

Use of Cross-Sectional Imaging in Predicting Surgical Location of Parotid Neoplasms

Vasu Divi, BA,* Michael A. Fatt, BS,* Theodoros N. Teknos, MD,* and Suresh K. Mukherji, MD†

Objective: The purpose of this study was to determine the diagnostic accuracy of using the retromandibular vein as seen on cross-sectional imaging to help differentiate superficial lobe from deep lobe tumors.

Methods: Of the patients who had parotid neoplasms between January 1997 and July 2002, we were able to identify 44 patients with preoperative imaging studies that were available for evaluation. The films were reviewed by a single head and neck radiologist to determine whether the neoplasms involved the superficial, deep, or both lobes of the parotid gland (total). The lateral margin of the retromandibular vein was used as a marker for the facial nerve, since the nerve is not always visible on CT and MRI scans. The radiologist's findings were then compared with the findings during surgery. The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of predicting the location of neoplasms were then calculated.

Results: For lesions in the superficial lobe, cross-sectional imaging was able to predict the location of the neoplasm with a sensitivity of 0.91 (95% CI, 0.70–0.98), specificity of 0.86 (95% CI, 0.63–0.96), PPV of 0.88 (95% CI, 0.67–0.97), and NPV of 0.90 (95% CI, 0.67–0.98). For lesions in both lobes (total), cross-sectional imaging was able to predict the location of the neoplasm with a sensitivity of 0.94 (95% CI, 0.68–0.99), specificity of 0.89 (95% CI, 0.71–0.97), PPV of 0.83 (95% CI, 0.58–0.96), and NPV of 0.96 (95% CI, 0.78–0.99).

Conclusion: Use of the retromandibular vein as a marker for the facial nerve is a sensitive method for identifying the location of parotid gland neoplasms on cross-sectional imaging. This supports the accuracy of using preoperative imaging to detect the position of parotid neoplasms with respect to the facial nerve.

Key Words: parotid gland, computed tomography, magnetic resonance, neoplasms

(*J Comput Assist Tomogr* 2005;29:315–319)

Received for publication August 31, 2004; accepted February 28, 2005.

From the *Department of Otolaryngology-Head & Neck Surgery, University of Michigan Medical Center, Ann Arbor, Michigan and †Department of Radiology, Division of Neuroradiology, University of Michigan Medical Center, Ann Arbor, Michigan.

Presented at The American Society of Head & Neck Radiology 37th Annual Meeting, Rancho Mirage, CA; October 2, 2003.

Reprints: Vasu Divi, 1904 Taubman Center, 1500 E. Medical Center Drive, Ann Arbor, MI 48105-0312 (e-mail: vasudivi@med.umich.edu).

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The parotid gland is divided into a deep and a superficial lobe by the facial nerve. This distinction has important implications in neoplasms of the parotid gland. The location of lesions in either the superficial, deep, or both lobes determines the surgical procedure that will be performed and influences the risk of complications. Benign lesions isolated to the superficial lobe can be treated with superficial parotidectomy, with minimal manipulation of the facial nerve. Malignant superficial lesions and lesions extending into the deep lobe usually require total parotidectomy, involving more risk to the facial nerve, longer operative time, and possibly a different surgical approach. Currently, routine preoperative imaging is not consistently used to determine the location of parotid neoplasms.

The parotid segment of the facial nerve courses just lateral to the lateral margin of the retromandibular vein. The facial nerve divides into its terminal branches at approximately the level of the soft palate. At this level, the branches of the facial nerve form a plane that separates the parotid gland into superficial and deep lobes (Fig. 1). The vein can be consistently seen on contrast-enhanced computed tomography (CT) or magnetic resonance imaging (MRI) within the substance of the parotid gland.

One of the limitations of imaging is that the facial nerve cannot be directly visualized; therefore, alternative landmarks must be used to predict its location within the gland. There have been a variety of methods proposed in the literature for tracing the facial nerve and differentiating the superficial from the deep lobe. Conn et al described an arc that extends 8.5 mm in each direction from the most posterior point of the ramus of the mandible based on a cadaveric study.¹ Ariyoshi and Shimahara described the facial nerve line, which extends from the lateral surface of the posterior belly of the digastric muscle to the lateral surface of the ascending ramus.² The spatial relationships of various soft tissue structures have been examined as well, including the retromandibular vein, Stensen duct, the styloid process, and vertebrae.^{3,4}

The purpose of our study was to assess the ability of CT and MRI to localize neoplasms within the parotid gland using the retromandibular vein as a marker for the facial nerve.

MATERIALS AND METHODS

This study was approved by the Institutional Review Board (#2002-0364) at our institution. Our study was a retrospective review of all patients with parotid neoplasms seen at our hospital between January 1997 and July 2002. A list of patients was generated by the department of

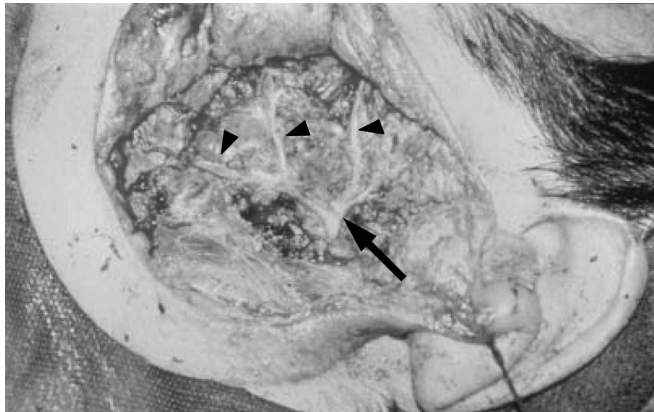


FIGURE 1. Surgical dissection during a superficial parotidectomy shows the pes anserinus (large arrow) along with the terminal branches of the facial nerve (arrowheads). The plane of the nerve divides the parotid gland into superficial and deep lobes.

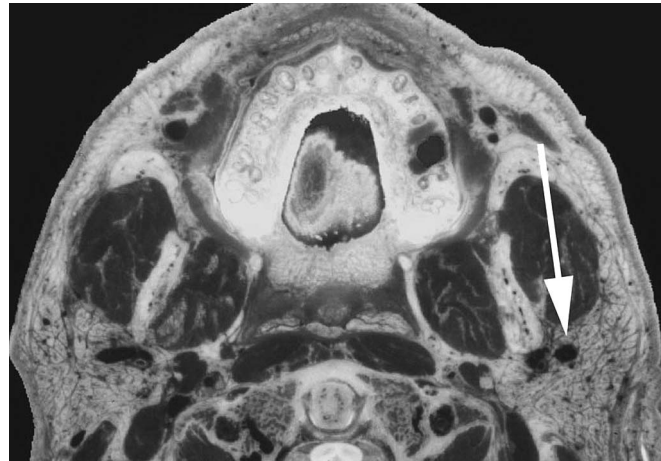


FIGURE 2. Cadaveric cross-sectional anatomy of parotid gland and retromandibular vein. Retromandibular vein is indicated by large white arrow.

Otolaryngology and a searchable database of pathology results at our institution. This list of patients was cross-referenced against radiology records to determine which patients had received preoperative CT or MRI scans. We identified 44 patients as having had a parotid tumor and preoperative imaging available at our institution or an outside hospital. The lesions were localized to either the superficial and/or deep lobe of the parotid gland. Lesions that were isolated to the tail of the parotid gland were excluded from this study.

There were 29 males and 15 females entered into the study. Of the 44 patients, 35 were evaluated with a preoperative CT and 9 patients were evaluated with a preoperative MRI. CT was performed utilizing 3–5 mm thick, contiguous axial images obtained from the skull base down to the thoracic inlet after IV contrast administration (150 cc Omnipaque-300). Only soft tissue windows were reviewed. MRI was performed with a 1.5 Tesla GE magnet with axial T1- and T2-weighted images, in addition to sagittal and coronal T1-weighted images. Axial T1-weighted post-contrast images were performed with and without fat suppression. In all studies, sufficient contrast was administered to allow for enhancement of the retromandibular vein.

All images were reviewed by a single, experienced head and neck radiologist. The radiologist was blinded to the surgical outcomes and operative findings. The plane of the retromandibular vein running anterior to posterior through the substance of the parotid gland was used as a marker for the facial nerve (Fig. 2). Lesions located lateral to the lateral margin of the retromandibular vein or lesions that displaced the vein medially were predicted to be located in the superficial lobe. Lesions found medial to the medial margin of the retromandibular vein or that displaced the vein laterally were predicted to be located in the deep lobe. Lesions on both sides of the actual or expected position of the vein were classified as “total” lesions, and involved both lobes. Lesions involving the caudal aspect of the gland and located within the tail of the parotid gland were not evaluated in our study.

Nineteen superficial parotidectomies, 3 deep lobe parotidectomies, and 22 total parotidectomies were performed. In all cases, a tissue diagnosis was obtained by frozen section and later confirmed on permanent review by the Pathology Department. Table 1 lists the pathology of the lesions. The surgical location of each lesion was determined based on the operative findings of the attending surgeon. The surgical results were compared with the radiologist’s predictions, and the results were used to calculate the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of using preoperative imaging.

RESULTS

A summary of our results is presented in Table 2. Twenty-three patients had lesions at surgery that were isolated to the superficial lobe, 5 patients had a lesion isolated to the deep lobe, and 16 patients had a lesion that involved both lobes (Fig. 3).

Of the 23 patients with tumors in the superficial lobe, 21 were correctly diagnosed by CT or MRI. Two of the lesions

TABLE 1. Pathology of Parotid Lesions

Benign lesions	15
Pleomorphic adenoma	11
Warthin tumor	4
Malignant lesions	29
Acinic cell CA	1
Adenocarcinoma	1
Anaplastic	1
Basal cell CA	1
Melanoma	4
Mucoepidermoid	5
Squamous cell CA	12
Undifferentiated	4
Total	44

TABLE 2. Results of Radiological Verses Surgical Findings

Surgical Location	No. pts	Radiologic Prediction		
		Superficial	Total	Deep
Superficial	23	21	2	—
Total	16	1	15	—
Deep	5	2	1	2

located in the superficial lobe at surgery were predicted to be located in both lobes based on imaging (Fig. 4). This yielded a sensitivity of 0.91, specificity of 0.86, PPV of 0.88, and NPV of 0.90.

Of the 5 patients with tumors in the deep lobe, 2 were correctly diagnosed by CT or MRI. Of the 3 deep lobe lesions incorrectly diagnosed, 2 were thought to be in the superficial

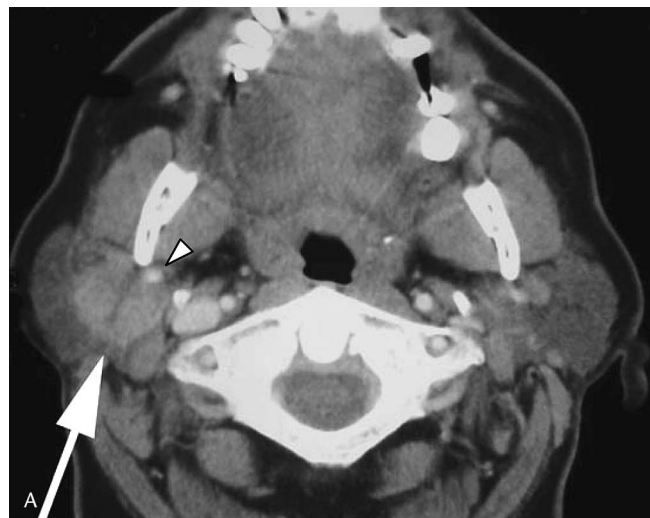


FIGURE 4. A, A 57-year-old male with a right parotid mass. Axial enhanced CT of parotid glands shows a lesion (arrow) that appears to extend deep to the retromandibular vein (arrowhead), and was thus classified as a total lesion. Surgical findings showed a Warthin tumor located within the superficial lobe. B, A 37-year-old male with a left parotid mass (arrow). Axial contrast-enhanced CT of parotid glands shows a lesion that appears to arise from the deep lobe and extend superficial to the retromandibular vein (arrowhead). The mass was felt to invade both lobes of the parotid gland. Surgical findings showed a Warthin tumor involving only the deep lobe of the parotid gland.

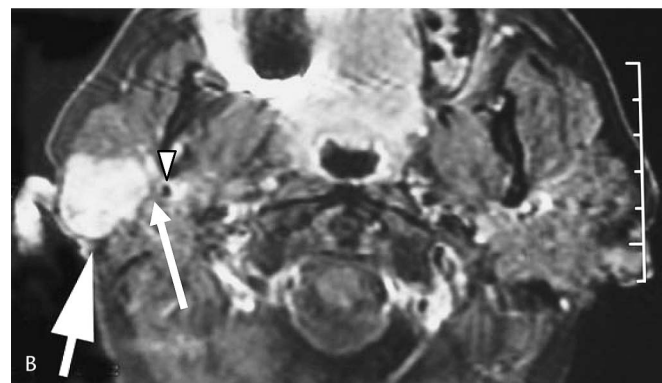
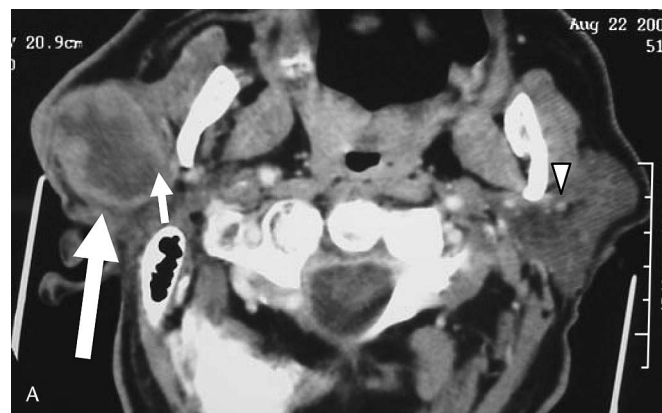


FIGURE 3. A, A 67-year-old male with right parotid mass. Axial contrast-enhanced CT shows a large mass (large arrow) involving the superficial lobe and extending deeply to involve the expected location of the retromandibular vein (small arrow). Note the normal position of the retromandibular vein on the opposite side (arrowhead). This squamous cell carcinoma was classified as involving both the superficial and deep lobes. These findings were confirmed at surgery. B, A 71-year-old female with right parotid mass. A T1 post-contrast MR image with fat suppression shows a lesion (large arrow) located within the superficial lobe. Note that the deep margin of the tumor (small arrow) is superficial to the retromandibular vein (arrowhead). Surgical findings confirmed a pleomorphic adenoma localized to the superficial lobe.

lobe and 1 was thought to be in both lobes based on imaging. This yielded a sensitivity of 0.40, specificity of 1.0, PPV of 1.0, and NPV of 0.93. Of the 3 misclassifications, 1 patient had metastatic melanoma to the ipsilateral pre-tragal lymph nodes. At surgery, this patient was found to have a second metastatic deposit that was isolated to the deep lobe that was not initially seen but was present in retrospect. A second patient had a low-grade mucoepidermoid carcinoma isolated to the deep lobe that was not identified on imaging. A small accessory parotid

gland lateral to masseter muscle was incorrectly identified as a superficial lesion. The third misclassification was a Warthin tumor that arose in the caudal portion of the deep lobe (Fig. 5). The lateral margin of the mass appeared to extend superficial to the lateral margin of the retromandibular vein. This was classified as a mass involving both lobes. At surgery, this was felt to be an isolated deep lobe tumor.

Of the 16 patients with tumors in the both lobes, 15 were correctly diagnosed by CT or MRI. One of the lesions in both lobes at surgery was thought to be located in the superficial lobe based on imaging. This yielded a sensitivity of 0.94, specificity of 0.89, PPV of 0.83, and NPV of 0.96.

A summary of these results is presented in Table 3. For all lesions, preoperative imaging was able to predict the location of 38 of 44 lesions, giving an overall accuracy of 86.4%.

DISCUSSION

The results of our study indicate that identification of the retromandibular vein on cross-sectional imaging studies can be used as a reliable landmark to help localize parotid lesions



FIGURE 5. A, A 35-year-old male with left parotid lesion. Axial contrast enhanced CT of parotid gland shows the lateral margin of the lesion (arrow) approximately in the plane of the retromandibular vein (arrowhead). B, Image taken from a different section of the same patient revealed a mass originating in the deep lobe and extending lateral (arrow) to the plane of the retromandibular vein (arrowhead). Therefore, this lesion was predicted to involve both lobes. At the time of surgery, the lesion was found to be a Warthin tumor isolated to the deep lobe.

TABLE 3. Statistical Analysis of Localization of Tumor Based on CT and MRI

	n	Sensitivity	Specificity	PPV	NPV
Superficial	23	.91 (.70-.98)	.86 (.63-.96)	.88 (.67-.97)	.90 (.67-.98)
Total	16	.94 (.68-.99)	.89 (.71-.97)	.83 (.58-.96)	.96 (.78-.99)
Deep	5	.40 (.07-.83)	1.0 (.89-1.0)	1.0 (.20-1.0)	.93 (.79-.98)

Numbers in parentheses represent 95% Confidence Interval.
PPV, positive predictive value; NPV, negative predictive value.

to the superficial or deep lobes. Lesions lateral to the retromandibular vein indicate that the lesions are located in the superficial lobe, whereas lesions medial to the retromandibular vein involve the deep lobe.

Knowledge of the location of a parotid mass can be helpful for preoperative planning by allowing the surgeon to determine the optimal surgical approach and to appropriately counsel the patient. Proper localization of a parotid space lesion is difficult to assess based on palpation. The surgeon may feel the mass but is unable to identify the deep extent. This information directly impacts the surgical approach of parotid neoplasms. In addition, patients should be informed of the risk to the facial nerve during surgery, since lesions in the deep or both lobes require more manipulation and possible sacrifice of the facial nerve. Due to the significant morbidity associated with facial nerve damage, it is appropriate to provide patients with the best preoperative information possible. This can allow for patients to emotionally prepare for facial nerve sacrifice when it is necessary. Estimation of the risk to the facial nerve is a part of the informed consent process, and localizing of the tumor can aid this estimation.

Currently, preoperative imaging of the parotid gland is not consistently performed because some surgeons feel that imaging is not accurate enough to correctly determine the location of the tumor or that knowing location would not significantly impact the outcome of the procedure.⁵ Our results suggest that cross-sectional imaging does have the accuracy to properly identify the location of parotid masses.

There have been many different methods proposed for determining whether tumors of the parotid gland lie superficial or deep to the facial nerve based on cross-sectional imaging. The use of the retromandibular vein has been assessed either alone or in conjunction with other soft tissue structures. Ariyoshi and Shimahara showed a 62.5% accuracy of using the retromandibular vein; however, their study only included 8 patients.² This is the largest study to date that used the retromandibular vein alone for determining location of lesions. Kurabayashi et al showed an overall accuracy of 86% in 28 patients using a line that connected the lateral border of the retromandibular vein to the main trunk of the facial nerve.⁶ Tumors were diagnosed as superficial if they were located predominantly superficial to this line, or diagnosed as deep if the tumor was not. Ragbir et al showed an overall accuracy of 62.5% using anatomic landmarks by defining a straight line from the midpoint of the styloid and mastoid process to the lateral border of the posterior belly of the digastric, which crosses the lateral border of the retromandibular vein.⁷ de Ru et al established a Utrecht line that connects the most dorsal

point of the visible ipsilateral half of a vertebra to the most dorsal point of the retromandibular vein.⁴ Tumors located totally or mostly lateral to the Utrecht line were diagnosed in the superficial lobe. Tumors totally or mostly medial to the Utrecht line were diagnosed in the deep lobe. Tumors divided into roughly equal parts by the Utrecht line were diagnosed as being in both lobes. Using this line, de Ru et al were able to identify the correct location of parotid neoplasms with 85.7% accuracy in 28 patients. In our study, our overall accuracy of using the retromandibular vein alone was 86.4%. These results compare favorably with previous studies that have attempted to locate tumors in the parotid gland.

One issue raised by Kurabayashi et al is that the retromandibular vein cannot always be visualized.⁵ In their trial, only 78% of the retromandibular veins were visible on imaging studies primarily due to tumors in the inferior lobe of the parotid or very large tumors. In our experience, we saw the retromandibular vein in the majority of cases. If the vein was not visible in its expected location, we assumed that the facial nerve was involved.

One of the unexpected findings in our study was the low diagnostic accuracy of identifying lesions isolated to the deep lobe. Two of the 3 misclassifications were due to lack of visualization on CT. It is possible that they have been detected on MR due to its improved soft tissue characterization when compared with CT.

We believe that the most clinically relevant statistic in this study is the measure of positive predictive value. Unlike a screening test, we are examining a group of patients that has a known disease, and we approach each patient from the perspective of trying to localize this disease. The positive predictive value can be used by the surgeon to determine the likelihood of finding the lesion in the location given by the radiologist. Our positive predictive values for superficial, total, and deep lesions were 88%, 83%, and 100%, respectively. These predictive values can give surgeons a high level of comfort with the radiologically determined location so that they can adequately plan for surgery and provide more thorough information to the patient.

Our study evaluated masses located within the main substance of the parotid gland and did not evaluate lesions located in the tail of the parotid. The pes anserinus arises within the parotid at approximately the level of the soft palate. These terminal branches of the facial nerve form the plane, which separates the superficial from the deep lobe. The bulk of the parotid gland diminishes in the tail of the gland. In addition, there are only 2 distal branches of the nerve located in the tail that do not have a consistent course. These are the deep cervical and marginal mandibular branches. As a result, the location of the distal retromandibular vein is not a consistent landmark for the facial nerve, and clinicians refer to these lesions as parotid tail masses and usually perform a superficial parotidectomy.

It is possible that the margins of the lesion may affect the ability to properly localize a lesion in the parotid gland. As demonstrated in Figure 1, the branches of the facial nerve form a wide plane that separates the superficial lobe from the deep lobe. Some of our results (as those illustrated in Figure 4) suggest that tumors with smooth margins may, in essence,

“push” the nerve plane as opposed to a tumor with very irregular margins. Tumors with highly irregular and jagged margins may have a greater propensity to extend between the branches of the facial nerve that form the plane between the superficial and deep lobes. As shown in Figure 4a and b, both misclassifications had smooth margins that extended to the retromandibular vein without frank involvement of glandular tissue on the opposite side of the vein.

Several of our misclassifications involved Warthin tumors, which was an unexpected finding. We feel that the misclassification of Warthin tumors may be attributable to 2 main factors. As discussed above, our results suggested that tumors (despite histology) that arose in the tail of the parotid gland and had smooth margins had a greater likelihood of being misclassified. Since Warthin tumors typically arise from the parotid tail and often have smooth margins, these findings would be a plausible explanation of finding of possible higher misclassification rate for Warthin tumor. Give that there were no cases of more lesions identified in the parotid gland than seen on imaging, it is unlikely that multifocality would be a likely explanation.

This is a retrospective study and has several limitations. We evaluated the retromandibular vein as visualized on CT as this was the modality most commonly requested by our referring clinicians. MR is currently the preferred cross-sectional modality for evaluating parotid masses due to its improved soft tissue characterization. Our results suggest that CT visualization of the retromandibular vein is an accurate method for properly localizing parotid tumors. As mentioned above, MR may be even more accurate as it may improve visualization of isolated deep lobe masses. However, with our limited number of MR examinations, we were not able to show a statistically significant difference between CT and MR.

In summary, use of the retromandibular vein as a marker for the facial nerve is a sensitive method for identifying the location of parotid gland neoplasms on cross-sectional imaging. This supports the sensitivity of using preoperative imaging to detect position of parotid neoplasms with respect to the facial nerve.

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