Shear wave elastography in differentiating between benign and malignant cervical lymph nodes in patients with oral carcinoma

Yoshihiko Sasaki and Ichiro Ogura

Radiology, The Nippon Dental University Niigata Hospital, Niigata, Japan; Department of Oral and Maxillofacial Radiology, The Nippon Dental University School of Life Dentistry at Niigata, Niigata, Japan

Objectives: To evaluate shear wave elastography in differentiating between benign and malignant cervical lymph nodes in patients with oral carcinoma.

Methods: 77 patients with oral squamous cell carcinoma were examined by B-mode and shear wave elastography with a 14 MHz linear transducer. The integrated shear wave elastography software allowed the operator to place regions of interest of various sizes within the elastography window, and automatically displayed shear elastic modulus data (kPa) for each region of interest. The relationship between size and shear elastic modulus of cervical lymph nodes was assessed by Pearson’s rank correlation test. The shear elastic modulus of cervical lymph nodes in benign and malignant were evaluated using the Mann–Whitney U test. The analyses were used with a 5% significance level.

Results: We plotted shear elastic modulus (X) against minimal axial diameter of cervical lymph nodes (Y), and observed a significant correlation \[ Y = 0.091 X + 4.648 \quad (R^2 = 0.603, \ p = 0.000, \ N = 77) \]. Furthermore, the shear elastic modulus of the malignant cervical lymph nodes (105.9 ± 5.2 kPa) was higher than that of benign (11.9 ± 4.4 kPa, \ p = 0.000).

Conclusions: The shear wave elastography is an effective technique for the objectively and quantitatively diagnosis of cervical lymph node metastases of the oral carcinoma.

Introduction

Ultrasonography has been widely accepted as a valuable diagnostic tool in the head and neck diseases. Color Doppler ultrasonography is effective for the diagnosis of oral and maxillofacial diseases. Strain elastography with ultrasonography is a relatively new imaging. Strain elastography is effective for the differential diagnosis of cervical lymph node metastases. In recent years, the strain elastography of tongue is effective for differentiating healthy tissues and squamous cell carcinoma (SCC). Shear wave elastography is a recent method using push pulses to stress tissues and an ultrafast ultrasound imaging technique to detect the induced shear waves. Elasticity values were determined for different tissues using shear wave elastography. We reported the usefulness of shear wave elastography in the oral and maxillofacial diseases and healthy tissue, such as sublingual gland, submandibular gland, anterior belly of digastic muscle and genioglossus muscle. Further, shear wave elastography is an acceptable method for diagnosing cervical lymph node metastases. However, the diagnostic criteria and reliability need to be further study. We evaluated shear wave elastography in differentiating between benign and malignant cervical lymph nodes in patients with oral carcinoma.
Methods and materials

This prospective study was approved by the ethics committee of our institution (The Nippon Dental University Niigata Hospital) (ECNG-R-318), and all patients provided written informed consent. 77 patients (41 male, 36 female; mean age 68.7 years (age 24–93 years)) with oral SCC (46 tongue, 12 buccal mucosa, 8 floor of mouth, 8 lower gingiva and 3 upper gingiva) were examined by B-mode and shear wave elastography with a 14 MHz linear transducer using Aplio 300 (Canon Medical Systems, Otawara, Japan) at our university hospital (The Nippon Dental University Niigata Hospital) from October 2017 to October 2018. The histopathological diagnoses of oral SCC were obtained by surgery or biopsy in all cases. The decision to select the node to be operated was performed according to contrast-enhanced CT and MRI findings. 10 patients with oral carcinoma in the positive node group using contrast enhanced CT and MRI were malignant by neck dissection. Untreated neck nodes of 67 patients with oral carcinoma, which were followed as benign lymph nodes for more than 1 years using contrast enhanced CT and MRI, were included in the negative node group. Table 1 shows characteristics of the patients with benign and malignant cervical lymph nodes of the oral carcinoma.

Ultrasonography examination was performed by one experienced radiologist with more than 20 years of experience (I O). The integrated shear wave elastography software allowed the operator to place regions of interest of various sizes within the elastography window, and automatically displayed shear elastic modulus data (kPa) for each region of interest. This study provided the maximum value of shear elastic modulus in the patient with lymph nodes.

The relationship between size on B-mode (maximal axial diameter and minimal axial diameter) and shear elastic modulus of cervical lymph nodes was assessed byPearson’s rank correlation test. The coefficient of determination ($R^2$) from the analyses was calculated to evaluate the relationship between size on B-mode (maximal axial diameter and minimal axial diameter) and shear elastic modulus of cervical lymph nodes. The size on B-mode (maximal axial diameter and minimal axial diameter) and shear elastic modulus of cervical lymph nodes in benign and malignant were evaluated using the Mann-Whitney U test. The analyses were performed using the statistical package IBM SPSS Statistics version 24 (IBM Japan, Tokyo, Japan) and was used with a 5% significance level.

Results

We plotted shear elastic modulus ($X$) against maximal axial diameter of cervical lymph nodes ($Y$), and observed a significant correlation [$Y = 0.108X + 7.893$ ($R^2 = 0.540$, $p = 0.000$, $N = 77$); Figure 1]. Similarly, we plotted shear elastic modulus ($X$) against minimal axial diameter of cervical lymph nodes ($Y$), and observed a significant correlation [$Y = 0.091X + 4.648$ ($R^2 = 0.603$, $p = 0.000$, $N = 77$); Figure 2].

Table 2 indicated the size and shear wave elastography in benign and malignant cervical lymph nodes in patients with oral carcinoma. The maximal axial diameter of the malignant cervical lymph nodes (19.3 ± 5.9 mm) was higher than that of benign (9.2 ± 2.7 mm, $p = 0.000$). The minimal axial diameter of the malignant cervical lymph nodes (14.4 ± 5.1 mm) was higher than that of benign (5.7 ± 1.7 mm, $p = 0.000$). Furthermore,
Shear wave elastography in cervical lymph nodes of the oral carcinoma
Sasaki, Ogura

The shear elastic modulus of the malignant cervical lymph nodes (105.9 ± 5.2 kPa) was higher than that of benign (11.9 ± 4.4 kPa, \( p = 0.000 \)). Figures 3 and 4 show benign and malignant cervical lymph nodes in patients with oral carcinoma, respectively.

**Discussion**

This study indicated the effective of shear wave elastography in differentiating between benign and malignant cervical lymph nodes in patients with oral carcinoma.

**Table 2** Size and shear wave elastography in benign and malignant cervical lymph nodes in patients with oral carcinoma

<table>
<thead>
<tr>
<th></th>
<th>Benign (( n = 67 ))</th>
<th>Malignant (( n = 10 ))</th>
<th>Total (( n = 77 ))</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of cervical lymph nodes (mm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximal axial diameter</td>
<td>( 9.2 \pm 2.7 )</td>
<td>( 19.3 \pm 5.9 )</td>
<td>( 10.5 \pm 4.7 )</td>
<td>( 0.000 )</td>
</tr>
<tr>
<td>Range</td>
<td>( 4.6–16.1 )</td>
<td>( 13.1–34.0 )</td>
<td>( 4.6–34.0 )</td>
<td></td>
</tr>
<tr>
<td>Minimal axial diameter</td>
<td>( 5.7 \pm 1.7 )</td>
<td>( 14.4 \pm 5.1 )</td>
<td>( 6.8 \pm 3.8 )</td>
<td>( 0.000 )</td>
</tr>
<tr>
<td>Range</td>
<td>( 2.4–11.1 )</td>
<td>( 8.8–27.0 )</td>
<td>( 2.4–27.0 )</td>
<td></td>
</tr>
<tr>
<td>Shear elastic modulus (kPa)</td>
<td></td>
<td></td>
<td></td>
<td>( 0.000 )</td>
</tr>
<tr>
<td>Mean ± standard deviation</td>
<td>( 11.9 \pm 4.4 )</td>
<td>( 105.9 \pm 5.2 )</td>
<td>( 24.1 \pm 32.1 )</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>( 4.3–24.0 )</td>
<td>( 97.6–113.9 )</td>
<td>( 4.3–113.9 )</td>
<td></td>
</tr>
</tbody>
</table>

We targeted the most maximum shear elastic modulus node per patient in the all examined nodes. Suh et al\(^{15}\) showed that the heterogeneous histology of lymph nodes with metastasis was more accurately reflected by the maximum value of shear elasticity modulus. Therefore, this study analyzed the maximum shear elastic modulus values, rather than the mean values.

Desmots et al\(^{14}\) indicated that head and neck lymph node metastasis were stiffer (72.4 ± 59.0 kPa) compared with benign nodes (23.3 ± 25.3 kPa). Tan et al\(^{16}\) showed indicated that malignant lymph nodes regarding superficial lymphadenopathy were stiffer (52.0 kPa) compared with benign nodes (24.1 kPa). Suh et al\(^{15}\) review that shear wave elastography is an acceptable imaging modality for diagnosing malignant cervical lymph nodes. In this study, the shear elastic modulus of the malignant cervical lymph nodes (105.9 ± 5.2 kPa) was higher than that of benign (11.9 ± 4.4 kPa, \( p = 0.000 \)). We consider that shear elastic modulus is linked to the histopathological differences between benign and malignant diseases.
B-mode ultrasonography is the method of first choice for the evaluation of cervical lymph nodes. A variety of diagnostic criteria have been reported to be useful to make distinctions between benign and malignant lymph nodes, such as size, shape, contour, internal structure, and the presence of hilus. In this study, we plotted shear elastic modulus (X) against maximal axial diameter of cervical lymph nodes (Y), and observed a significant correlation \[ Y = 0.108X + 7.893 \] (R^2 = 0.540, \( p = 0.000, N = 77 \)). Similarly, we plotted shear elastic modulus (X) against minimal axial diameter of cervical lymph nodes (Y), and observed a significant correlation \[ Y = 0.091X + 4.648 \] (R^2 = 0.603, \( p = 0.000, N = 77 \)). The maximal axial diameter of the malignant cervical lymph nodes (19.3 ± 5.9 mm) was higher than that of benign (9.2 ± 2.7 mm, \( p = 0.000 \)). The minimal axial diameter of the malignant cervical lymph nodes (14.4 ± 5.1 mm) was higher than that of benign (5.7 ± 1.7 mm, \( p = 0.000 \)). Ogura et al. indicated that Color Doppler ultrasonography was effective for the diagnosis of oral and maxillofacial diseases. We consider that the combination of B-mode, Color Doppler, and shear wave elastography is an effective technique for the diagnosis of cervical lymph node metastases of the oral carcinoma.

There were several limitations to this study. Our study had too small malignant cervical lymph nodes. We consider our results are as a preliminary study.

In conclusion, we showed the usefulness of shear wave elastography in differentiating between benign and malignant cervical lymph nodes in patients with oral carcinoma. The shear wave elastography is an effective technique for the objectively and quantitatively diagnosis of cervical lymph node metastases of the oral carcinoma.

Acknowledgment

This work was supported by JSPS KAKENHI Grant Number JP 18K09754.

References


