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Original article

Basic investigation of the laminated alginate impression technique: Setting time, permanent deformation, elastic deformation, consistency, and tensile bond strength tests

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ABSTRACT

Purpose: Laminated alginate impression for edentulous is simple and time efficient compared to border molding technique. The purpose of this study was to examine clinical applicability of the laminated alginate impression, by measuring the effects of different Water/Powder (W/P) and mixing methods, and different bonding methods in the secondary impression of alginate impression.

Methods: Three W/P: manufacturer-designated mixing water amount (standard), 1.5-fold (1.5×) and 1.75-fold (1.75×) water amount were mixed by manual and automatic mixing methods. Initial and complete setting time, permanent and elastic deformation, and consistency of the secondary impression were investigated (n=10). Additionally, tensile bond strength between the primary and secondary impression were measured in the following surface treatment; air blow only (A), surface baking (B), and alginate impression material bonding agent (ALGI-BOND: AB) (n=12).

Results: Initial setting times significantly shortened with automatic mixing for all W/P ($p < 0.05$). The permanent deformation decreased and elastic deformation increased as high W/P, regardless of the mixing method. Elastic deformation significantly reduced in 1.5× and 1.75× with automatic mixing ($p < 0.05$). All of these properties resulted within JIS standards. For all W/P, AB showed a significantly high bonding strength as compared to A and B ($p < 0.01$).

Conclusions: The increase of mixing water, 1.5× and 1.75×, resulted within JIS standards in setting time, suggesting its applicability in clinical setting. The use of automatic mixing device decreased elastic strain and shortening of the curing time. For the secondary impression application of adhesives on the primary impression gives secure adhesion.

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1. Introduction

According to a 2011 Japanese national dental disease survey [1], the prevalence of edentulousness decreased from 7.9% in 1975 to 5.2% in 2011. However, the prevalence of edentulousness among people aged 75 years or older has greatly increased from 21% in 1975 to 64% in 2011. The increasing age of edentulous patients may indicate a rise in the number of patients for whom conventional treatments are both mentally and physically insufficient. Further, the present circumstances may require diversity among the treatments for individual patients.

The appropriate insertion of complete dentures is considered to a major factor in the oral and general health of edentulous patients. In order to construct complete dentures with appropriate support and stability, it is necessary to generate a record of the appropriate denture base surface area, flange contour, and mucosal surface and to generate a record of the lining mucosa by making an impression. Therefore, the objectives of making a complete denture impression are as follows: to generate a record of all anatomical landmarks in the oral cavity; to obtain strong adhesion or retention with the mucosal surface; and to obtain an appropriate border shape to maintain the adhesion [2]. The conventional precise impression method records movement of the muscular tissue of the circumference of the mouth in a modeling compound, and identifies the range of a denture base. Then, the final impression is made using a precision impression material. This method has an advantage that determines the range of a denture base strictly and can manufacture a minute master cast. However, the treatment period is extensive [3], is greatly affected by the skill of the operator, and is burdensome for the patient. This treatment is particularly difficult to recommend as a first choice for elderly patients, patients with systemic diseases, and patients receiving treatment at home.

Alginate impression material, which is inexpensive and easy to handle, is frequently used to make complete denture impressions in general clinical settings [4]. However, because alginate impression material involves the use of a stock tray to make a preliminary impression, it is sometimes difficult to generate an impression that adheres strongly to the mucosal surface or the appropriate border shape. Therefore, a laminated alginate impression technique, in which the alginate impression material is double-layered before making an impression, has been devised in order to compensate for this flaw, and many clinicians have used this technique and noted its advantages [5,6]. The laminated alginate impression technique for edentulous patients is comprised of several steps. First, a preliminary impression is made with a standard Water/Powder (W/P) by using a stock tray. Next, the impression surface is treated baked or application of an alginate-bonding agent, and W/P is subsequently increased and a secondary impression is made with alginate impression material that is sufficiently fluid. This process is expected to achieve results similar to those of conventional precise impressions. The effects of the laminated alginate impression technique devised by Nakazawa et al. [7,8] on model shapes have been reported. However, the physical properties of alginate impression material with an increased W/P and the effect of different preliminary impression surface treatments on bonding strength in the preliminary and secondary impressions are unclear. Adequate scientific evidence is lacking regarding whether this technique can be sufficiently adapted to a clinical setting.

Therefore, the objective of the present study was to examine the clinical applicability of the laminated alginate impression technique, by measuring the effects of different alginate impression material W/P and mixing methods in the secondary impression on the properties of the material (setting time, permanent deformation, elastic deformation, and consistency) and the effects of different preliminary impression surface treatments on bonding strength in preliminary and secondary impressions.

Null hypothesis of the study was: 1. There is no difference in the physical properties of the alginate impression material that has been mixed with three different W/P of alginate impression material as a secondary impression by two different mixing method. 2. There is no difference in tensile bond strength between the primary and secondary impression due to different method of surface treatment of primary impression.

2. Materials and methods

2.1. *Physical properties of the secondary impression*

2.1.1. *Study samples and measuring items*

Seven and half grams of alginate impression material (Algiace Z, Dentsply Sankin, Ibaraki, Japan) was mixed with distilled water ($17.0 \pm 0.5\ ^{\circ}C$) with 3 W/P; 17 ml (manufacturer-designated mixing water amount; hereafter "standard"), 25.5 ml distilled water (1.5-fold of the manufacturer-designated mixing water amount; hereafter "1.5×"), and 29.8 ml of distilled water (1.75-fold of the manufacturer-designated mixing water amount; hereafter "1.75×") [9]. The mixing methods were manual mixing for 40 s and automatic mixing for 12 s by using an automatic mixer (Mikrona Mixer, Mikrona, Switzerland). Thus, six different mixed impressions (three W/P, mixed by two mixing methods, n=10 respectively) were used for the measurement. The measuring items were setting time, permanent deformation, elastic deformation and consistency. All measurement were followed to Japanese Industrial Standard (JIS) T-6505 [10] at constant room temperature ($23.5 \pm 1\ ^{\circ}C$).

2.1.2. *Setting time*

The mixed impression materials were poured into metal rings (a diameter of 30 mm) placed on a glass board. The materials were brought into contact with the impression surface at 10-s intervals by using a polymethyl methacrylate (PMMA) stick polished at one end. The initial setting time was defined as the amount of time that elapsed until the material no longer adhered to the stick surface, and the complete setting time was defined as the amount of time that elapsed until the PMMA stick marks disappeared.