Viscoelastic properties of implants placed in bone augmented by guided bone regeneration

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We measured the viscoelastic properties of implants placed in bone augmented by guided bone regeneration (GBR). Moreover, the viscoelastic properties of implants in bone augmented by GBR (GBR group) were compared with those of IMZ implants with either an element made of pure titanium (Ti group) or an intramobile element made of polyoxymethylene (IME group). The viscoelastic properties of the implants were measured by an automatic mobility diagnostic system that we developed. Statistical analysis was performed using the Kruskal-Wallis test for comparison between groups at a significance level of 0.05. When a significant difference was found, the Dunn test was applied for after-the-fact comparison.

There were significant differences among the three groups for all parameters (viscosity c1, viscosity c2, and elasticity k) by the Kruskal-Wallis test. The three parameters were greatest for the GBR group, and the values were lower for the Ti and IME groups in that order. Moreover, even when only the internal element in the same implant was changed, there was a tendency for the Ti group to have greater values than the IME group. We concluded that implants where GBR has been used show good viscoelastic properties. (J Osaka Dent Univ 2006 ; 40 : 145–148)

Key words: Implants; Guided bone regeneration; Viscoelasticity

INTRODUCTION

A key of implant success is that the device integrates with the surrounding tissue and is maintained over a long period of time.1,2 We previously evaluated this osteointegration from the viewpoint of the viscoelastic properties of the implant by using an automatic mobility diagnostic system.3,4 Implants and natural teeth show different viscoelastic properties during function. Implants are often placed where there are bone defects or insufficient bone quantity. We measured the viscoelastic properties of implants placed in bone augmented by guided bone regeneration (GBR)5,6 and compared them with the viscoelastic properties of implants placed in normal bone.

MATERIALS AND METHODS

The viscoelastic properties of Bränemark implants where GBR had been used (GBR group) were compared with those of standard implants in normal bone. Ten IMZ implants of 4 mm in diameter and 15 mm in length that had been placed in humans were studied. We measured the viscoelastic properties when the implant had an element of pure titanium (with the same form as an intramobile element) and when it had an intramobile element made of polyoxymethylene.

The viscoelastic properties of the implants were measured using an automatic mobility diagnostic system that we developed (Fig. 1). A schematic diagram of the system is shown in Fig. 2. It in-
cluded a personal computer for analysis, an amplifier, and a measurement probe that consisted of a portable vibrator, an impedance head and a load cell. Vibration was applied to the implant by placing the tip perpendicular to the buccal surface of the prosthesis. The excitation frequency was between 30 and 1,000 Hz and the input acceleration was 0.05 G on average. The contact force to the object was preliminarily set at 0.49 ± 0.049 N (50 ± 5 g). The load cell restricted the automatic computer sampling to this range. The acceleration and force response were measured by the contact point of the impedance head. The response was sampled by an analog-to-digital converter and Fast Fourier Transform (FFT) processing was performed. Through this process, the mechanical mobility frequency properties were obtained for the peri-

A total of 256 items of data were sampled. FFT processing was performed using the Hanning window function, and averaging was performed 16 times. The dynamic parameters viscosity $c_1$, viscosity $c_2$ and elasticity $k$ were automatically obtained by a curve-fitting method using a personal computer. Statistical analysis was performed using the Kruskal-Wallis test for comparison between groups at a significance level of 0.05. When a significant difference was found, the Dunn test was applied for after-the-fact comparison.

**RESULTS**

The results are shown in Figs. 3–5 for the three dynamic parameters viscosity $c_1$, viscosity $c_2$ and elas-
Viscoelastic properties of implants

**Viscoelastic properties**

**Guided bone regeneration**

Implants are often placed where there are bone defects or a deficiency in bone quality. In these cases autogenous, freeze-dried or artificial bone is often placed in the site. GTR was first advocated in 1992 as a method to promote the growth of new bone by regeneration or hyperplasia in the bone defect. However, it is difficult to predict the amount of bone that will be obtained. The process is a matter of trial and error. This method can only be used after the patient has received detailed explanation of the purpose, procedure, advantages and disadvantages, and has given their consent. A greater amount of bone can usually be obtained when GBR is used. The esthetic recovery is better and the patient is often happier.

**Measurement device**

Living tissue is viscoelastic. The viscosity and elasticity factors are thought to exist in series or in parallel in living tissue. When analyzing the biological characteristics of peri-implant bone, it is necessary to isolate and detect the viscosity factors and elasticity factors. There have been few reports concerning the viscoelasticity of implants. Although the Periotest® developed by Schulte and used widely clinically is easy to use, accurate measurements may be difficult to obtain because the applied force may be too great for the supporting tissue. In addition, this device only measures elasticity. The automatic mobility diagnostic system employed in this study can identify dynamic parameters associated with mechanical mobility and viscoelasticity that occur when the weak force of 50 g is applied buccolingually. In addition, the quantitative values for elasticity and viscosity make it possible to compare, evaluate and analyze the degree of implant osteointegration over time.  

**DISCUSSION**

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**Viscoelastic properties**

Although there have been histological studies on GBR, no reports have evaluated its viscoelastic properties. The viscoelastic properties of implants placed in bone augmented with GBR were significantly greater than of those placed in normal bone. Although the viscoelasticity with GBR was greater in the area where the bone was augmented than in normal bone, the implants did have a soft feeling when they were placed. It is thought that supporting bone probably matures during the time from when the implant is placed until the prosthesis is put on. In addition, placement of the prosthesis may cause the bone to further mature. Moreover, when the internal element was changed in the same implant there was a tendency for the Ti group to have greater values than the IME group.

These results seem to indicate that implants placed where the bone has been augmented by GBR show appropriate viscoelastic properties.

We would like to express our gratitude to Dr. M. Inoue at the Department of Oral Implantology of Osaka Dental University who provided considerable support in this research.

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