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MECHANICAL PROPERTIES OF ARTIFICIAL TEETH

BY

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ABSTRACT

In selecting the teeth for fabrication of complete or partial dentures, each patient's anatomic and physiologic requirements and the properties of the artificial teeth themselves should be taken into consideration. The purpose of this study was to evaluate the mechanical properties of the artificial teeth by the static compression test and the impact test. Specimens were the lower first molar porcelain and resin teeth (Livdent FB-20 teeth by G.C. Co., Tokyo, Japan). All were of the same shape. In the static compression test, the fracture load and deformation of the artificial teeth were measured with an Instron-type universal testing machine at a cross-head speed of 1.0 mm/min. Elastic modulus, ultimate strength and absorbed energy were calculated. In the impact test, the acceleration of a falling impactor was measured with a drop impact apparatus. The load applied to the specimen was equivalent to 300N. Absorbed energy and deformation were calculated.

The resin teeth showed a lower elastic modulus, higher fracture toughness and shock-absorbing ability than the porcelain teeth. Resin teeth should be selected when the first requisite is high shock-absorbing ability, and porcelain teeth should be selected when the first requisite is high masticating efficiency.

Key words: Artificial teeth, Compression test, Impact test, Shock-absorbing ability, Mechanical property

INTRODUCTION

Either porcelain denture teeth or acrylic resin denture teeth are used in the fabrication of complete or partial dentures. In choosing the denture teeth, each patient's anatomic and physiologic requirements and the properties of the artificial teeth themselves should be taken into consideration. Phillips [1] lists high fracture toughness, low abrasion resistance, silence on contact, cold flow under stress and minimal abrasion of the opposing dentition as some of the characteristics of resin teeth. Myerson [2] pointed out that the yielding character of the plastic absorbs some of the energy of impact and reduces noise. Many investigators have reported the wear characteristics of artificial teeth (Khan et al. [3]; von Fraunhofer et al. [4]), but there have been few studies on other mechanical properties (Shimoyama et al. [5]). The purpose of this investigation was to evaluate the mechanical properties of the artificial teeth by a static compression test and an impact test.

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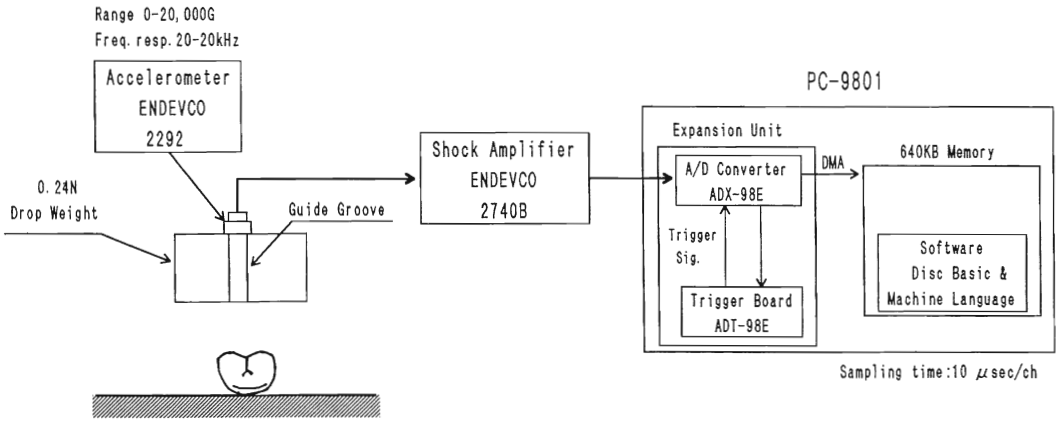

Fig. 1 Drop Impact Apparatus

Materials and Methods

The materials were lower first molar porcelain and resin teeth (Livdent FB-20 teeth by G.C. Co., Tokyo, Japan). All were of the same shape (size: 28M/30). The resin teeth is composed of highly cross-linked poly methyl methacrylate. The batch numbers of the porcelain and resin teeth were 210611 and 261007, respectively. In Japan, only the Livdent teeth are available as porcelain and resin teeth of the same shape.

The static compression test was performed with an Instron-type universal testing machine (Tensilon, the Orientec Co., Ltd., Tokyo, Japan) at a cross-head speed of 1.0 mm/min. The fracture load and deformation of the artificial teeth were measured. The elastic modulus, ultimate strength and absorbed energy of the specimens were calculated from the load-deformation curve obtained. On calculation, the cross-section of the specimens approximated an ellipse of 51.1 mm^2 in area.

The impact test was performed with a drop impact apparatus (Fig. 1). The acceleration of a falling impactor was measured. The absorbed energy and deformation of the specimens were calculated. Impact energy can be changed by using the interchangeable weights and different heights of the impactor. Referring to the previous studies on the biting force of removable dentures (Sasagawa [6]; Fukamizu [7]), we regarded the suitable load applied to the mesiobuccal cusp of the lower first molar as 300N in our test procedure. The aluminium impactor was 0.24N in weight and was dropped downwards onto the mesiobuccal cusp of the specimen on a steel table from a height of 15.0 cm. The impact speed was 1.71 m/sec on the cusp.

Student's *t* test was used to compare the difference of the two materials.

Results

The typical load-deformation curves of the porcelain teeth and resin teeth obtained by the static compression test are shown in Figure 2. Table 1 shows the fracture load, elastic modulus, ultimate strength, absorbed energy and deformation of the specimens in the static compression test. The elastic modulus of the porcelain teeth was significantly ($p<0.001$) higher than that of the resin teeth. The absorbed energy of the resin teeth was significantly ($p<0.001$) more than that of the porcelain teeth.

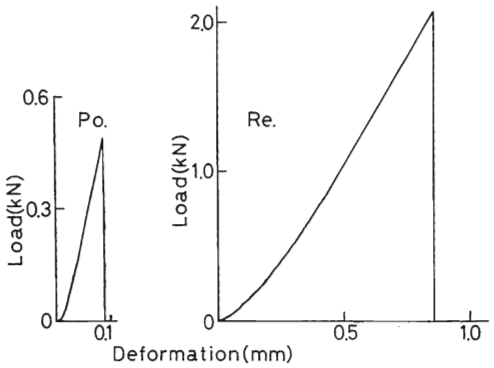

Fig. 2 Typical Load-deformation Curves of Porcelain Teeth and Resin Teeth Obtained by Static Compression Test
Po.: Porcelain teeth Re.: Resin teeth

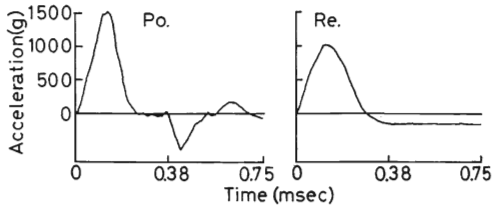

Fig. 3 Typical Acceleration versus Time Curves of Porcelain Teeth and Resin Teeth Obtained by Impact Test
Po.: Porcelain teeth Re.: Resin teeth

Table 1. Mechanical Properties of Artificial Teeth Determined by Compression Test. n=13

	Porcelain teeth	Resin teeth
Fracture load (kN)	0.54±0.09**	2.2±0.18
Elastic modulus (MPa)	664.2±49**	276.3±20
Ultimate strength (MPa)	10.7±1.7**	43.0±3.4
Absorbed energy (J)	0.02±0.003**	0.72±0.03
Deformation (mm)	0.081±0.004**	0.86±0.08

**: $p<0.001$

Table 2. Mechanical Properties of Artificial Teeth Determined by Impact Test. n=8

	Porcelain teeth	Resin teeth
Acceleration (g)	1555.5±100**	1141.5±94.5
Absorbed energy ($\times 10^{-3}$J)	25.8±3.5*	30.2±3.1
Deformation (mm)	0.22±0.036*	0.33±0.06

**: $p<0.001$ *: $p<0.05$

The typical acceleration versus time curves of the porcelain teeth and resin teeth obtained by the impact test are shown in Figure 3. Table 2 shows the acceleration, absorbed energy and deformation of the specimens in the impact test. The absorbed energy of the resin teeth was significantly ($p<0.05$) more than that of the porcelain teeth.

Discussion

The artificial teeth of the dentures are stressed during mastication and clenching. The process of mastication can be considered an impact situation. The energy absorbed by the teeth is related to the

masticating efficiency. Therefore the static compression test and the impact test are useful to evaluate the mechanical properties of the artificial teeth.

In the static compression test and the impact test, the energy absorbed by the resin teeth was greater than that absorbed by the porcelain teeth. Therefore the resin teeth are tougher than the porcelain teeth. The resin teeth have a lower elastic modulus, greater toughness and higher shock-absorbing ability than the porcelain teeth, in agreement with the results of our previous study (Shimoyama et al. [5]).

Our results revealed that the porcelain teeth are brittle and show only a slight deformation. Appelbaum [8] pointed out that porcelain is a hard, unforgiving material, and although prematurities may increase the fracture potential of a porcelain tooth, these premature contacts are transmitted directly to the underlying alveolar bone. The force of this improper occlusion results in an increased potential for bone resorption. The use of resin teeth avoids the click and trauma hazards of dentures made with all porcelain teeth. In the early papers (Appelbaum [8]; Dirksen [9]), the wear and the cold flow of plastic teeth seriously affect the vertical dimension and masticating efficiency. To maintain the comminuting efficiency of the prosthesis, porcelain teeth should be used.

In conclusion, resin teeth should be selected when the first requisite of artificial teeth in the construction of dentures is high shock-absorbing ability, and porcelain teeth should be selected when the requisite is high masticating efficiency.

Further investigation is being carried out to evaluate the mechanical properties of the artificial teeth by placing them in the resin denture base under a condition similar to the actual clinical application.

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