Abstract

Background and aims. Although salivary gland tumors are not very common, early diagnosis and treatment is crucial because of their proximity to vital organs, and therefore, determining the efficacy of new imaging procedures becomes important. This study aimed to evaluate the efficacy of magnetic resonance imaging (MRI) and color doppler ultrasonography parameters in the diagnosis and differentiation of benign and malignant salivary gland tumors.

Materials and methods. In this cross-sectional study, color doppler ultrasonography and MRI were performed for 22 patients with salivary gland tumor. Demographic data as well as MRI, color doppler ultrasonography, and surgical parameters including tumor site, signal in MRI images, ultrasound echo, tumor border, lymphadenopathy, invasion, perfusion, vascular resistance index (RI), vascular pulse index (PI) were analyzed using Chi-square test, Fisher’s exact test, and independent t-test.

Results. The mean age of patients was 46.59±13.97 years (8 males and 14 females). Patients with malignant tumors were older (P < 0.01). The most common tumors were pleomorphic adenoma (36.4%), metastasis (36.4%), and mucoepidermoid carcinoma (9%). Nine tumors (40.9%) were benign and 13 (59.1%) were malignant. The overall accuracy of MRI and color doppler ultrasonography in determining tumor site was 100% and 95%, respectively. No significant difference observed between RI and PI and the diagnosis of tumor.

Conclusion. Both MRI and ultrasonography have high accuracy in the localization of tumors. Well-identified border was a sign of benign tumors. Also, invasion to adjacent structures was a predictive factor for malignancy.

Key words: Color, doppler, magnetic resonance imaging, salivary gland neoplasms, ultrasonography.
Clinical signs and symptoms predicting benign or malignant nature of tumors are nonspecific. However, most benign or low grade malignant tumors are presented as painless masses with slow growth. Progressive malignancies or inflammations are accompanied with pain and rapid growth. Facial nerve paralysis associated with parotid mass is highly predictive of malignancy and poor prognosis. However, benign mixed tumors accompanied with facial nerve paralysis are also reported.2,3

There have been controversial data regarding the role of imaging prior to surgery for parotid tumors. Although some studies recommend fine needle aspiration (FNA) alone for the evaluation of superficial parotid masses prior to superficial parotidectomy, others suggest imaging procedures before surgery.3,4 It is important to determine whether the tumor is intra or extra glandular as well as superficial or deep in advance of the surgical procedures; therefore, using imaging techniques help not only in planning the operation but also in evaluating further possible relapses and complications.2 Although various imaging techniques have been used to evaluate salivary gland tumors, ultrasonography has received significant attention in cases where it could only reveal superficial tumors while the relation of tumor to other adjacent structures could not be identified. However, it is still a cost effective non-invasive technique.1,2,5

Color doppler ultrasonography was recently introduced as an imaging technique for the evaluation of salivary gland tumors as well as vascular system and it is believed to have future applications in this field.1 A study on capabilities of ultrasound in salivary gland tumors showed B-mode ultrasonography and color doppler imaging could reveal the presence of masses in the gland, their topography and dimensions, and specific vascularization, which are effective in treatment planning.5 Zengel et al6 stated ultrasound examination alone is sufficient to diagnose benign tumors, however, other techniques such as computed tomography or magnetic resonance imaging (MRI) may also be required in malignant tumors to determine infiltration to the skull base.6

MRI is recommended by many studies as an accurate imaging technique to evaluate tumors and adjacent soft tissue structures and also to study the associations between them.1,7 Also the results of a study revealed that gadolinium-enhanced dynamic MRI could help in differentiating benign from malignant parotid gland tumors and characterizing the pathologic types of benign tumors.8 This study was aimed to evaluate the efficacy of MRI and color doppler ultrasonography parameters in the diagnosis and differentiation of benign and malignant salivary gland tumors.

Material and Methods

In this cross-sectional study, 22 patients who were suspected to have salivary gland tumor and were referred to one of the three referral centers including the Department of Oral Medicine at the Faculty of Dentistry, Ghaem Hospital, and Omid Hospital, all located in Mashhad, Northeast of Iran, during an 18-month period were enrolled. MRIs and color doppler ultrasonographies were performed for 22 and 20 patients, respectively. The site of tumor located in the palate made it impossible for the radiologist to perform ultrasonic evaluations in two patients.

This study was approved by the research deputy of Mashhad University of Medical Sciences regarding methodological and ethical issues. A written consent was obtained from each individual prior to the procedures. The aims of the study were explained to the participants and their questions were answered.

Philips MRI system (Philips, The Netherlands) with 0.5 Tesla power was used to produce T1, T2, coronal, and axial images with 1-4 mm section thickness. All ultrasonographies performed using Toshiba Ultrasound system (Toshiba, Japan) with 7.5 MHz power.

MRI images were reviewed by two radiologists who were not informed of the histopathological diagnoses. Evaluated parameters in MRI were tumor site, signals of T1 and T2 images, tumor border, tumor homogeneity, lymphadenopathy, and invasion to adjacent structures. Tumors sites were classified into parotid (the ramus of the mandible was used as an index to differentiate superficial and deep tumors as if the tumor grows to the medial portion of ramus it would be considered as deep), submandibular, sublingual, and minor salivary glands.

Tumor border was classified as well-defined, and ill-defined. T1 and T2 signals were categorized into hypointense if tumor signals were lower than adjacent muscles, isointense if signals were analogous, and hyperintense if tumor signals were higher than adjacent muscles (Figure 1). Homogeneity was classified as homogenous and heterogeneous.

Also all documents of invasion to adjacent structures as well as metastases were registered.

Ultrasound data included tumor site, echo, border, vascular resistance index (RI), vascular pulse index (PI), perfusion pattern and scale, and lymphadenopathy.

Tumor echo was classified as hypoechoic, hyperechoic, and complex echo according to the comparison with normal tissue echo pattern. Complex echo was defined as a combination of hyperechoic and hypoechoic patterns in the tumor site.
Figure 1. (A) Axial view of a high signal pleomorphic adenoma in left parotid; (B) Coronal view of a low signal malignant oncocytoma in left parotid; (C) Pleomorphic adenoma with no perfusion. Note the signal flow related to the facial artery (arrow). (D) Warthin tumor with +++ perfusion scale and mixed (central and peripheral) perfusion pattern.

RI and PI were measured by the ultrasonography system. Perfusion pattern was classified into the central, peripheral, and combined, and scaled into four scores as follows:
- 0: no perfusion or signal flow
- +: blood vessels at gland hilar
- ++: sparse blood vessels
- +++: big or intensive blood vessels

After imaging process all patients underwent surgery and all tumors were removed and histopathological diagnoses were made. The data including tumor site, lymphadenopathy, and tumor invasion to adjacent structures were registered by the surgeon. The removed tumors were sent to the Department of Pathology for histopathological evaluations, after which the final diagnoses were registered. Tumors were categorized as either benign or malignant.

MRI, color doppler ultrasonography, and surgical data were compared. Data were analyzed using SPSS v.18.0. Chi-square statistics, Fisher’s exact test, and independent t-test were employed to analyze qualitative and quantitative data. P value ≤ 0.05 were considered as statistically significant.

Results

The mean age of patients was 46.59±13.97 years (46.78±11.5 for females and 46.25±18.41 for males; minimum 23, maximum 67). Of 22 patients, 8 were male (36.4%) and 14 were female (63.6%).

Figure 2. Tumor signals in magnetic resonance imaging (MRI) T1 (A) and T2 (B) weighted images.
The most common diagnoses were pleomorphic adenoma (36.4%), metastases (36.4%), and mucoepidermoid carcinoma (9%). Nine tumors (40.9%) were benign and 13 (59.1%) were malignant. The prevalence of malignancy among males and females was 53.9% and 46.1%, respectively. Malignancy was significantly more prevalent among older patients (P<0.01). Common locations of tumors were parotid (86.4%), palate (9.1%), and submandibular area (4.5%).

The overall accuracy of MRI and ultrasonography in detection of tumor location was 100% and 95% (one false report of a parotid tumor), respectively. Seventeen tumors (85%) were hypoechoic and 3 (15%) had complex echo (2 metastatic cases of squamous cell carcinoma—SCC, and 1 malignant oncocytoma). No significant relation between the echo pattern and malignancy was present (P > 0.05). The majority of benign and malignant tumors were isointense in T1 images (Figure 2), while all benign tumors were hyperintense in T2 images. However, hypointense and isointense were similarly observed among malignant tumors in T2 images (Figure 2).

All malignant and benign tumors were heterogeneous.

All benign tumors had well-defined borders in both MRI and ultrasonography. However, 15.4%, 61.5%, and 23.1% of malignant tumors were well-defined, ill-defined, and poorly defined in MRI evaluation, revealing 100% sensitivity. Meanwhile, ultrasonography revealed 72.7% of malignant tumors as ill-defined (Table 1). There was a significant difference between malignant and benign tumors regarding tumor border parameter (P < 0.001).

MRI images showed no benign tumor invaded adjacent structures, while 92.3% of malignant tumors had local invasions and only one mucoepidermoid carcinoma had no local invasion. A significant relationship between malignancy and existence of local invasion was discovered (P < 0.001). Sensitivity, specificity, and positive predictive value (PPV) of local invasion for the prediction of malignancy was 92.3%, 100%, and 100%, respectively. Moreover, the accuracy of MRI in the detection of local invasion was 100%.

Lymphadenopathy was reported in 5 tumors by MRI and ultrasonography, including 3 malignant tumors (2 metastatic SCCs and 1 lymphoma) and 2 benign tumors (both pleomorphic adenomas). Of these five tumors excluding the lymphoma, the remaining 4 tumors had well-defined borders.

Regarding tumor perfusion scale, a big proportion of malignant tumors (36.3%) had ++ score, while majority of benign tumors (33.3%) were + or without signal flow (Table 2). Perfusion pattern in 50% of benign and malignant tumors was peripheral and mixed, respectively (Table 3).

Mean RI values in benign and malignant tumors were 0.77±0.1887 and 0.78±0.1167 and mean PI values were 1.71±0.9311 and 1.70±0.7815, respec-

### Table 1. Frequency of tumor border patterns in Ultrasonography among different tumors (20 tumors)

| Tumors                      | Well-identified | Ill-identified |
|-----------------------------|-----------------|----------------|
| Pleomorphic adenoma         | 8 100           | 0 0            |
| Warthin                     | 1 100           | 0 0            |
| Malignant oncocytoma        | 0 0             | 1 100          |
| Adenoid cystic carcinoma    | 0 0             | 1 100          |
| Lymphoma                    | 0 0             | 1 100          |
| Metastatic tumors           | 2 25            | 6 75           |

### Table 2. Frequency of perfusion scale among different tumors (20 tumors)

| Tumors                      | No perfusion | + | ++ | +++ |
|-----------------------------|--------------|---|----|-----|
| Pleomorphic adenoma         | 3 37.5       | 3 | 37.5 | 2 | 25 | 0 | 0 |
| Warthin                     | 0 0          | 0 | 0 | 0 | 0 | 1 | 100 |
| Malignant oncocytoma        | 0 0          | 0 | 0 | 0 | 1 | 100 |
| Adenoid cystic carcinoma    | 0 0          | 0 | 0 | 1 | 100 | 0 | 0 |
| Lymphoma                    | 0 0          | 0 | 0 | 0 | 0 | 1 | 100 |
| Metastatic tumors           | 3 37.5       | 1 | 12.5 | 3 | 37.5 | 1 | 12.5 |

### Table 3. Frequency of perfusion patterns among different tumors (14 tumors*)

| Tumors                      | Central | Peripheral | Mixed (central and peripheral) |
|-----------------------------|---------|------------|---------------------------------|
| Pleomorphic adenoma         | 1 20%   | 3 60%      | 1 20%                           |
| Warthin                     | 0 0%    | 0 0%       | 1 100%                          |
| Malignant oncocytoma        | 0 0%    | 0 0%       | 1 100%                          |
| Adenoid cystic carcinoma    | 0 0%    | 0 0%       | 1 100%                          |
| Lymphoma                    | 0 0%    | 100%       | 0 0%                            |
| Metastatic tumors           | 1 20%   | 2 40%      | 2 40%                           |

*Six of the 20 tumors evaluated by color doppler ultrasonography were without vessels.
According to de Ru et al, 11 MRI and palpation are complex cases. Hospitals, which tended to be more serious and nature of patients referred to Ghaem and Omid more frequent (59.1%) which may be due to the mors, while in our study malignant tumors were and account for two thirds of all salivary gland tu-

Benign salivary gland tumors are more common textbooks.1,7,10 The most common sites of tumors were pleomorphic adenoma that is similar to radiology textbooks. The majority of patients in this study were female (63.6%) and the most common was pleomorphic adenoma that is similar to radiology textbooks.1,7,10 The most common sites of tumors were parotid (86.4%), palate (9.1%), and submandibular (4.5%) areas, which were similar to the results of previous studies.1,7,10 The mean age of patients in this study was 46.59±13.97 years. Mean age of male patients with benign tumors was lower than those with malignant tumors, similar to previous reports.1,7,10 de Ru et al11 showed that both MRI and ultrasonography are accurate imaging techniques for localizing salivary gland tumors with respective accuracies of 100% and 90%, which is in accordance with our results. According to Brennan et al,12 in most patients with parotid tumors except when there is extension to deep lobe or malignancy is probable, sonography is sufficient for imaging benign parotid tumors before surgery. However, ultrasonography was not very accurate in localizing deep tumors and reported them as superficial. Goto et al13 also reported similar results.

In the present study, the ramus of the mandible was used as an index for localizing tumors, which revealed 100% accuracy. Divi et al14 used retro-mandibular vein as the index with 95% accuracy.14 According to de Ru et al,11 MRI and palpation are more accurate in localizing tumors.11 Our results showed that the majority of tumors had hypoechoic patterns in sonography which was similar to previous studies.9,15 Moreover, 3 tumors had complex echo which also received +++ score by color doppler ultrasonography scale. White et al17 state that complex echo pattern is a common finding in hemangioma due to its vascular nature. Although Ishii et al16 claim that it is possible to differentiate tumors based on their echo pattern, our study could not replicate such a finding.16 All benign tumors in our study had high signals in T2 images, while only 7.7% of malignant tumors showed high signals. Also the sensitivity of hyperintense pattern in T2 images for the detection of benign tumors was 100%. According to Som et al,1 most of benign tumors have high signals in T2 images as a result of being well-differentiated, while malignant tumors have lower signals due to their poor-differentiation. Malignant tumors in our study had low to moderate signals in T2 images, which is similar to other studies.1,7,18 There was one lymphoma case in our study which had low signals in both T1 and T2 images and was associated with lymphadenopathy and brain metastasis. Tauber et al19 also reported two cases of lymphoma with low and moderate signals in T1 and T2 images. Christe et al20 showed that infiltration of subcutaneous tissue is a specific sign predictive of malignancy. Other studies also reported invasion to adjacent structures as the accepted parameter for prediction of malignancy which was also confirmed by our results.20,21 All benign tumors in our study revealed well-defined borders, which is in line with previous reports.1,7,10 Ill-defined margins of a parotid tumor are highly suggestive of malignancy.11,18 Okahara et al22 suggested tumor border as the most helpful parameter for the differentiation of benign and malignant tumors in MRI. We also found a significant relationship between well-defined tumor borders and benign nature of tumors in ultrasonography. Bradley et al23 reported a 3 folded more possibility of malignancy in tumors with RI > 0.8 and PI > 1.8.23 We did not find any significant difference regarding RI and PI between malignant and benign tumors. Schick et al24 concluded that although color doppler ultrasonography could not differentiate benign and malignant tumors from each other, a high systolic peak and higher perfusion rate would increase the possibility of malignancy even if the tumor was reported in conventional ultrasonography as benign. Sladana et al9 reported a significant difference between the perfusion pattern of pleomorphic adenoma and other tumors (P=0.01) showing that the majority of pleomorphic adenomas (75%) had peripheral perfusion. Also 53.57% of such tumors had + perfusion score and 35.7% had ++ score. Besides, 90% of malignant tumors had central perfusion and 70% had +++ score. They similarly
could not find a relation between PI and RI values and malignancy. In the present study, 37.5% of pleomorphic adenomas had + perfusion score and 25% had ++. Also, perfusion pattern for 60% of pleomorphic adenomas and 36% of malignant tumors was central.

It was not possible to represent the association of tumors and facial nerve using MRI which was due to the 0.5 Tesla power MRI system used in this study.

Conclusions

MRI and ultrasonography have high accuracy rates in localizing salivary gland tumors. It seems ultrasonography would be an appropriate imaging technique in case of localizing intra and extra glandular tumors and could not accurately display invasion to deeper adjacent anatomic structures. Also in the absence of introral probe, it would be impossible to display tumors in the palate. Moreover, ultrasonography cannot show the associations between tumor and adjacent structures, and thus, it would be better to use MRI whenever tumors are big or judged to have higher possibility for malignancy. The presence of invasion to adjacent structures was seen to be an acceptable parameter in the prediction of malignancy in MRI. Also a significant relationship between well-defined tumor border and benign nature of tumors was present in ultrasonographic evaluations.

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