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ORIGINAL RESEARCH

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Point-of-care ultrasound scan as the primary modality for evaluating parotid tumors

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Abstract

Objectives: This study aimed to explore ultrasonography as a single imaging modality for the initial assessment of parotid lesions compared to computed tomography (CT) and magnetic resonance imaging (MRI).

Methods: A retrospective cross-sectional study was performed on 264 parotid gland lesions evaluated in a dedicated point-of-care ultrasound (POCUS) clinic with concurrent fine needle biopsy (FNB). Two hundred and nine of these lesions also underwent CT or MRI imaging. Histopathology results, when available, were recorded and compared to imaging impressions.

Results: Surgeon-performed POCUS classified parotid masses accurately when compared to final histopathology (90/96, 94%). Using predefined criteria, POCUS determined the nature of parotid lesions more definitively than the descriptive CT or MRI radiology reports (p <.001). Sub-analysis showed that ultrasonography was able to distinguish between benign pathologies with high degree of accuracy (Warthin tumor—82%, pleomorphic adenoma—64%).

Conclusions: POCUS can accurately distinguish between benign and malignant parotid lesions. POCUS may suffice as the only imaging study for benign lesions, obviating the need for additional cross-sectional imaging. This can be combined with fine needle or core biopsy in the same visit, resulting in expedient diagnosis, low cost, and lack of radiation exposure.

Level of Evidence: 2b, individual cross-sectional cohort study.

KEYWORDS

fine needle aspiration, fine needle biopsy, parotid, ultrasound

1 | INTRODUCTION

Salivary gland tumors comprise 3%–6% of all head and neck neoplasms, approximately 85% of which originate in the parotid gland.[1–3] Preoperative imaging and fine needle biopsy (FNB) are often performed to assist with appropriate counseling and surgical planning.[4]

Ultrasonography (US) has been used as the primary imaging modality for parotid mass evaluation in much of Europe and Asia, whereas computed tomography (CT) and magnetic resonance imaging

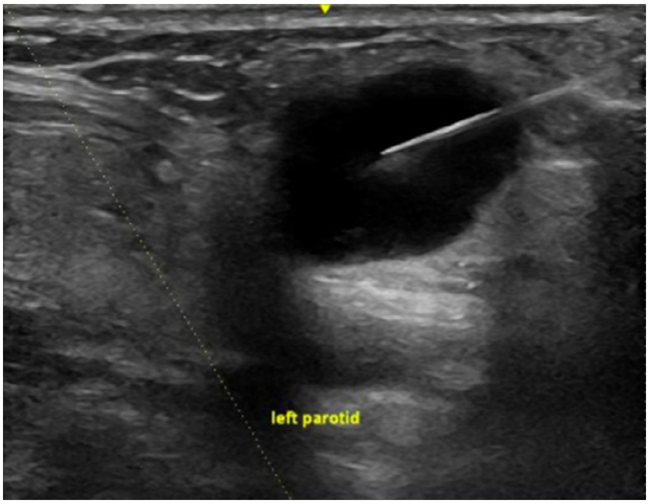

FIGURE 1 Benign-appearing parotid lesion on ultrasonography, ultimately determined to be a pleomorphic adenoma. Note the smooth, well-demarcated borders, and homogeneous hypoechogenicity

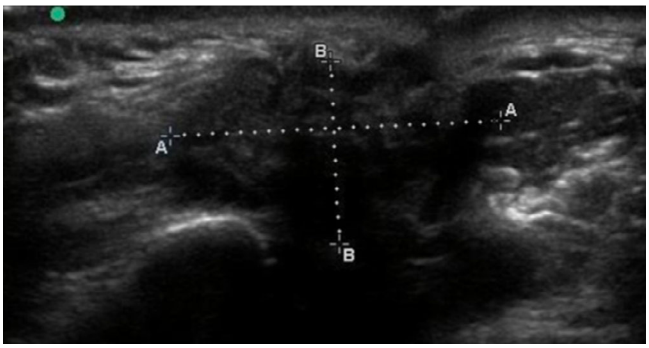

FIGURE 2 Malignant-appearing parotid lesion on ultrasonography, ultimately determined to be squamous cell carcinoma. Note the poorly defined borders and invasion into nearby parotid parenchyma, heterogeneous echogenicity, and lack of deep enhancement

(MRI) is routinely the first-line modality in the United States.[2,5] Ninety percent of parotid tumors arise in the superficial lobe, rendering them amendable to US assessment.[3,4,6,7] On US, benign tumors generally demonstrate deep enhancement and a homogenous hypoechoic structure, regular and well-defined borders, and demarcated vessel distribution[6,8,9] (Figure 1). Conversely, malignant lesions may have a heterogenous structure with irregular borders and extra-parenchymal spread into adjacent structures, or diffuse and poorly demarcated perfusion patterns[6,8,9] (Figure 2). Internal necrosis, cystic change, and lymph node involvement may also be seen.[4]

The sternocleidomastoid m., posterior belly of the digastric m., masseter m., retromandibular vein, and mandible are helpful in localizing masses on US.[10] The retromandibular vein is a reliable surrogate marker for the facial nerve, thereby distinguishing between superficial and deep lobe tumors.[8] However, deep lobe tumors or those near the mandible condyle may be shielded by the overlying parotid gland or nearby bone, rendering US less effective in these cases.[2,9] In cases where there is concern for perineural spread, skull base or bony involvement, or extra-parenchymal spread, CT, and MRI are effective tools for further classification.[2–4,11,12]

Economically, US is less expensive than both CT and MRI. As of August 2021, the Medicare reimbursement for a soft tissue neck CT with contrast averaged $245 and a head/neck MRI with and without contrast cost $473, whereas a head and neck US cost $118.[13] There are also well-described allergic reactions and nephrotoxic effects from the contrast dye used in CT and MRI, as well as potential carcinogenic effects of cumulative radiation exposure from repeat CT imaging.[14]

Our study hypothesizes that surgeon-performed point-of-care ultrasound (POCUS) should be the initial and, in many cases, the only imaging study needed for workup of parotid lesions, obviating the need for CT or MRI.

2 | METHODS

The Tufts Medical Center Institutional Review Board approved this study.

A retrospective cross-sectional chart review was performed on all patients referred to a dedicated US clinic in a busy community otolaryngology practice between 2014 and 2021. The site is certified by the American Institute of Ultrasound Medicine (AIUM). All POCUS and US-guided FNBs were performed by the lead author with training and certification in head and neck US courses sponsored by the American College of Surgeons and American Thyroid Association. The senior author has more than 8 years' experience performing these procedures.

Each US was performed with a 7.5–10 MHz linear probe. In addition to B-mode, US color-flow imaging was utilized. Scans and procedures were performed in a supine position with slight neck extension in a standard reclining examination chair. Scans are performed in transverse and longitudinal/oblique planes; depth and grain were adjusted for each lesion for optimal viewing. Photographs were taken of each lesion. FNBs under US guidance were performed during this same visit with a 27-gauge needle.

When evaluating each lesion's US image, the operator was blinded to any previously available CT- or MRI-radiologist impression as well as any available histopathology. Lesions were classified as benign, malignant, or indeterminate based on US characteristics such as echogenicity, vascularity, border clarity, multicentricity, and location. Benign lesions were further subclassified into Warthin tumor, pleomorphic adenoma, lymph node, or cyst. Criteria used by the operator are detailed in Table 1. The CT and/or MRI imaging characteristics and the radiologist impressions of benign versus malignant were recorded when available. Radiology reports were evaluated from five different radiology departments at surrounding community hospitals.

Imaging results from all three modalities were then compared to the final surgical histopathology. The number of lesions identified as benign or malignant on both imaging and final surgical histopathology were recorded, as were the lesions whose imaging characteristics

TABLE 1 Ultrasonography features used to classify benign and malignant lesions

Features suggestive of malignancy						
Ill-defined borders	Lack of homogeneity	Invasion into nearby structures	Lymph node enlargement	Disorganized color pattern		
Features suggestive of pleomorphic adenoma						
Hypoechoic	Solid	Round/oval	Well-defined	Lobulated surface	Through-transmission deep enhancement	Peripheral color flow
Features suggestive of Warthin's tumor						
Hypoechoic or anechoic	Often predominantly cystic with multiple septae	Inferiorly placed	Well-defined	Bilateral	Through-transmission deep enhancement	

TABLE 2 Imaging impression versus final surgical histopathology

	US		CT/MRI		*p*-value
	Final surgical histopathology matched	US impression total	Final surgical histopathology matched	CT/MRI impression total	
Benign	90	96	31	34	.61
Malignant	17	21	7	13	.09
Indeterminate		1		54	
Overall	107	118	38	101	<.001

TABLE 3 Sub-analysis of benign-appearing parotid lesions on ultrasonography compared to final surgical histopathology

US appearance determination	*n*	Surgical histopathology correlated	Other benign tumor on histopathology	Malignant tumor on histopathology
Pleomorphic adenoma	42	27 (64%)	11 (26%)	4 (10%)
Warthin's tumor	44	36 (82%)	6 (14%)	2 (4%)
Other (cyst, lymph node, etc.)	9	6 (67%)	2 (22%)	1 (11%)

were discordant from their final histopathology results. The accuracy of determining benign or malignant was calculated as a percentage for each imaging modality. These averages were then compared for each imaging modality using a chi-square test. An additional calculation was performed to assess the percent accuracy of US in identifying Warthin tumor and pleomorphic adenomas compared to histopathology.

3 | RESULTS

Over an 8-year period, 265 parotid fine needle aspirations were performed utilizing POCUS in a dedicated US clinic in an office setting within a single large community otolaryngology practice. Of these, 79% ($n = 209$) also underwent additional cross-sectional imaging—CT or MRI. The patients' ages ranged from 33 to 90; 104 subjects were female, 105 were male.

Of these 209 patients with cross-sectional imaging results, 67% ($n = 140$) of patients underwent a CT scan, 21% ($n = 44$) underwent an MRI, and 12% ($n = 25$) underwent both. One-hundred and eighteen of these 209 masses ultimately underwent excision and therefore had final pathology available. Of the 118 surgically excised lesions, 34 had been determined benign on CT/MRI (29%), 13 malignant (11%), and 71 indeterminate (60%). When correlating with final pathology, 31/34 were accurately called benign (negative predictive value [NPV] 91%), 7/13 were accurately called malignant (positive predictive value [PPV] 54%), and 9/47 were discordantly called benign or malignant (19%) (Table 2).

All patients in our study underwent POCUS. Of the 118 lesions that ultimately underwent surgical excision, 96 (81%) were classified as benign on US and 21 (18%) were suspicious for malignancy. One lesion was classified as "indeterminate" (1%). When correlating with final pathology, 90/96 were accurately called benign (NPV 94%), 17/21 were accurately called malignant (PPV 81%), and 10/117 were discordantly deemed benign or malignant (9%) (Table 2). The sensitivity of POCUS was 74%, and the specificity was 96%. For CT/MRI images, the sensitivity was 70% and the specificity was 84%.

A chi-square test was performed to compare the rate of lesions accurately labeled benign and malignant by POCUS and CT/MRI, with surgical histopathology as the gold standard. Taken in sum, POCUS was able to determine a benign or malignant lesion more accurately than the CT/MRI radiology report description (p <.001, Table 2).

An additional analysis was performed on the parotid lesions considered benign on US ($n = 95$). The likely benign lesions were further classified into three categories—pleomorphic adenoma, Warthin's tumor, or other, which included lymph nodes or purely cystic lesions. Forty-two were considered likely to be a pleomorphic adenoma, 44 were considered Warthin's tumors, and 9 were classified as "other." When compared to final surgical pathology, 64% ($n = 27$) were accurately called pleomorphic adenomas, 82% ($n = 36$) were accurately called Warthin tumors, and 67% ($n = 6$) were accurately called "other." Twenty percent ($n = 19$) of the 95 were classified as another type of benign tumor on preoperative US assessment (Table 3).

4 | DISCUSSION

Twenty to thirty percent of parotid tumors are malignant, and therefore preoperative assessment is critical for ensuring proper management.[4] US is less commonly used in the United States than in Europe and Asia, where this modality is often the first diagnostic test for parotid pathology.[5–7] Our study suggests that surgeon-performed POCUS is an effective tool in determining the nature of parotid lesions, saving patients from the financial, time-related, and radiation burdens of CT/MRIs.

In our study, we compared the ability of US and cross-sectioning imaging (CT and MRI) to discern the benign or malignant potential of parotid lesions. Very few CT or MRI reports provided a determination of benign vs. malignant, often listing both as possibilities. The role of the radiologist is not necessarily to make a diagnosis of malignant or benign; as a result, many CT and MRI reports were descriptive in nature, focusing on the location, size, density, and enhancement of the lesion.

When a benign determination was made on cross-sectional imaging, our study found that these assessments were generally concordant with final histopathology, when available (31 of 34 lesions, 91%; Table 2). Similarly, surgeon-led POCUS was also found to be highly accurate in assessing the benign potential of lesions when compared to final histopathology (90 of 96 lesions, 94%, Table 2). This difference was not found to be statistically significant ($p = .61$). The assessment of malignant potential differed between the modalities but did not reach statistical significance ($p = .92$): US demonstrated an 81% accuracy rate (17 of 21 lesions) versus 54% with CT/MRI (7 of 13 lesions).

However, these values fail to include the substantial number of lesions labeled indeterminant on cross-sectioning imaging (54 of 101 lesions, 54%). Comparatively, only one lesion was labeled indeterminant on POCUS (1 of 118, 1%). When accounting for these lesions, our study found that overall accuracy in determining benign or malignant potential on imaging differed significantly ($p < .001$); US rate was 90% (107 of 118 lesions) versus the CT/MRI rate of 38% (38 of 101 lesions; Table 2).

Cross-sectional imaging is warranted for the assessment of parotid lesions in select instances. CT and/or MRI may better delineate deep tumors or those with suspected perineural spread or bony invasion.[4,7] Its use in further classifying and determining the extent of malignant tumors can be critical to preoperative planning. However, we advocate for the judicious use of cross-sectional imaging, given the expense and proven effectiveness of US in evaluating such lesions.[4] Additionally, cross-sectional imaging quality may be compromised by motion artifact, artifact from dental fillings or implants, or patients who are intolerant to loud noise or are claustrophobic.[3,5,11]

Our study showed that a substantial number of cross-sectional imaging radiology reports were descriptive in nature rather than suggestive of benign or malignant potential. In practice, this requires the surgeon to view the images him/herself to assess this potential and plan surgical intervention accordingly. Given that both US and cross-sectional imaging require surgeon interpretation for planning, the authors advocate for surgeon-led POCUS, which can expedite care while also allowing for diagnostic sampling via FNB during the same visit, if warranted.

In our benign lesion sub-analysis (Table 3), our study suggests that some pathologies may be accurately predicted based on US characteristics (Table 1). Pleomorphic adenomas are hypoechoic, homogenous, well-defined, lobulated with posterior acoustic enhancement, and are poorly or peripherally vascularized on Doppler US[6]; in our study, 67% of pleomorphic adenomas were accurately identified on preoperative US. Warthin tumors may be bilateral or multiple in 15% of patients, rounded or lobulated, hypoechoic, and may show cystic change with internal septation and hypervascularity on Doppler US.[6] In our study, 88% of Warthin tumors were accurately predicted on preoperative US. Cysts may demonstrate classic smooth borders and are anechoeic, while benign intraparotid lymph nodes can be identified by an intact hilum and ovoid shape.

There are several strengths to this study. All lesions were assessed by US by single operator, eliminating the variability in US-operator ability. This single operator (lead author) adhered to the characteristics in Table 1 to classify masses as benign or malignant. Every lesion included in the study also had final histopathologic data, the gold standard in characterizing malignant potential. There are several limitations to the study; while one operator limits variability, numerous operators could improve the inter-operator reproducibility of the results. Additionally, increasing our *n* would perhaps allow for greater statistical significance.

Some reports suggest POCUS is subject to operator skill, and that otolaryngologists fear performing their own radiographic assessments and prefer to rely on those performed in radiology departments.[15] Indeed, there may be some hesitation from otolaryngologists toward incorporating US into the practice, particularly as a sole imaging modality for characterizing parotid masses. However, there are numerous well-established US training courses and certification programs to gain experience. Furthermore, the authors believe that surgeons are particularly well-equipped to interpret US, as a thorough knowledge of anatomy is paramount.

5 | CONCLUSION

POCUS of is an inexpensive, low-risk, and effective tool for evaluating parotid lesions. Its accuracy in predicting the nature of salivary gland lesions compares favorably to that of cross-sectional imaging. Moreover, US can accurately localize these lesions by identifying adjacent structures such as the sternocleidomastoid m., digastric m., and retromandibular v. FNB can be performed at the same visit, thus expediting care. For deep masses or malignant lesions with suspected local invasion or perineural spread, CT or MRI should be performed. Our study suggests that POCUS can often be confidently used as an initial, and perhaps sole, imaging modality for parotid masses without adverse features.

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