Original Research

Differences in Viscoelastic Properties of Periodontium between Japanese and Chinese

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Clinical significance

In prosthodontic treatment, objective determination of tooth mobility is an important component of evidence-based dentistry. However, there were no data available about racial differences in the viscoelastic properties of periodontium. Such data for objective estimation of tooth mobility are needed.

ABSTRACT

Purpose : This study examined differences in the viscoelasticity of the periodontium between Japanese and Chinese subjects and the influence of their living environment on the periodontium.

Materials and Methods : We selected 93 and 113 upper central incisors, 100 and 100 upper canines, and 104 and 98 upper first molars of the Japanese and Chinese subjects, respectively, for examination in this study. The viscoelasticity of the periodontium was measured using an automatic diagnostic system that measured tooth mobility. The evaluated parameters were viscosity c_1 , c_2 and elasticity k . An analysis of variance was used to compare the upper central incisors, canines, and first molars in the Japanese and Chinese subjects. An unpaired t -test was used for comparison between sexes and between Japanese and Chinese.

Results : The viscoelastic parameters showed significant differences among central incisors, canines, and first molars in both the Japanese and Chinese. Almost all periodontal viscoelastic parameters were significantly different between Japanese males and females, while only a few such parameters showed significant gender differences in the Chinese. All parameters except c_1 of the central incisors in men and all parameters in women showed significant differences between the Japanese and Chinese subjects.

Conclusion : There were differences in the viscoelastic properties of the periodontium between Japanese and Chinese subjects.

Key words

tooth mobility, viscoelasticity, periodontium, Japanese, Chinese

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INTRODUCTION

The mobility of teeth is reported to be greatly influenced by the amounts and properties of periodontal tissue and how well this tissue function¹⁾. Therefore, determination of tooth mobility in prosthodontic treatment is important for making a diagnosis, deciding the course of treatment, and evaluating therapeutic efficacy and prognosis. In clinical practice, tooth mobility is usually examined by palpation with tweezers; however, a more objective examination is essential as the importance of evidence-based dentistry has been recognized. Although numerous methods for examining tooth mobility have been reported²⁻⁵⁾, only a few of them have been clinically applied because of certain disadvantages.

Considering that the living body is viscoelastic, we have developed an automatic diagnostic system for tooth mobility^{6,7)} that is capable of evaluating both the viscosity and elasticity of the periodontium. This system can noninvasively evaluate the mechanical characteristics of periodontium from the standpoint of viscosity and elasticity. The reference intervals in Japanese have already been established⁷⁾, and this system has been applied clinically in Japan.

The viscoelastic properties of periodontium may be different between races, depending on anatomical factors and dietary practices. Although the morphology of the jaw and face, the anatomy of the periodontal area, and eating habits have been compared among the races, there have been no reports on the relationship of such factors with racial differences in the viscoelastic properties of the periodontium.

As the first step in the present study to determine whether or not there are racial differences in the viscoelastic properties of the periodontium, the viscoelastic properties of healthy

teeth were measured using an automatic diagnostic system for tooth mobility. Data were compared between Japanese and Chinese study subjects of the same Mongoloid race, but with different eating habits.

MATERIALS AND METHODS

The subjects were healthy adult volunteers in their twenties who exhibited no systemic or stomatognathic abnormalities. They comprised 57 Japanese volunteers (33 men and 24 women, mean age : 24.0 years, range : 21-28 years) and 62 Chinese volunteers (33 men and 29 women, mean age : 22.9 years, range : 20-29 years, the Han Chinese).

The test teeth included the upper central incisors, canines, and first molars with M 0 of clinical mobility from palpation with tweezers, no periodontal abnormalities evident from pocket probing and X-ray examination, and no history of restorative treatment, including resin filling. Of the Japanese and Chinese subjects, a total of 93 and 113 central incisors, 100 and 100 canines, and 104 and 98 first molars were measured, respectively (Table 1).

It was necessary to ensure that the teeth used for this study had no abnormalities and came from healthy subjects. However, it was actually impossible to exclude test teeth in every pathological condition from this study. Therefore, in the present study, healthy volunteers in their twenties were selected as subjects because it was considered relatively easy to standardize the study conditions between the two countries.

Table 1 Number of teeth studied

	Japanese		Chinese	
	Men	Women	Men	Women
Central incisors	58	35	57	56
Canines	54	46	45	55
First molars	60	44	43	55

The viscoelastic properties of the periodontium were measured using an automatic diagnostic system for tooth mobility^{6,7)} that we have developed. This system consists of a personal computer for analyzing data, power, strain and charge amplifiers, and a measuring probe. Random vibrations were applied at 10–1,000 Hz range to the crown surface, and the acceleration and force were detected from the same driving point. With this system, it is possible to noninvasively measure the viscoelastic properties of the periodontium and analyze five parameters: viscosity c_1 and c_2 , elasticity k , and mass m_1 and m_2 . Among these five viscoelastic parameters, c_1 and c_2 (showing viscosity) and k (representing elasticity) were analyzed in the present study.

Since the possibility could not be ruled out that there would be differences in the selection of healthy teeth, especially in the evaluation of clinical mobility between the investigators of two countries, test teeth were selected and their periodontal viscoelastic properties were measured in both countries after sufficient previous arrangement and training.

An analysis of variance (ANOVA) was used to compare the upper central incisors, canines, and first molars in the Japanese and Chinese. An unpaired t -test was used for comparison between gender and also between Japanese and Chinese.

RESULTS

The results of the assessment of viscoelastic properties in several kinds of teeth in the Japanese and Chinese subjects are found in Fig. 1. The viscoelastic values of the central incisors were the lowest, while the values for the canines were almost the same as those of the first molars in both Japanese and Chinese. All parameters showed differences among the kinds of teeth in

both Japanese and Chinese; the results of the ANOVA showed significant differences ($p < 0.01$) for every viscoelastic parameter.

Gender differences for each kind of teeth tested were investigated for the Japanese and Chinese subjects. Figure 2 shows the results for the Japanese. The viscoelastic values tended to be higher in men than in women, and statistical analysis using an unpaired t -test showed significant differences ($p < 0.05$ or 0.01) in all parameters of central incisors, c_2 of canines, and c_2 and k of first molars. The values for these parameters were lower in women than in men, indicating higher tooth mobility in women.

Figure 3 shows the results of comparison between male and female Chinese. Gender differences were generally small for the viscoelastic parameters. Statistical analysis showed gender differences in c_2 and k of the first molars, but no such differences were found for the central incisors and canines.

A comparison of the viscoelastic parameters of each kind of teeth between Japanese and Chinese men is found in Fig. 4. There was no difference in c_1 of the central incisors, but the values of other viscoelastic parameters were 1.4 to 2.5 times higher in the Chinese than in the Japanese. Statistical analysis using an unpaired t -test showed significant differences ($p < 0.01$) in c_2 and k of central incisors and all viscoelastic parameters of the canines and first molars.

Figure 5 compares the viscoelastic parameters of each kind of teeth between Japanese and Chinese women. In the women, there were differences in all parameters, and their values were 1.5 to 2.3 times higher in the Chinese than in the Japanese. Statistical analysis also showed significant differences ($p < 0.01$) in all parameters for the central incisors, canines, and first molars. Briefly, these results indicated that the values for viscoelastic properties were lower and tooth mobility was higher in the Japanese than in the

Fig. 1 Differences in viscoelastic parameters among upper central incisors, canines and first molars in Japanese and Chinese

Fig. 2 Differences in viscoelastic parameters between male and female Japanese

Fig. 3 Differences in viscoelastic parameters between male and female Chinese

Fig. 4 Differences in viscoelastic parameters between Japanese and Chinese men

Fig. 5 Differences in viscoelastic parameters between Japanese and Chinese women

Chinese.

DISCUSSION

Studies have already been performed on periodontal viscoelastic measurement. Noyes et al.⁸⁾ made a dynamic model of the periodontium that they considered viscoelastic and analyzed teeth using this model. As a result, the periodontium was found to be viscoelastic, and periodontal changes were observed under various conditions. However, the measuring systems²⁻⁴⁾

were large and could not be applied clinically. Therefore, we developed an automatic diagnostic system for tooth mobility^{6,7)} intended for clinical application and conducted our studies using it. As a result, it has become possible to measure periodontal viscoelastic properties at chairside within a few seconds and analyze and diagnose the tooth mobility easily and promptly owing to the improvement in software.

There were differences in all viscoelastic parameters of the periodontium among the kinds of teeth in both the Japanese and Chinese sub-

Table 2 Averages of root areas and the viscoelastic values for unit area

Nationality	Tooth	Root area (mm ²)	Sex	c ₁ (Ns/m)/mm ²	c ₂ (Ns/m)/mm ²	k (N/m)/mm ²
Japanese	Central incisors	218.48*	Men	0.17	1.54	912.84
			Women	0.14	1.33	789.95
	Canines	316.56*	Men	0.14	1.27	1,175.8
			Women	0.15	1.16	1,131.8
	First molars	456.06*	Men	0.09	0.79	710.9
			Women	0.09	0.78	565.5
Chinese	Central incisors	148**	Men	0.26	3.34	2,017.6
			Women	0.29	3.44	1,930.6
	Canines	217**	Men	0.41	3.72	2,973.5
			Women	0.38	3.55	2,758.5
	First molars	360**	Men	0.29	2.47	1,895.0
			Women	0.25	2.24	1,662.6

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jects. These differences were presumably ascribable to the influence of root length, periodontal surface area, and the number of roots. Table 2 shows the values obtained by dividing the mean of the periodontal viscoelastic values in Japanese and Chinese subjects by their mean periodontal surface areas^{9,10)}. The values for the upper central incisors were almost the same as those for the upper canines; however, the values for the first molars were lower than those of the other kinds of teeth in the Japanese. Almost the same tendency was observed in the Chinese. Such differences presumably are due to anatomical and functional differences, i.e., central incisors and canines are single-rooted, while first molars are multi-rooted, and central incisors and canines mainly work as guides, while first molars support occlusal force. However, further detailed studies of this point are warranted.

Gender differences in the viscoelastic properties of the periodontium were noted in all kinds of test teeth in the Japanese, while they were noted only in the first molars in the Chinese. The values for all viscoelastic parameters showing gender differences were lower in women than in men in both countries. It may be necessary to consider menstrual cycle-induced viscoelastic

changes in women in the evaluation of viscoelastic properties. Therefore, according to the report of Matsumoto et al.¹¹⁾, measurement was not conducted for 1 week before the onset of menstruation to avoid the influence of the menstrual cycle. Differences in the condition of the periodontal tissue and also in occlusal force and skeleton are considered to be related to gender differences. According to most reports^{12,13)}, there are gender differences in occlusal force and skeleton in both Japanese and Chinese, and these are higher in men than in women. In the present study, the results obtained for the Japanese subjects were in accord with the above reports, while the results obtained for the Chinese teeth other than the first molars were not necessarily in good agreement with the literature. Therefore, it seems necessary to examine the Chinese results from the standpoint of other factors.

Since there were differences in the viscoelastic properties of the periodontium between Japanese and Chinese, it became necessary to assess the anatomical influence, such as root surface area and root length, and the influence of eating habits, on periodontal viscoelastic properties. In the comparison of root length between Japanese and Chinese, the mean root lengths of

upper central incisors, canines, and first molars were 12.1, 14.5, and 12.0 mm, respectively in the Japanese⁹⁾, while they were 11.3, 14.2, and 12.4 mm, respectively in the Chinese¹⁰⁾, with no clear difference between the two countries. On the other hand, there may be clear differences in eating habits between the two countries. In Japan, the eating style has become Westernized, whereas in China, harder foods are eaten compared with foods eaten in Japan¹⁴⁾. It has been reported¹²⁾ that the occlusal force of first molars was about two-fold higher in Chinese men and women than in Japanese men and women. The presence of differences in periodontal viscoelastic properties between the Mongoloid people living in Japan and China suggests that factors such as eating habits are closely related to such properties.

CONCLUSION

In the present study, the viscoelastic properties of central incisors, canines, and first molars in Japanese and Chinese were measured using an automatic diagnostic system for tooth mobility, and the values of viscosity parameters c_1 and c_2 and those of elasticity parameter k were observed for differences between the kinds of teeth, gender, and the two nationalities (Japanese and Chinese).

The following results were obtained :

1. The viscoelastic parameters were significantly different among central incisors, canines, and first molars in both Japanese and Chinese.

2. Almost all periodontal viscoelastic parameters showed significant gender differences in the Japanese, while only a few such parameters showed significant gender differences in the Chinese.

3. All parameters except c_1 of central incisors in men and all parameters in women were significantly different between Japanese and

Chinese.

These results suggest that there are racial differences in the viscoelastic properties of the periodontium of Japanese and Chinese.

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