

Usefulness of shear wave elastography in the diagnosis of oral and maxillofacial diseases

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ABSTRACT

Purpose: To evaluate the usefulness of shear wave elastography in the diagnosis of oral and maxillofacial diseases.

Materials and Methods: Ten patients with oral and maxillofacial diseases and 28 volunteers drawn from our student doctors were examined by shear wave elastography with a 14-MHz linear transducer using an Aplio 300 apparatus (Canon Medical Systems, Otawara, Japan). A statistical analysis of the shear elastic modulus (kPa) of healthy tissue (the sublingual gland, submandibular gland, anterior belly of the digastric muscle, and geniohyoid muscle) in the 28 volunteers was performed using 1-way repeated measures analysis of variance with the Tukey honest significant difference test. The maximum shear elastic modulus (kPa) of 8 patients with squamous cell carcinoma (SCC) and 2 patients with benign lesions was evaluated with the Mann-Whitney U test. The analysis used a 5% significance level.

Results: The mean shear elastic modulus of the sublingual gland (9.4 ± 3.7 kPa) was lower than that of the geniohyoid muscle (19.2 ± 9.2 kPa, $P = .000$) and the anterior belly of the digastric muscle (15.3 ± 6.1 kPa, $P = .004$). The maximum shear elastic modulus of the SCCs (109.6 ± 14.4 kPa) was higher than that of the benign lesions (46.4 ± 26.8 kPa, $P = .044$).

Conclusion: Our results demonstrated the usefulness of shear wave elastography in the diagnosis of oral and maxillofacial diseases. Shear wave elastography has the potential to be an effective technique for the objective and quantitative diagnosis of oral and maxillofacial diseases. (*Imaging Sci Dent* 2018; 48: 161-5)

KEY WORDS: Neck; Carcinoma, Squamous Cell; Elasticity Imaging Techniques; Ultrasonography

Introduction

Ultrasonography has been widely accepted as a valuable diagnostic tool for head and neck diseases. Color Doppler ultrasonography is effective for the diagnosis of oral and maxillofacial diseases.¹ Strain elastography with ultrasonography is a relatively new imaging technique that has been found to be effective for the differential diagnosis of cervical lymph node metastasis.^{2,3} In recent years, strain elastography of the tongue has been found to be effective for differentiating healthy tissues and squa-

mous cell carcinoma (SCC).^{4,5}

Shear wave elastography is a recently developed method that uses push pulses to stress tissues and an ultrafast ultrasound imaging technique to detect the induced shear waves.⁶⁻⁸ Elasticity values have been determined for different tissues using shear wave elastography.^{9,10} Shear wave elastography is an acceptable method for diagnosing cervical lymph node metastasis, although its diagnostic criteria and reliability need to be further studied.¹¹⁻¹⁴ Furthermore, the usefulness of shear wave elastography for diagnosing oral and maxillofacial diseases and differentiating pathological lesions from healthy tissue has not been reported in the literature. This study aimed to evaluate the usefulness of shear wave elastography in the diagnosis of oral and maxillofacial diseases and the distinction of pathological lesions from healthy tissue (the sublingual

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gland, submandibular gland, anterior belly of the digastric muscle, and geniohyoid muscle).

Materials and Methods

This prospective study was approved by the ethics committee of our institution. Ten patients (8 males and 2 females; mean age, 72.6 years [range, 34-87 years]) with oral and maxillofacial diseases and 28 volunteers drawn from our student doctors (12 males and 16 females; mean age, 23.9 years [range, 23-26 years]) were examined by B-mode, color Doppler sonography and shear wave elastography with a 14-MHz linear transducer using an Aplio 300 apparatus (Canon Medical Systems, Otawara, Japan) at our university hospital from October 2017 to March 2018. Informed consent was obtained from all volunteers and patients. The volunteers were healthy and had no severe medical history or symptoms. The histopathological diagnoses of oral and maxillofacial diseases were obtained by surgery or biopsy in all cases after performing ultrasonography.

The ultrasonography examinations were performed by an experienced radiologist with more than 20 years of experience. On B-mode ultrasonography, the pathological lesions were assessed for their boundaries, echogenicity, and internal architecture. Color Doppler ultrasonography

was performed to evaluate the vascular signals within the lesions. The integrated shear wave elastography software allowed the operator to place regions of interest (ROIs) of various sizes within the elastography window, and automatically displayed shear elastic modulus data (kPa) for each ROI. Three ROIs with similar sizes were measured in each normal structure and lesion to obtain the shear elastic modulus (kPa). The quantitative indices of the shear elastic modulus (kPa) in healthy tissue were measured for the sublingual gland, submandibular gland, anterior belly of the digastric muscle, and geniohyoid muscle in the volunteers. Shear elastic modulus values for lesions and normal tissue areas as controls were also measured in 8 patients with SCC and 2 patients with benign lesions (1 pleomorphic adenoma and 1 cavernous hemangioma). The values from the healthy control tissues were measured at a significant distance from the areas affected by the diseases.

The shear elastic modulus of normal structures was compared between men and women using the Mann-Whitney U test. The statistical analysis of the shear elastic modulus of normal structures was performed using 1-way repeated-measures analysis of variance with the Tukey honest significant difference test. The maximum shear elastic modulus (kPa) of the SCC and benign lesions was

Table 1. Shear elastic modulus (kPa) of healthy tissue in the oral and maxillofacial region (mean±standard deviation; range)

Healthy tissue	Male (n = 12)	Female (n = 16)	P value
Sublingual gland	10.2±3.4; 6.0-15.4	8.9±3.8; 2.4-17.8	0.223
Submandibular gland	12.4±4.2; 6.9-18.6	13.8±5.1; 6.1-25.2	0.450
Anterior belly of the digastric muscle	16.9±5.9; 8.5-27.5	14.1±6.1; 4.9-23.8	0.280
Geniohyoid muscle	21.0±10.0; 7.5-38.4	17.8±8.5; 6.0-35.7	0.450

Table 2. Ultrasonographic appearance of the oral and maxillofacial lesions

Histopathological diagnosis (Number of cases)	Boundary		Echogenicity		Internal architecture		Vascular signals		Shear elastic modulus: mean ± SD (kPa)	
	Clear	Unclear	Hypoechoic	Isoechoic	Homogeneous	Heterogeneous	Presence	Absence	Lesion	Normal tissue
Benign tumors (2)	2	0	1	1	0	2	2	0	46.4±26.8	10.9±1.2
Pleomorphic adenoma (1)	1	0	0	1	0	1	1	0	65.3	10.0
Cavernous hemangioma (1)	1	0	1	0	0	1	1	0	27.4	11.7
Malignant tumors (8)	2	6	0	8	0	8	5	3	109.6±14.4	7.0±2.7
Buccal mucosa SCC (4)	0	4	0	4	0	4	4	0	108.4±18.3	8.3±3.3
Cervical lymph node metastasis of SCC (4)	2	2	0	4	0	4	1	3	110.8±12.0	5.6±1.2

SD: standard deviation, SCC: squamous cell carcinoma

Table 3. Shear wave elastography in oral and maxillofacial healthy tissue and lesions (mean±standard deviation; range)

	Number	Shear elastic modulus (kPa)	P value
Healthy tissue			
Sublingual gland	28	9.4 ± 3.7 (2.4-17.8)	–
Submandibular gland	28	13.2 ± 4.7 (6.1-25.2)	0.117
Anterior belly of the digastric muscle	28	15.3 ± 6.1 (4.9-27.5)	0.004
Geniohyoid muscle	28	19.2 ± 9.2 (6.0-38.4)	0.000
Lesions			
Squamous cell carcinoma	8	109.6 ± 14.4 (90.0-125.8)	0.044
Benign lesions	2	46.4 ± 26.8 (27.4-65.3)	

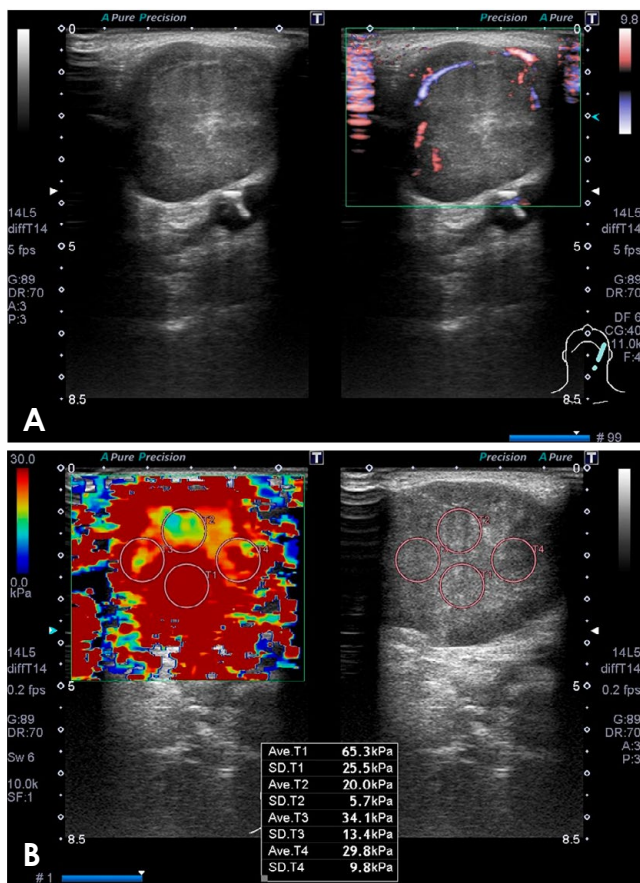


Fig. 1. Ultrasonograms of a pleomorphic adenoma of the left submandibular gland in an 84-year-old man. A. The lesion shows clear boundaries and is isoechoic and heterogeneous, with vascular signals within the lesion. B. T1 (65.3 kPa), T2 (20.0 kPa), T3 (34.1 kPa), and T4 (29.8 kPa) show the shear elastic modulus values of this submandibular gland tumor.

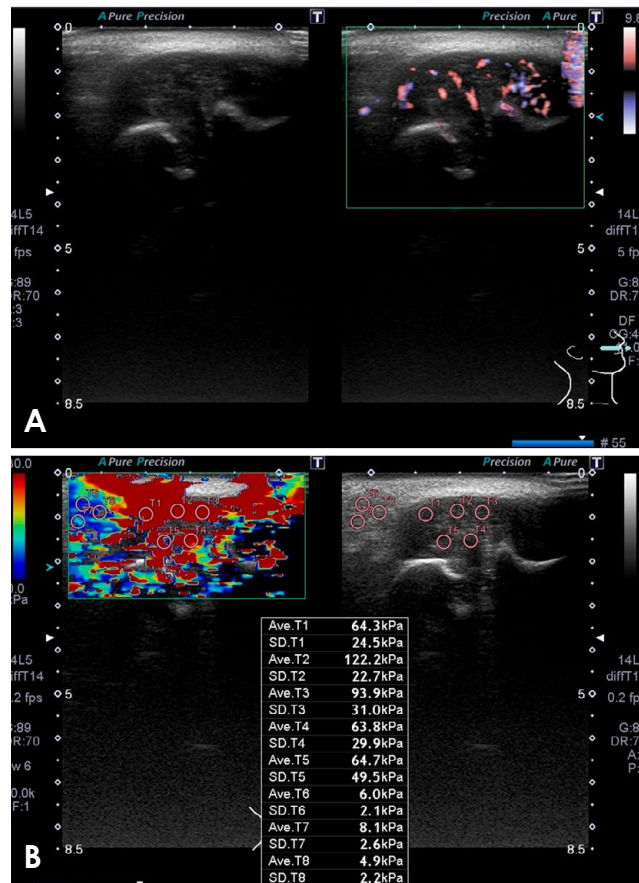


Fig. 2. Ultrasonograms of a squamous cell carcinoma on the right side of the buccal mucosa in a 56-year-old man. A. The lesion shows unclear boundaries, and is isoechoic and heterogeneous, with vascular signals within the lesion. B. T1 (64.3 kPa), T2 (122.2 kPa), T3 (93.9 kPa), and T4 (63.8 kPa) show the shear elastic modulus values of this buccal mucosal tumor.

evaluated using the Mann-Whitney U test. The analyses were performed using SPSS version 24 (IBM Japan, Tokyo, Japan) with a 5% significance level.

Results

Table 1 presents the shear elastic modulus values of

healthy tissue in the oral and maxillofacial region. The differences in the shear elastic modulus of each of the normal structures (sublingual gland, submandibular gland, anterior belly of the digastric muscle, and geniohyoid muscle) between males and females was not significant.

Table 2 presents findings regarding the ultrasonographic appearance of the oral and maxillofacial lesions. Of

the 8 SCCs, 6 had unclear boundaries, 8 were isoechoic relative to the adjacent tissues, 8 had a heterogeneous appearance on B-mode ultrasonography, and 7 had internal vascularity using color Doppler sonography.

Table 3 shows the shear wave elastography findings for the oral and maxillofacial healthy tissue and lesions. The mean shear elastic modulus of the sublingual gland (9.4 ± 3.7 kPa) was lower than that of the geniohyoid muscle (19.2 ± 9.2 kPa, $P = .000$), the anterior belly of the digastric muscle (15.3 ± 6.1 kPa, $P = 0.004$), and the submandibular gland (13.2 ± 4.7 kPa, $P = 0.117$). The maximum shear elastic modulus of the SCCs (109.6 ± 14.4 kPa) was higher than that of the benign lesions (46.4 ± 26.8 kPa, $P = .044$) (Figs. 1 and 2).

Discussion

This study demonstrated the effectiveness of shear wave elastography of the oral and maxillofacial region. Shear wave elastography is useful for the objective and quantitative diagnosis of oral and maxillofacial lesions.

Arda et al.⁹ showed that the mean elasticity values for the submandibular glands were 11.1 ± 3.2 kPa for males and 10.8 ± 3.1 kPa for females. In this study, the mean elasticity values for the submandibular glands were 12.4 ± 4.2 kPa for males and 13.8 ± 5.1 kPa for females. Furthermore, our results showed that the mean shear elastic modulus of the sublingual gland (9.4 ± 3.7 kPa) was lower than that of the geniohyoid muscle (19.2 ± 9.2 kPa, $P = .000$), the anterior belly of the digastric muscle (15.3 ± 6.1 kPa, $P = .004$), and the submandibular gland (13.2 ± 4.7 kPa, $P = .117$). The authors therefore concluded that evaluating the shear elastic modulus of healthy tissue is valuable for the differential diagnosis of oral and maxillofacial diseases.

Bhatia et al.⁶ showed that mean elasticity values for mucoepidermoid carcinoma, pleomorphic adenoma, and Warthin tumor were 107.0 ± 44.2 kPa, 22.5 ± 12.4 kPa, and 16.9 ± 4.8 kPa, respectively. Desmots et al.¹³ reported that head and neck lymph nodes with metastasis were stiffer (72.4 ± 59.0 kPa) than benign nodes (23.3 ± 25.3 kPa). In this study, the maximum shear elastic modulus of the SCCs (109.6 ± 14.4 kPa) was higher than that of the benign lesions (46.4 ± 26.8 kPa, $P = .044$). As an explanation of why the malignant tumors had higher shear elastic modulus values than the benign or normal tissue, Ogura et al.¹⁵ showed that the consistency of tongue carcinoma correlated with tumor thickness and other clinical or histopathological findings. We therefore suggest that the

shear elastic modulus is linked to the histopathological differences between benign and malignant diseases.

Suh et al.¹⁴ showed that the heterogeneous histology of lymph nodes with metastasis was more accurately reflected by the maximum value. Therefore, this study analyzed the maximum shear elastic modulus values, rather than the mean values.

There were several limitations to this study. All volunteers were relatively young because they were drawn from our student doctors. Our study also had a small sample of benign lesions. Therefore, further studies of healthy tissue in older individuals with a larger number of patients are necessary to confirm the diagnostic utility of this modality.

In conclusion, this study showed that shear wave elastography was useful for diagnosing oral and maxillofacial diseases. Shear wave elastography is an effective technique for the objective and quantitative diagnosis of oral and maxillofacial diseases.

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