this approach include cosmetic defects of facial incisions, infraorbital nerve anesthesia, and potential occlusal interference.

Although the literature is replete with detailed descriptions to guide surgeons in performing these approach procedures, data comparing the efficacy and surgical exposure obtained via the transtemporal versus transfacial approaches are lacking. In the absence of objective criteria, the choice of surgical approach is generally guided by the experience and personal preference of the surgeon.^{4,5}

The goal of this cadaveric study was to directly compare transtemporal and facial translocation approaches in terms of surgical exposure and operative maneuverability to selected anatomic sites. Parameters used for objective measurements were (1) distance from the surgical plane to key anatomic landmarks and (2) the angle of exposure facilitated by each procedure. Further, measurement of tissue displacement that was required to accomplish each procedure was incorporated, since this factor may ultimately impact postoperative morbidity.

MATERIALS AND METHODS

Cadaver Dissection

Surgical procedures were performed on five fresh frozen adult cadavers (ten sides) with no known

head and neck pathology. Procedures were Fisch Type-C ($n=5$), standard facial translocation ($n=8$), extended facial translocation ($n=3$), transzygomatic ($n=6$), facial translocation with mandibulotomy ($n=3$), and bilateral facial translocation ($n=3$). All dissections were performed using standard surgical instruments. The mastoidectomy and osteotomies were performed with use of a high-speed drill (Midas Rex, L.P., Fort Worth, TX).

The transtemporal approach was performed as described by Fisch.¹ A postauricular hemicoronal incision was made to enable elevation of an anteriorly based flap along the subperiosteal level at the mastoid and subgaleal plane along the scalp. The external auditory canal was transected and closed in a blind sac. The trunk of the facial nerve and its temporal branch were dissected and exposed through the parotid gland. The zygomatic arch and body were exposed to the lateral orbital rim in the subperiosteal plane in an effort to protect the temporal branches of the facial nerve. The zygomatic arch was then osteotomized and mobilized inferiorly along with the masseter muscle. The temporalis muscle was elevated from the lateral skull and left attached to the coronoid process. A canal wall down mastoidectomy was performed. All mastoid and middle ear air cell tracts were removed exposing the jugular bulb and internal carotid artery (ICA) at the hypotympanum. The vertical segment of the ICA was identified with diamond burrs. The bone of the floor of the middle cranial fossa and the glenoid fossa were removed, facilitating exposure of the foramen spinosum and foramen ovale. The middle meningeal artery and V3 were divided. The mandibular condyle was exposed and retracted inferiorly. The bony eustachian tube was then drilled out to trace the ICA along the floor of the middle fossa up to the foramen lacerum. Soft tissues were elevated from the petrous apex. The pterygoid processes were divided at their base to expose the foramen rotundum and the maxillary nerve. The pterygoid muscles were detached from the mandible, exposing the nasopharynx through its lateral wall.

Figure 1 (A) Standard facial translocation. The broken line represents an osteotomy at frontonasal, zygomaticofrontal, and zygomaticotemporal sutures. (B) Standard facial translocation approach. The broken line represents an osteotomy at the pterygomaxillary fissure, root of pterygoid, and hard palate.

The standard facial translocation approach was performed through a modified Weber-Ferguson, hemicoronal, and palatal interdental incisions. The incision was started at the midline of the upper lip and extended along the philtral ridge into the anterior nares for ~5 mm. The incision was continued around the ala to reach the midpoint between the tip of the nose and the base of the ala. It was then continued superiorly between the lateral and dorsal esthetic subunits of the nose. At the base of the nose, a V-shaped laterally directed extension was made to the medial canthus. This was then continued as a subconjunctival incision to the lateral canthus. The lateral canthus was then bisected and the incision continued laterally and superiorly for ~2 cm along a lateral eye furrow. The hemicoronal incision was made in the standard fashion. An intraoral interdental incision was made to expose the midpalatal region. This incision was started from the ipsilateral tuberosity of the maxilla to the palatal gingival sulcus. This was continued as an interdental incision to the contralateral first molar region. A mucoperiosteal flap was elevated to expose the midpalatal suture. These incisions were selected based on the ease of access for osteotomies, optimal vascularity of the disassembled facial skeleton, and exposure for reconstructive plating. Osteotomies were performed to separate three principal sutures attaching the midface to the skull

base: frontonasal, zygomaticofrontal, and zygomaticotemporal sutures. The midpalatal and pterygomaxillary sutures were then separated, the latter with use of a curved osteotome inserted behind the tuberosity of the maxilla. These osteotomies were then connected by dividing thin intervening bones (Figs. 1A and 1B), enabling translocation of the maxilla and the zygomatic bone as composite units enveloped in overlying soft tissue.

The extended facial translocation involves extension of a standard facial translocation to include the nose, ipsilateral maxilla, and the zygomatic bone as a single composite unit. The incision is similar to the standard facial translocation, except that the vertical incision along the nose is placed on the contralateral side and at the root of the nose extended medially to the ipsilateral medial canthus. Osteotomies were modified to include the nose within the composite subunit through bilateral separation of the frontonasal sutures and vomer from the anterior skull base. The vertical nasal bone osteotomy was placed on the contralateral side. In addition, a midpalatal osteotomy was performed along the contralateral nasal floor.

The transzygomatic approach was performed through a hemicoronal incision with osteotomies outlined in Fig. 2. The mandibulotomy was performed through a lower lip-split incision. The site

Figure 2 Transzygomatic approach. The broken line represents the site of the osteotomy.

of the osteotomy was between the ipsilateral lateral incisor and canine teeth.

Quantitative Measurements

Parameters used to evaluate the selected approaches were (1) the measured depth from an anatomic reference point to the surgical plane, (2) maximal angle of exposure obtained for access to the selected anatomic points, (3) the area of skull base exposed, and (4) the ratio of the area of skull base exposed to tissue displaced (E/D ratio). Depth of exposure was determined by measuring the shortest tangential line from the set point of interest to the level of the surgical plane. The maximal angle of exposure was determined using a malleable wire and protractor. Skull base exposure was estimated by calculating the area of the surgical field exposed. The area of tissue displaced was measured at the long and short aspects of the exposed surgical field. These values enabled calculation of a ratio of the area of the skull base exposed to the tissue displaced (E/D ratio). The value of mandibulotomy as an adjunct procedure to standard facial translocation or transzygomatic approaches was then compared utilizing the same parameters to access the defined anatomic landmarks.

Figure 3 Infratemporal fossa compartments are divided by an imaginary line drawn from the ipsilateral medial pterygoid plate and glenoid fossa.

Anatomic landmarks within the infratemporal fossa were classified into two compartments, as described by Kumar et al.⁶ The compartments were termed (1) infratemporal or (2) petrottemporal, separated by an imaginary line drawn between the ipsilateral medial pterygoid plate and the glenoid fossa (Fig. 3). Infratemporal structures included the foramen rotundum, root of pterygoid plates, pharyngeal opening, and isthmus of the eustachian tube. Petrotemporal structures were the foramen ovale, foramen spinosum, carotid canal, and the base of the styloid process. A further substratification was made based on the superior-inferior dimension, designating structures as above or below the level of the maxillary occlusal plane. All the aforementioned anatomic landmarks were identified above the occlusal plane, while the cervical ICA was the sole chosen landmark that is below it.

Statistical Analysis

Statistical analysis to compare different surgical groups was performed using the student *t*-test. A value of $p < 0.05$ was considered significant.

RESULTS

The findings of this study are summarized in Tables 1 through 3. Direct comparison of the “depth of exposure” of transtemporal versus standard facial translocation approaches failed to reveal a statistically significant difference, with median distances ranging from 3 to 6 cm (Table 1). A statistically significant improvement in exposure by reducing the depth of exposure was observed when the standard facial translocation approach was expanded to an extended facial translocation or bilateral facial translocation approaches (median distances ranging from 1 to 3 cm, $p = 0.05$). Proximity was especially

improved in extended approaches for access to structures anterior to the foramen ovale and to contralateral anatomic landmarks.

Direct comparison of the described approaches based on the “maximal angle of exposure” revealed this parameter as most discordant and, therefore, perhaps paramount when selecting an approach. While the transtemporal approach facilitates an excellent angle of exposure for structures of the petrottemporal region (40 to 101 degrees), transfacial approaches were superior for exposure of structures in the infratemporal fossa (48 to 116 degrees). Predictably, contralateral structures were better exposed by either extended midfacial or bilateral translocation approaches (Table 2).

The standard facial translocation was directly compared with the extended facial translocation approach. A significant difference was observed with the angle of exposure of the contralateral structures (Table 2). The mean maximal angle of exposure of the pharyngeal opening of the contralateral eustachian tube was 68 degrees with

Table 1 Angle of Exposure to Key Surgical Landmarks in Different Approaches (in Degrees)

Approach	Angle (max/min)	Ipsilateral Pharyngeal ET Orifice	Contralateral Pharyngeal ET Orifice	Base of Pterygoid Process	Foramen Ovale	Styloid Process	Anterior Carotid Genu	Posterior Carotid Genu	Cervical ICA
Transtemporal	Min ^(SD)	31 ^(7.4)	23 ^(4.2)	36 ^(9.4)	40 ^(4.1)	82 ^(22.0)	41 ^(8.9)	61 ^(11.0)	N/A
	Max ^(SD)	46 ^(3.8)	28 ^(2.8)	51 ^(9.0)	66 ^(12.0)	101 ^(23.0)	56 ^(15.0)	88 ^(14.0)	N/A
Transzygomatic	Min ^(SD)	29 ^(1.7)	N/A	35 ^(14.0)	25 ^(8.0)	24 ^(3.2)	26 ^(7.1)	20 ^(0.0)	19 ^(N/A)
	Max ^(SD)	52 ^(7.3)	N/A	62 ^(25.0)	74 ^(16.0)	49 ^(12.0)	44 ^(6.5)	41 ^(4.0)	34 ^(N/A)
Transzygomatic with mandibulotomy	Min ^(SD)	45 ^(7.1)	N/A	87 ^(20.0)	63 ^(32.0)	55 ^(42.0)	48 ^(20.0)	45 ^(7.1)	66 ^(37.0)
	Max ^(SD)	88 ^(32.0)	N/A	131 ^(20.0)	118 ^(11.0)	112 ^(20.0)	87 ^(13.0)	92 ^(5.6)	116 ^(5.7)
Standard midfacial translocation	Min ^(SD)	67 ^(15.0)	48 ^(16.0)	81 ^(19.0)	72 ^(21.0)	44 ^(16.0)	59 ^(22.0)	52 ^(11.0)	43 ^(6.4)
	Max ^(SD)	95 ^(12.0)	68 ^(29.0)	116 ^(34.0)	105 ^(24.0)	83 ^(23.0)	85 ^(18.0)	80 ^(23.0)	77 ^(31.0)
Standard midfacial with mandibulotomy	Min ^(SD)	89 ^(36.0)	59 ^(25.0)	100 ^(30.0)	78 ^(26.0)	63 ^(25.0)	62 ^(26.0)	68 ^(7.2)	78 ^(46.0)
	Max ^(SD)	114 ^(9.2)	101 ^(5.1)	114 ^(13.0)	111 ^(7.9)	95 ^(11.0)	98 ^(5.3)	99 ^(9.3)	106 ^(13.0)
Extended midfacial translocation	Min ^(SD)	82 ^(28.0)	45 ^(13.0)	87 ^(20.0)	70 ^(27.0)	58 ^(23.0)	67 ^(42.0)	55 ^(26.0)	60 ^(21.0)
	Max ^(SD)	105 ^(14.0)	78 ^(7.6)	131 ^(20.0)	113 ^(3.0)	86 ^(13.0)	107 ^(23.0)	90 ^(18.0)	88 ^(9.0)
Bilateral midfacial translocation	Min ^(SD)	88 ^(13.0)	80 ^(17.0)	102 ^(7.6)	86 ^(12.0)	74 ^(15.0)	103 ^(20.0)	68 ^(5.5)	87 ^(10.0)
	Max ^(SD)	141 ^(9.0)	100 ^(7.1)	180 ⁽⁰⁾	125 ^(19.0)	104 ^(9.0)	127 ^(7.6)	116 ^(14.0)	107 ^(22.0)

ET, Eustachian tube; ICA, internal carotid artery; SD, standard deviation; N/A, not applicable.

Table 2 Depth of Exposure to Key Surgical Landmarks in Different Approaches (in Degrees)

Approach	Ipsilateral Pharyngeal ET Orifice	Contralateral Pharyngeal ET Orifice	Base of Pterygoid Process	Foramen Ovale	Styloid Process	Anterior Carotid Genu	Posterior Carotid Genu	Cervical ICA
Transtemporal	6.1 ^(0.4)	7.7 ^(0.7)	6.0 ^(2.0)	4.2 ^(0.8)	3.1 ^(1.2)	4.9 ^(0.6)	3.1 ^(0.5)	2.6 ^(N/A)
Transzygomatic	5.5 ^(0.8)	N/A	5.2 ^(0.9)	4.5 ^(1.0)	5.7 ^(0.8)	4.9 ^(0.4)	5.1 ^(0.7)	6.1 ^(N/A)
Transzygomatic with mandibulotomy	4.2 ^(0.3)	N/A	2.8 ^(1.0)	3.0 ^(1.3)	4.1 ^(0.8)	4.3 ^(1.1)	4.1 ^(1.8)	4.5 ^(1.7)
Standard midfacial translocation	4.0 ^(0.5)	5.9 ^(1.4)	3.2 ^(1.3)	3.7 ^(1.0)	4.6 ^(1.1)	4.9 ^(1.0)	4.8 ^(1.0)	5.2 ^(0.2)
Standard midfacial with mandibulotomy	3.8 ^(0.7)	5.3 ^(1.3)	3.1 ^(0.2)	3.3 ^(0.1)	4.4 ^(0.6)	4.0 ^(0.1)	4.0 ^(0.1)	3.8 ^(1.3)
Extended midfacial translocation	3.3 ^(1.1)	4.4 ^(1.6)	2.8 ^(1.0)	2.5 ^(0.6)	4.0 ^(0.4)	3.4 ^(0.7)	3.8 ^(0.7)	4.0 ^(0.4)
Bilateral midfacial translocation	2.5 ^(0.6)	2.8 ^(0.3)	1.4 ^(0.8)	2.8 ^(0.7)	4.4 ^(1.0)	3.4 ^(0.4)	3.9 ^(0.4)	4.3 ^(1.1)

ET, Eustachian tube; ICA, internal carotid artery; N/A, not applicable.

standard facial translocation as compared with 78 degrees with extended facial translocation. This difference was statistically significant ($p = 0.003$). The standard facial translocation was then compared with the transtemporal approach. The angles of structures in the petrottemporal region were comparable in both approaches; however, there was significant improvement in the angle of exposure of infratemporal structures with the facial translocation approach.

The ratios of tissue exposed to tissue displaced were similar for all approaches (ranging from 2 to 7) except the transzygomatic approach (Table 3). The transzygomatic approach was found to have an unfavorable ratio of 21.

Surgical exposure with facial translocation or transzygomatic approaches along with mandibulotomy revealed a significant improvement in the exposure of the surgical field below the maxillary occlusal plane. The median depth of exposure of the cervical ICA via a transzygomatic approach was improved from 6.1 cm to 4.5 cm by incorporating mandibulotomy. This improvement was also seen for standard translocation approaches with improvement in the depth from 5.2 cm to 3.8 cm. The measured differences in the depth of exposure were not statistically significant. However, the dif-

ference in the maximal angle of exposure of the cervical ICA was significant with the addition of mandibulotomy in both transzygomatic (median 116 vs 34 degrees) and midfacial translocation (106 vs 77 degrees) approaches.

DISCUSSION

The extracranial infratemporal fossa (EIF) is an anatomically compact space densely occupied by neurovascular and soft-tissue structures. The resulting complexity predictably leads to a wide array of benign and malignant tumors of neuronal, vascular, or muscular origin. In addition, lesions from neighboring structures may extend into this region because of numerous bordering foramina and fossae. Examples of encroaching lesions include meningiomas and trigeminal schwannomas extending from the cavernous sinus or middle cranial fossa, juvenile nasopharyngeal angiofibromas from the nasopharynx via the pterygopalatine foramen, chordomas and chondrosarcomas from the clivus, and carcinomas from the maxillary sinus and parotid neoplasm.⁷ Since the majority of these lesions are benign, surgical procedures that facilitate complete

Table 3 Area of Exposure (in square centimeter) Area of Displacement (in square centimeter) and E/D Ratio

	Transtemporal	Transzygomatic	Transzygomatic with Mandibulotomy	Standard Midfacial Translocation	Standard Midfacial Translocation with Mandibulotomy	Extended Midfacial Translocation	Bilateral Midfacial Translocation
Area exposed (in square centimeter)	7.4 ^(3.6)	6.6 ^(1.0)	28 ^(15.0)	31 ^(6.3)	51 ^(6.7)	53 ^(17.0)	94 ^(11.0)
Area displaced (in square centimeter)	28 ^(14.0)	135 ^(108.0)	164 ^(44.0)	107 ^(24.0)	184 ^(16.0)	123 ^(26.0)	164 ^(21.0)
E/D ratio	0.26	0.05	0.17	0.29	0.28	0.43	0.57
D/E ratio	3.78	20.45	5.86	3.45	3.61	2.32	1.74

E/D, exposed/displaced; D/E, displaced/exposed.

resection with acceptable morbidity are especially desirable. As preoperative tissue diagnosis may not always be possible, the approach must also be adaptable for radical resection should one encounter more aggressive pathology.

Three-dimensionally, the EIF can be perceived as an inverted pyramidal-shaped space with the apex directed inferiorly. Anatomic boundaries are delimited by the following structures. The superior margin is marked by the greater wing of the sphenoid and the zygomatic arch, along with the intervening imaginary plane. The level at the insertion of the medial pterygoid muscle at its attachment to the angle of the mandible marks the inferior border. The medial margin is formed by the lateral pterygoid plate, the tensor veli palatini muscle, and the anterior half of the medial pterygoid muscle and fascia. The lateral boundary is marked by the ascending ramus of the mandible. The anterior-posterior dimension extends from the maxillary tuberosity to the level of the anterior aspect of the parotid, posterior fibers of the medial pterygoid muscle, and the medial pterygoid fascial layer.⁸ The precise anatomy of this region has received significant attention in recent literature⁹ and was comprehensively described by Vrionis et al¹⁰ and Bejjani et al.⁴

Surgical procedures for exposure and access to the EIF can be broadly classified into two categories: transfacial or transtemporal. Transfacial approaches, popularized by Janeka,^{2,3} entail modular disassembly of facial subunits based on the site and extends to the desired surgical exposure. The design of the modular subunits follows developmental neurovascular territories, thereby insulating the essential structures within the boundaries of the subunits. Osteotomies delineate the margins of the subunits such that subsequent disarticulation and tissue dissection are accomplished with an intent to keep essential structures protected and relatively undisturbed. Reconstruction of the face is achieved by reassembly of the facial subunits with satisfactory aesthetic and functional outcomes. Transtemporal approaches, described by Fisch,¹ entail lateral access through the temporal bone for exposure to the skull

base and the contents of the infratemporal fossa. Variations of transfacial and transtemporal approaches are well described, with morbidity profiles generally paralleling the extent of bone removal and tissue dissection.^{2,5,8,11,12}

In planning resection of a lesion at the EIF, surgical maneuverability is important for adequate oncological resection and for the optimal aesthetic and functional outcome. Limited objective data are currently available comparing the efficacy and limitations of the various approach procedures. As such, the selected technique is often based on the preference or personal experience of the surgeon.^{2,13-15} In recent years, a growing body of literature has emerged to facilitate objective comparison of the various commonly selected procedures.^{6,12,14-19}

An early study quantifying the extent of operative exposure was reported by Honeybul et al,¹⁵ who measured the surgical "window of access" created by the orbitozygomatic infratemporal fossa approach (OIFA) for anterior and middle fossa lesions. Utilizing detailed cadaveric dissection, subtemporal exposure of intracranial targets was measured to quantify the boundaries of the surgical "window" created when incorporating a zygomatic osteotomy as an extension of the standard subtemporal or trans-sylvian approach. The authors assessed the depth from the surgical plane to the anatomic sites, while accounting for anticipated tissue retraction necessary to achieve the set exposure. Well-positioned osteotomies and disarticulations resulted in a more directed "line of vision" and, as such, the OIFA was shown to offer up to a 300% greater access when incorporating a lateral displacement of the zygoma.

Subsequently, three separate studies were performed at a single institution by Schwartz et al,²⁰ Spektor et al,²¹ and Horgan et al²² to quantify and compare various skull base approaches by measuring surgical access in terms of "area of exposure" and "surgical freedom." Schwartz et al studied the frontotemporal approach to assess the utility of an orbital rim osteotomy with or without the removal of the zygomatic arch. Their results

confirmed that removal of the orbital rim offered a statistically significant operative advantage, while further expansion osteotomies at the zygomatic arch offered no added surgical freedom. Spektor et al similarly quantified the area of exposure and surgical freedom for various far lateral approaches, while Horgan et al measured exposures obtained by a progressively widened petrosal approach. Though results of these studies generally confirm greater exposure with extending osteotomies, their findings also reveal that additional bony removal does not always correlate with improved surgical freedom in facilitating resection.

In a study by Gonzalez et al⁸ on extended orbitozygomatic approaches, the authors highlight the importance of angle of exposure as a key parameter in the assessment and comparison of the various surgical approaches. Their findings reveal that extended bony resection significantly improves exposure by widening the “angle of attack,” resulting in a decreased working distance and greater surgical maneuverability. Direct comparison of selected approaches revealed more appreciable variation in the angle of exposure, rather than in operative distance or surgical depth. The authors favor angle of exposure as a more clinically relevant factor to be appreciated when planning a surgical approach. The value of the angle of exposure was further validated by Cantore et al²³ and Day et al²⁴ who emphasized that increasing the available angles of exposure through osteotomies or bone removal is one of the tenets of contemporary cranial base surgery. Our study also corroborates this finding.

To extrapolate data obtained from anatomic cadaver studies to clinical practice it is necessary to combine a pathologic classification system and the data of surgical approaches which can safely access these subsites.²⁵ Kumar et al⁶ proposed a subdivision of the extracranial skull base into five compartments based on location of lesions. Viewed from the inferior surface of the base of the skull, the compartments are divided by imaginary lines that connect set anatomic landmarks as follows: a single central midline compartment is demarcated laterally by lines drawn from each medial pterygoid plate to

the edge of the foramen magnum. Lateral to this are infratemporal and petrottemporal compartments. These two compartments are separated by lines drawn from the medial pterygoid plate to the glenoid fossa. In a retrospective review of 56 skull base lesions, the authors were able to assign most of the lesions to one of these compartments. One of the limitations of this classification system is that the vertical dimension is omitted from the localization of a lesion. This is particularly important for large lesions, commonly seen in this location, which can often extend to the parapharyngeal space. We believe that subdividing the skull base compartments in a vertical plane at the maxillary occlusal plane improves clinical applicability of the classification system proposed by Kumar et al.⁶

By extrapolating the data from the present study to the modified pathologic skull base classification system described by Kumar et al⁶ it would be possible to develop an algorithm which may have direct clinical application. As observed in this study, those lesions in the infratemporal compartment are best approached by the standard facial translocation approach and those in the petrottemporal compartment by the transtemporal approach. When there is extension of the infratemporal lesion to the midline an extended facial translocation may be required. With extension of the lesion to a plane below the maxillary occlusal plane, additional mandibulotomy may be necessary.

Although an algorithm can be proposed based on these objective criteria, this system should at best serve as a guideline to choosing access procedures. The choice of procedure for a given lesion, however, should always rest on the judgment, skill, and experience of the operating surgeon.

The limitations of this study are similar to those inherent to all cadaveric models. The soft-tissue properties of fresh frozen cadaver heads are different from live dissection and, as such, would influence the measurements of tissue displacement and other parameters. Further, cadaveric heads are free of pathology, and therefore distortion of the anatomic structures by lesions cannot be determined in these studies.

CONCLUSION

Improved imaging capabilities enable surgeons to gain greater appreciation for the size and location of infratemporal fossa lesions, thereby enabling more detailed preoperative planning. Objective assessment of exposure and access provided by the various procedures effective within this region could lead to a useful guideline for choosing a surgical approach. By extrapolating the anatomic quantitative data with a modified pathologic skull base classification system, we have proposed an algorithm as a guideline for the selection of surgical approaches to the infratemporal region.

ACKNOWLEDGMENTS

This project was supported by an Association for Osteosynthesis research grant. We also thank Synthes Corporation, Paoli, PA, for providing the cadaver heads and technical assistance for the dissection.

REFERENCES

1. Fisch U. Infratemporal fossa approach to tumors of the temporal bone and base of skull. *J Laryngol Otol* 1978; 92:949-967
2. Janecka IP, Sen CN, Sekhar LN, Arriaga M. Facial translocation: a new approach to the cranial base. *Otolaryngol Head Neck Surg* 1990;103:413-419
3. Janecka IP. Classification of facial translocation approach to the skull base. *Otolaryngol Head Neck Surg* 1995;112:579-585
4. Bejjani GK, Sullivan B, Salas-Lopez E, et al. Surgical anatomy of the infratemporal fossa: the styloid diaphragm revisited. *Neurosurgery* 1998;43:842-853
5. Kennedy JD, Haines SJ. Review of skull base surgery approaches: with special reference to pediatric patients. *J Neurooncol* 1994;20:291-312
6. Kumar A, Valvassori G, Jafar J, Mafee M. Skull base lesions: a classification and surgical approaches. *Laryngoscope* 1986;96:252-263
7. Ruckenstein MJ, Denys D. Lateral skull-base surgery: a review of recent advances in surgical approaches. *J Otolaryngol* 1998;27:46-54
8. Gonzalez LF, Crawford NR, Horgan MA, Deshmukh P, Zabramski JM, Spetzler RF. Working area and angle of attack in three cranial base approaches: pterional, orbitozygomatic and maxillary extension of the orbitozygomatic approach. *Neurosurgery* 2002;50:550-555
9. Suhardja AS, Cusimano MD, Agur AMR. Surgical exposure and resection of the vertical portion of the petrous internal carotid artery: anatomic study. *Neurosurgery* 2001;49:665-670
10. Vrionis FD, Cano WG, Heilman CB. Microsurgical anatomy of the infratemporal fossa as viewed laterally and superiorly. *Neurosurgery* 1996;39:777-786
11. Aziz KMA, Sanan A, van Loveren HR, Tew JM, Keller JT, Pensak ML. Petroclival meningiomas: predictive parameters for transpetrosal approaches. *Neurosurgery* 2000;47:139-152
12. Arriaga MA. Transtemporal approaches. In: Janecka IP, Tiedemann K, eds. *Skull Base Surgery: Anatomy, Biology, and Technology*. Philadelphia: Lippincott-Raven; 1997: 221-242
13. Honeybul S, Neil-Dwyer G, Evans BT, Lang DA. The transzygomatic approach: an anatomic study. *Br J Oral Maxillofac Surg* 1997;35:334-340
14. Guinto G, Abello J, Molina A, et al. Zygomatic-transmandibular approach for giant tumors of the infratemporal fossa and parapharyngeal space. *Neurosurgery* 1999;45:1385-1398
15. Honeybul S, Neil-Dwyer G, Lees PD, Evans BT, Lang DA. The orbitozygomatic infratemporal fossa approach: a quantitative anatomical study. *Acta Neurochir (Wien)* 1996;138:255-264
16. Ammirati M, Bernando A. Analytical evaluation of complex anterior approaches to the cranial base: an anatomic study. *Neurosurgery* 1998;43:1398-1408
17. Fisch U, Pillsbury HC. Infratemporal fossa approach to lesions of the temporal bone and base of skull. *Arch Otolaryngol* 1979;105:99-108
18. Lello G, Statham P, Steers J, McGurk M. Craniofacial access to the anterior and middle cranial fossae and skull base. *J Craniomaxillofac Surg* 1997;25:285-293
19. Moore CE, Ross DA, Marentette LJ. Critical pathways in anterior cranial base surgery. *Otolaryngol Head Neck Surg* 1999;121:113-118
20. Schwartz MS, Anderson GJ, Horgan MA, Kellogg JX, McMenomey SO, Delshaw JB Jr. Quantification of increased exposure resulting from orbital rim and orbitozygomatic osteotomy via the frontotemporal transsylvian approach. *J Neurosurg* 1999;91:1020-1026
21. Spektor S, Anderson GJ, McMenomey SO, Horgan MA, Kellogg JX, Delshaw JB Jr. Quantitative description of the far-lateral transcondylar transtuberular approach to the foramen magnum and clivus. *J Neurosurg* 2000;92:824-831
22. Horgan MA, Anderson GJ, Kellogg JX, et al. Classification and quantification of the petrosal approach to the petroclival region. *J Neurosurg* 2000;93:108-112
23. Cantore G, Ciappetta P, Delfini R. Choice of neurosurgical approach in the treatment of cranial base lesions. *Neurosurg Rev* 1994;17:109-125

-
24. Day JD. Commentary on: Gonzalez LF, Crawford NR, Horgan MA, Deshmukh P, Zabramski JM, Spetzler RF. Working area and angle of attack in three cranial base approaches: pterional, orbitozygomatic, and maxillary extension of the orbitozygomatic approach. *Neurosurgery* 2002;50:555–557; discussion 555–557
 25. Som PM, Shugar JM, Parisier SC. A clinical-radiographic classification of skull base lesions. *Laryngoscope* 1979; 89:1066–1076