macrophages, multinucleated giant cells, and tissue fibrosis. Cholesterol granuloma is not associated with epithelial elements, which distinguishes this condition from cholesteatoma.[5,6] The patients described here had no history of trauma of the orbit.

Cholesterol granuloma of the frontal bone is a rare entity, typically involving the lateral part of the supraorbital ridge in middle-aged men.[2,3] McNab and Wright[5] reported 27 cases of orbitofrontal CG (24 men and 3 women) whose ages ranged from 25 to 68 years (mean, 43.7 years). Right and left orbits were equally affected in these cases. Few reports indicate any recurrence as assessed years after surgery.[2] The most common presenting symptom is proptosis and inferomedial displacement of the globe. Other symptoms include periorbital headache, diplopia, decreased vision, ptosis, and eyelid swelling. Computed tomography scan of the orbits typically reveals a cystic well-circumscribed homogeneous soft tissue mass (of the same density as the brain and lacking contrast-medium enhancement) in the superolateral bony orbit. An osteolytic defect, without a sclerotic bony margin, can be seen along with destruction of the outer table of the frontal bone. This slowly expanding lesion may cause gradual erosion of the bone and can eventually involve the orbit, frontal sinus, lacrimal fossa, and brain, showing a very large destructive mass with extensive intracranial and orbital extensions. A few patients had a small lytic lesion in the frontal bone without any associated soft tissue mass.[3,7] On MRI, CG is characterized by a non–contrast-enhancing lesion with high signal intensity on both T1- and T2-weighted images.[5,7] In the case reports presented here, however, patient 1 did not reveal bone erosion on CT scan, and patient 2 showed moderate signal intensity on T1-weighted images and high signal intensity on T2-weighted images. Both the image findings of the CT scan in patient 1 and MRI scan in patient 2 represent unusual presentations for CG.

The differential diagnosis of CG includes other homogeneous lesions with bone erosion that occur in the diploic space of the frontal bone, such as lacrimal gland carcinoma, aneurysmal bone cysts, dermoid or epidermoid cysts, cystic ossifying fibroma, eosinophilic granuloma, frontal sinus mucoceles, and metastasis.[1,3,5] Dermoids and epidermoids typically do not cause pain and classically have sclerotic bone margins on CT scan. Aneurysmal bone cysts are associated with hemorrhage, granulomatous inflammation, and bone destruction, but they typically occur in young children. A lacrimal gland carcinoma is usually associated with severe pain and irregular bony destruction. Cystic ossifying fibroma typically occurs in young patients and has a distinct sclerotic margin and scattered foci of calcification. Eosinophilic granuloma also usually occurs in young patients and produces an osteolytic lesion with irregular and sclerotic margins. Metastases to the frontal bone are usually painful and cause irregular bone destruction without expansion. Therefore, these typical clinical and radiologic features help to differentiate among most of these conditions to distinguish them from orbital CG prior to any surgical interventions.[3] However, few patients with CG can be correctly diagnosed presurgically because of the extremely rare occurrence of this condition. Usually, the presumed diagnosis is made during surgery with the observation of a cyst containing yellow-brown viscous materials, friable yellow solid materials, and porous bone erosion. The final diagnosis in our patients was confirmed by histopathology examination of the submitted tissue. The absence of squamous- or respiratory-type epithelium of the cyst led to the diagnosis of CG. The fluid from the cyst was remarkable for numerous inflammatory cells, blood breakdown products, multinucleate giant cells, and cholesterol crystals.

Orbitofrontal CG requires surgical excision. After exposure of the lesion by anterior orbitotomy through subbrow incision, treatment for most of these patients involves aspiration of the contents and curettage of the lining with an extraperiosteal approach.[1–5] It is not necessary to resect a wide margin of the surrounding bone. Patients with large masses extending into the lateral quadrant of the orbit or anterior cranial fossa may require lateral orbitotomy or frontal craniotomy for better exposure and complete removal of the lesion.[2] An endoscopic approach to orbitofrontal CG has been proposed, especially in lesions with intracranial extension.[2,8] A 70-degree rigid endoscope approach was used to visualize and remove the granulomaous tissue from the inner surface of frontal bone and dura. As an alternative, a combined anterior orbital and endoscopic approach may be used as opposed to either frontal craniotomy or lateral orbitotomy in selected cases of orbitofrontal CG. Severe cases with great deformity of the skull bone involving cosmetic problems may require reconstruction after complete removal of the lesion. In our cases, the patients were subjected to anterior orbitotomy through subbrow incision. Surgical excision is successful, with a low incidence of recurrence. In order to prevent recurrence, the granulomaous lesion must be removed completely.

In summary, orbital CG is a rare entity that has a predilection for men in their fourth decade and usually occurs within the frontal bone overlying the lacrimal fossa. Both ultrasonic examination and CT/MRI of the orbits reveal a cystic lesion that may erode the bony structure including orbital roof, frontal sinus, and cranial base. Computed tomography scan may reveal no bone erosion, and MRI scan may show moderate signal intensity on T1-weighted images. Anterior orbitotomy through subbrow incision by drainage and curettage is curative in all reported cases, and a low incidence of recurrence is observed. Histopathologic analysis reveals numerous inflammatory cells, blood degradation products, and cholesterol clefts. The absence of epithelial elements led to the diagnosis of CG.

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Application of a Computer-Aided Navigation Technique in Surgery for Recurrent Malignant Infratemporal Fossa Tumors

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Background: Because of the complexity of the local anatomy, tumors in the infratemporal fossa present a great challenge to oral and maxillofacial surgeons. Recurrent malignant tumors in this area are particularly difficult and precarious to resect because scars from previous operations may dislocate some important structures.

Methods: From August 2010 to December 2013, all recurrent cases of malignant infratemporal fossa tumors at Peking University Stomatological Hospital were enrolled in this study. The patients were divided into 2 groups: the navigation group and the nonnavigation group, with different managements. The following factors were evaluated: operation time, bleeding volume, tumor size, surgical approach and complications, follow-up survey, and outcomes. In addition, survival analyses were performed for all patients.

Results: In total, 42 patients were investigated. The mean operation time for the navigation group was not significantly longer than that of the nonnavigation group (283.64 versus 252.10 min, respectively; $P = 0.393$); the group's mean intraoperative bleeding volumes were similar (536.36 versus 503.87 mL, respectively; $P = 0.814$). The surgical approach was determined and categorized as an inferior approach (transmandibular approach, with or without splitting of the mandible), anterior approach (transmaxillary approach), lateral approach (subtemporal-preauricular approach), or combined approach. The inferior approach was most frequently used in both groups (ie, 63.6% for the navigation group and 80.6% for the nonnavigation group). The tumors were completely resected in 4 patients from the navigation group and 24 patients from the nonnavigation group. Regarding complications in the navigation and nonnavigation groups, the incidence was not significantly different (27.2% versus 41.9%, respectively; $P = 0.485$). The 3-year survival for patients in the navigation group was 71.6% compared with 52.9% in the nonnavigation group, with no significant difference. In the survival analysis, no significant factor was determined.

Conclusions: A computer-aided navigation technique has been successfully introduced to resect infratemporal fossa tumors and was successfully applied to the resection of recurrent malignant tumors. This new technique alone does not determine the outcome of patients with recurrent malignant infratemporal fossa tumors. Although some improvements are necessary, the visible navigation during surgery could increase the accuracy and safety of the operations and enhance surgeon confidence.

Key Words: Infratemporal fossa, recurrent tumor, navigation technique, survival

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The infratemporal fossa is located deep to the ramus of the mandible and the zygomatic arch and is adjacent to the lateral pterygoid plate and the medial wall. It contains the deep lobe of the parotid gland, lateral pterygoid muscle, medial pterygoid muscle, styloid muscles, internal carotid artery, and cranial nerves IX to XII. These important structures are easily damaged because of excessive exposure during surgery. Malignant tumors in the infratemporal fossa are usually too close to the internal carotid artery or to the bone to be resected; hence, these tumors have a considerable recurrence rate. At the same time, recurrent malignant tumors in this area are even more difficult and dangerous to resect because some of the important local structures may be dislocated by scars from previous operations.[1–3]

Computer-assisted preoperative planning based on three-dimensional image reconstruction considerably assists oral and maxillofacial surgeons in comprehending the location of vital anatomic structures in the skull base and infratemporal fossa. In this manner, the best approach can be chosen, and the plan can then be translated into the operating room where it can be used in conjunction with image-guided navigation.[4] The application of a computer-aided navigation technique could increase accuracy and reduce the risks inherent in the surgery; this technique has already been used to resect neoplasms in the skull base.[5] In 2010, the intraoperative computer-aided navigation system was introduced to our department, and more than 40 patients with infratemporal fossa tumors have been surgically treated using this new technique. This study reviews patients with recurrent malignant tumors of the infratemporal fossa who were surgically treated with computer-aided navigation and discusses the advantages and disadvantages of this new technique.

MATERIALS AND METHODS

Object of the Study

This study was approved by the institutional review board of Stomatological Hospital of Peking University. From August 2010 to December 2013, all patients with recurrent malignant tumors of the infratemporal fossa at Peking University Stomatological Hospital were enrolled in this study. The inclusion criteria were recurrent malignant tumor of the infratemporal fossa close to the skull base and surgical treatment with or without computer-assisted preoperative planning and intraoperative navigation. Patients without follow-up were excluded. The patients were divided into 2 groups—the navigation group and the nonnavigation group—based on the different management styles.

Hardware and Software

Sixteen-slice spiral computed tomography (CT) (Siemens, Germany), computer-aided navigation and IPlan systems (BrainLab, Germany), and IBM SPSS version 19.0 software (SPSS Corp, United States of America) were used.

Preoperative Preparation

Patients in the nonnavigation group underwent conventional surgery, whereas those in the navigation group underwent the following procedures.

Acquisition of Three-Dimensional Reconstruction Data

We used an enhanced CT scan (scan range, from cranial vault to clavicle; scan layer thickness, 1.25 mm). To ensure the accuracy and reproducibility of the position of the mandible, all patients were asked to maintain a central position during the CT scan. The data were stored in an international standard format (DICOM 3.0).

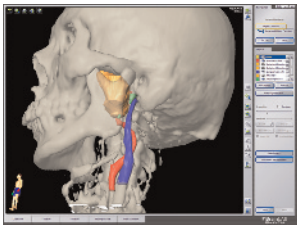

FIGURE 1. The three-dimensional reconstructed images calculated by the IPlan system. The tumor (yellow), styloid process (green), internal carotid artery (red), and jugular vein (blue) have been reconstructed.

Three-Dimensional Image Reconstruction of Vital Structures

The data in a DICOM format were imported into the IPlan system, and using the reconstruction module, we outlined the border of a specific structure (eg, the maxilla, mandible, styloid process, pterygoid process, internal carotid artery, and jugular vein) and the tumor in different colors. The unusable data were discarded, and the three-dimensional reconstructed images were automatically calculated by the system (Fig. 1).

Computer-Simulated Surgical Design

After observing the spatial position of the vital structures, the most appropriate operative approach was chosen. In the virtual surgery module of the IPlan system, the reconstructive image was separated and moved to simulate the surgical procedure. To obtain the best design, at least 2 plans were tested. In the design, the extent of the tumor should be outlined using the principles of malignant tumor resection, whereas the safety of the main blood vessels and the limit of osteotomy should also be considered (Fig. 2).

Computer-Aided Navigation Surgery

The preoperative design data were imported into the BrainLab navigation system. The digital reference frame with 3 small reflective balls was fixed on the parietal bone of the patient, and the details of the soft tissue were detected by the sensor using a laser scan of the facial surface by Z-touch. The BrainLab system automatically matches the details of the soft tissue with the preoperative design; then, a verification and comparison were performed with a series of marked points in both the hard and soft tissues. This procedure usually requires several repeats to be matched with the appropriate design. The operation was performed on the basis of the selected navigation plan, and as necessary, the navigation probe was used to indicate the dynamic position to avoid damaging the vital structures and to remove the tumor as precisely as possible (Figs. 3, 4).

Evaluating Factors

The following data were collected: patients' sex, age, duration of operation, volume of bleeding, size of the tumor, surgical

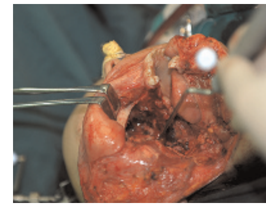

FIGURE 3. Intraoperative navigation with a probe to indicate the tumor border.

approach, defects and reconstruction, complications, and prognosis. The data were analyzed using SPSS software. A $P < 0.05$ was considered to be statistically significant. A Kaplan-Meier survival curve was generated for each group; these curves were compared using the log-rank test. A Cox multivariate proportional hazard model was used to identify the variables. All statistical analyses were performed using SPSS for Windows, version 19.0.

RESULTS

Clinical Characteristics of the Patients

A total of 42 patients were enrolled in the study (11 patients in the navigation group and 31 patients in the nonnavigation group; Table 1). The mean age, duration until tumor recurrence, and tumor size (ie, the maximum diameter of the tumor) between the 2 groups were not significantly different (Table 2).

Intraoperative and Postoperative Outcomes

The 42 patients underwent surgery under general anesthesia, and the surgeons were chief physicians or professors in our department. The mean operation time for the navigation group (283.64 min) was not significantly longer than that of the nonnavigation group (283.64 versus 252.10 min, respectively; $P = 0.393$); the mean intraoperative bleeding volume for the navigation group was slightly less than that for the nonnavigation group, but this difference was not significant (536.36 versus 503.87 mL, respectively; $P = 0.814$). The surgical approaches were determined and divided into 4 categories: the inferior approach (transmandibular approach with or without the splitting of the mandible), anterior approach (transmaxilla approach), lateral approach (subtemporal-preauricular approach), and combined approach. The inferior approach was the most frequently used approach in both groups (63.6% in the navigation group and 80.6% in the nonnavigation group). The tumors were completely resected in 4 patients in the navigation group and in 24 patients in the nonnavigation group. In comparison, fewer complications occurred in the navigation group than in the nonnavigation group, but the incidence of complications in the 2 groups was not significantly different (27.2% versus 41.9%, respectively; $P = 0.485$). The mean follow-up duration of the 2 groups was 10 and 13.39 months ($P = 0.139$). The 3-year survival of patients in the navigation group was 71.6% compared with 52.9% in the nonnavigation

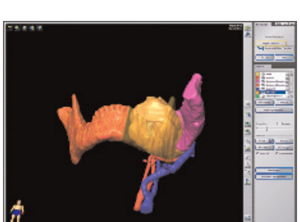

FIGURE 2. Preoperative planning: a mandibular split approach was designed to expose the tumor.

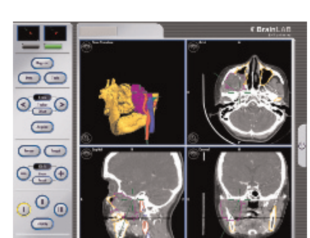

FIGURE 4. The navigation screen shows the visible image of the tumor and provides real-time status of the tumor resection.

TABLE 1. General Information of the 42 Patients

No.	Group	Sex	Age	Duration Until Recurrence, y	Preoperative Therapy	Operation Approach	Operation Time, min	Intraoperative Bleeding Volume, mL	Tumor Size, cm	Resection Completeness	Pathologic Diagnosis	Complications	Postoperative Therapy	Follow-Up Duration, mo	Recurrence	Patient Mortality
1	Nonnavigation	F	40	2	–	I	285	1000	5	No	Osteosarcoma	Vision decrease	–	6	Yes	Alive
2	Nonnavigation	F	34	0.5	–	A	190	1300	8	Yes	Malignant pleomorphic adenoma	–	R	12	No	Alive
3	Nonnavigation	M	33	0.1	–	A	300	2200	5	Yes	Clear cell carcinoma	Subcutaneous emphysema	–	12	No	Alive
4	Nonnavigation	F	48	1	–	I	290	400	8	Yes	Osteosarcoma	Facial paralysis	–	15	No	Alive
5	Nonnavigation	F	39	0.5	–	I	170	350	6	Yes	Chondrosarcoma	–	–	24	No	Alive
6	Nonnavigation	M	35	0.5	–	I	330	770	7	Yes	Well-differentiated mucoepidermoid carcinoma	–	R	24	No	Alive
7	Nonnavigation	M	60	0.1	–	I	120	200	6	Yes	Epithelial-myoepithelial carcinoma	–	–	20	No	Alive
8	Nonnavigation	F	49	0.3	–	I	450	500	6	Yes	Malignant pleomorphic adenoma	Middle ear effusion	–	12	Yes	Dead
9	Nonnavigation	F	54	0.5	–	I	375	350	5	Yes	Adenoid cystic carcinoma	–	R	17	No	Alive
10	Nonnavigation	F	66	0.5	–	C	165	600	4	Yes	Squamous cell carcinoma	–	R	12	Yes	Alive
11	Nonnavigation	M	49	0.8	R	I	90	350	5	No	Malignant pleomorphic adenoma	–	R	12	No	Alive
12	Nonnavigation	F	56	0.3	–	C	250	600	4	No	Malignant fibrous histiocytoma	–	–	12	Yes	Dead
13	Nonnavigation	M	43	0.5	–	I	200	230	4	Yes	Squamous cell carcinoma	–	R	12	Yes	Alive
14	Nonnavigation	M	68	0.5	–	I	270	350	6	Yes	Squamous cell carcinoma	–	R	12	No	Alive
15	Nonnavigation	M	40	1	R & C	I	190	300	8	Yes	Ductal carcinoma of parotid gland	Wound infection	–	24	No	Dead
16	Nonnavigation	M	11	0.3	–	I	180	200	2	No	Epithelial-myoepithelial carcinoma	–	R	24	Yes	Alive
17	Nonnavigation	M	55	0.2	–	I	330	500	4	Yes	Poorly differentiated mucoepidermoid carcinoma	Pneumonia	–	12	Yes	Dead
18	Nonnavigation	M	48	0.3	–	C	180	300	5	Yes	Epithelial-myoepithelial carcinoma	–	–	36	No	Alive
19	Nonnavigation	M	34	3	R	I	210	150	4	Yes	Rhabdomyosarcoma	–	R	12	No	Dead
20	Nonnavigation	F	17	0.3	–	I	220	200	5	Yes	Liposarcoma	Facial paralysis	R	6	Yes	Alive
21	Nonnavigation	M	62	0.3	–	I	345	500	3	Yes	Squamous cell carcinoma	Facial paralysis	–	24	No	Alive
22	Nonnavigation	F	56	0.4	–	I	170	220	5	No	Malignant pleomorphic adenoma	Mouth-opening limitation	R	4	Yes	Dead
23	Nonnavigation	M	72	3	–	I	180	400	5	Yes	Epithelial-myoepithelial carcinoma	–	R	12	Yes	Dead
24	Nonnavigation	M	42	0.2	R & C	I	195	200	5	Yes	Squamous cell carcinoma	–	R	6	Yes	Dead
25	Nonnavigation	F	21	0.1	–	I	210	400	4	No	Rhabdomyosarcoma	–	R	12	Yes	Dead
26	Nonnavigation	M	47	0.1	–	I	330	550	4	Yes	Epithelial-myoepithelial carcinoma	Mouth-opening limitation	–	12	Yes	Dead
27	Nonnavigation	M	55	0.25	–	I	120	100	3	Yes	Squamous cell carcinoma	–	–	4	No	Alive
28	Nonnavigation	M	64	3	–	I	260	1000	7	Yes	Rhabdomyosarcoma	Fracture of titanium plate	–	5	No	Alive

TABLE 1. (Continued)

No.	Group	Sex	Age	Duration Until Recurrence, y	Preoperative Therapy	Operation Approach	Operation Time, min	Intraoperative Bleeding Volume, mL	Tumor Size, cm	Resection Completeness	Pathologic Diagnosis	Complications	Postoperative Therapy	Follow-Up Duration, mo	Recurrence	Patient Mortality
29	Nonnavigation	M	46	5	–	L	420	600	17	Yes	Well-differentiated mucoepidermoid carcinoma	Sialosyrinx	–	4	No	Alive
30	Nonnavigation	M	64	1.2	R	I	390	600	10	No	Squamous cell carcinoma	Upper gastrointestinal bleeding	–	7	No	Alive
31	Nonnavigation	M	65	0.2	–	I	400	200	3	Yes	Squamous cell carcinoma	–	–	9	No	Alive
32	Navigation	F	29	6	–	I	190	1000	7	No	Synovial sarcoma	–	R	6	Yes	Alive
33	Navigation	M	50	19	R	A	240	450	7	No	Osteosarcoma	–	–	4	Yes	Dead
34	Navigation	F	50	4	c	A	205	450	7	No	Osteosarcoma	–	–	5	Yes	Alive
35	Navigation	F	61	0.8	–	I	510	1200	10	No	Malignant peripheral nerve sheath tumor	–	–	5	Yes	Dead
36	Navigation	F	21	5	R	A	210	200	7	No	Malignant meningioma	Leakage of CSF	–	12	Yes	Alive
37	Navigation	F	22	5	R	I	350	500	8	no	Liposarcoma	–	–	6	Yes	Dead
38	Navigation	F	51	0.5	R & C	I	480	350	5	Yes	Acinar cell carcinoma	Facial paralysis	–	12	No	Alive
39	Navigation	M	43	0.2	–	C	150	500	4	Yes	Ameloblastic carcinoma	–	R	12	No	Alive
40	Navigation	M	45	0.1	–	I	195	400	3	No	Malignant pleomorphic adenoma	–	R	12	Yes	Alive
41	Navigation	M	18	0.3	–	I	195	350	7	Yes	Malignant hibernoma	Injury of the hypoglossal nerve		12	No	Alive
42	Navigation	F	75	8	–	I	395	500	6	Yes	Clear cell carcinoma	–	–	24	No	Alive

C, chemotherapy; CSF, cerebrospinal fluid; F, female; M, male; R, radiotherapy.

TABLE 2. Clinical Characteristics of the Patients

Patient Characteristics	Navigation Group, N = 11	Nonnavigation Group, N = 31	*P*
Age, mean (range), y	42.27 (18–75)	47.52 (11–72)	0.352
Sex, M/F	4/7	20/11	0.159
Maximum diameter, cm	6.45 (1.916)	5.58 (2.742)	0.337
Mean recurrent duration, y	4.45	0.86	0.06

group, with no significant differences ($P = 0.936$). The intraoperative and postoperative outcomes are summarized in Table 3.

Survival Analysis

All 42 patients were followed, and the mean and median follow-up times were 12.5 and 12 months (range, 4–36 mo). The mean survival was 25.739 months. In the univariate analysis, no significant difference was found in the following factors: group ($P = 0.936$), sex ($P = 0.625$), age ($P = 0.385$), complications ($P = 0.832$), and tumor size ($P = 0.547$). The same result was found after a multivariate analysis. The 3-year survival rate in cases in which the tumor was completely resected was 61.8%, and it was 47.1% ($P = 0.052$) in cases in which the tumor was incompletely resected. In the multivariate analysis, the *P* value was 0.100. Although no absolute statistical significance was found ($P < 0.05$), the completeness of the tumor resection was regarded as a factor that influenced survival. The 3-year survival rate of patients with carcinoma was 62.3% compared with 45.0% ($P = 0.110$) in patients with sarcoma, with no significant difference (Table 4).

DISCUSSION

Tumors located in the infratemporal fossa are difficult to expose and are often close to several vital anatomic structures. Recurrent malignant tumors in this region are varied in pathologic type (in this study, there were 16 different pathologic diagnoses). The adhesion of local tissues, the dislocation of blood vessels, and the difficulty of the next surgery are greatly increased by previous surgeries. In particular, it is necessary to establish the relationship between the tumor and the local structures. An enhanced CT scan might show the shape of the blood vessels and of the tumor, and it is now frequently used during preoperative examinations of infratemporal tumors. Although some CT machines have supporting three-dimensional analysis software and could achieve an image reconstruction of the bones and blood vessels, tumors are generally not well reconstructed. We require additional assistance from a computer-aided analysis software to obtain the three-dimensional reconstructed image.[6–8]

Computer-reconstructed three-dimensional images of the tumor have a strong stereoscopic effect and clearly show the spatial position, which substantially contributes to the surgical approach.[9] The intraoperative computer-aided navigation increases the accuracy of the operation and reduces damage and complications, which reduces the difficulty of the operation.[5] The BrainLab navigation and IPlan systems have already been used in the area of oral and maxillofacial surgery in our department. They indicate the surgical approach and provide visible navigation throughout the surgical procedure, which increases operation safety and enhances the confidence of the surgeons.[10]

On the basis of this study, it seems that the computer-aided navigation technique cannot effectively improve a patient's prognosis, and as a new technique, it has been successfully introduced into surgeries of the infratemporal fossa area. Although many additional procedures are performed during the operation, such as fixing the digital reference frame and registration, the total time cost was not longer than that of conventional operations.

Compared with the nonnavigation group, the incidence of complete tumor resection was significantly lower in the navigation group ($P = 0.024$), but the technique itself should not be given all the credit. A phenomenon was found in that there was no recurrence in any of the patients in the navigation group, in which the tumor was completely removed. However, there was considerable recurrence in the nonnavigation group (Table 3). During the preoperative planning, we outlined the border of the tumor and the safe distance, and with the help of the navigation system, the tumors were resected more completely than if the navigation system had not been used.

However, the most obvious disadvantage of the computer-aided navigation is the drifting of soft tissues, which puzzled many surgeons. In contrast to hard tissues, soft tissues are easily shifted during surgery because of traction and exposure. Consequently, the location of soft tissues can only be estimated and, of course, was not determined using the navigation system.[11,12] As for the resection of tumors in the infratemporal fossa, the principal threat is the drifting of the internal carotid artery. Hence, an experienced surgeon should never entirely depend on a computerized system and neglect the importance of manual regulation.[10] In the navigation, only the bony structure images (eg, the mandible in the center occlusion) can be determined with confidence because they are relatively stable with respect to the digital reference frame. An

TABLE 3. Intraoperative and Postoperative Outcomes

Variable	Navigation Group (N = 11), n	Nonnavigation Group (N = 31), n	*P*
Operation time, min	283.64	252.10	0.393
Intraoperative bleeding, mL	536.36	503.87	0.814
Operation approach, n (%)			
Inferior	7 (63.6)	25 (80.6)	–
Anterior	3 (27.3)	2 (6.5)	–
Lateral	0 (0)	1 (3.2)	–
Combined	1 (9.1)	3 (9.7)	–
Tumor resection			
Completely	4	24	0.024
Incompletely	7	7	
Complications, n (%)	3 (27.2)	13 (41.9)	0.485
Follow-up duration, mean (range), mo	10.00 (4–24)	13.39 (4–36)	0.139
Recurrent case and rate, n (%)	7 (63.6)	13 (41.9)	0.216
Recurrent rate of tumor in cases of complete resection, n (%)	0 (0)	8 (33.3)	–
3-y survival, %	71.6	52.9	0.936

TABLE 4. Survival Analysis

Factors (N = 42)	3-Year Survival	*P*	Hazard Ratio (95% CI)	*P*
Group				
Navigation (n = 11)	0.716	0.936	0.737 (0.187–2.903)	0.663
Nonnavigation (n = 31)	0.529			
Sex				
Male (n = 24)	0.557	0.625	1.780 (0.327–9.685)	0.505
Female (n = 18)	0.603			
Age				
≤40 (n = 13)	0.718	0.385	0.266 (0.053–1.346)	0.109
>40 (n = 29)	0.471			
Complications				
Yes (n = 16)	0.328	0.832	0.611 (0.135–2.776)	0.524
No (n = 26)	0.652			
Tumor max diameters				
≤5 cm (n = 22)	0.567	0.547	0.950 (0.253–3.564)	0.940
>5 cm (n = 20)	0.614			
Resection completeness				
Yes (n = 28)	0.618	0.052	3.054 (0.809–11.534)	0.100
No (n = 14)	0.471			
Pathologic type				
Carcinoma (n = 27)	0.623	0.110	0.221 (0.033–1.503)	0.123
Sarcoma (n = 15)	0.450			

intraoperative image system may supply real-time navigation of soft tissues, but it has not been widely used because of the high cost and the x-ray exposure.[5] Whenever navigation is performed, the shifted bone block must be placed in the previous position to minimize operation error.

CONCLUSIONS

Preoperative planning and an intraoperative computer-aided navigation technique have been successfully introduced for the resection of tumors in the infratemporal fossa. This technique is even more valuable for recurrent malignant tumors of this region. It provides a visible image of the tumor and the surrounding vital structures and could help surgeons remove tumors as precisely as possible. Although some aspects of this system could be improved, the visible navigation during such surgeries could increase surgical accuracy and safety and increase surgeon confidence.

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Imaging Findings and Clinical Features of Intracal Lymphoplasmacyte-Rich Meningioma

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Purpose: The purpose of this study was to analyze the imaging findings and clinical features of intracal lymphoplasmacyte-rich meningioma.

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