The influence of storage duration on the setting time of type 1 alginate impression material

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The influence of storage duration on the setting time of type 1 alginate impression material

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Abstract. Alginate is one of the most commonly used dental impression materials; however, its setting time is subject to change depending on storage conditions and duration. This creates problems because consumer carelessness can affect alginate shelf life and quality. In the present study, the setting times of two groups of type I alginate with different expiry dates was tested. The first group consisted of 11 alginate specimens that had not yet passed the expiry date, and the second group consisted of alginites that had passed the expiry date. The alginate powder was mixed with distilled water, poured into a metal ring, and tested with a polished rod of poly-methyl methacrylate. Statistical analysis showed a significant difference (p<0.05) between the setting times of the alginate that had not passed the expiry date (157 ± 3 seconds) and alginate that had passed the expiry date (144 ± 2 seconds). These findings indicate that storage duration can affect alginate setting time.

1. Introduction
Study models and working models are needed in many area of dental practice, such as in the planning and evaluation of treatment and the fabrication of indirect restorations and dentures. These models, which are replicas of the soft and hard tissues of the oral cavity, are produced to allow extra-oral design and fabrication. The most commonly used materials for the production of both study and working models are currently alginate or irreversible hydrocolloid [1]. Dental practitioners prefer to use alginate as an impression material due to its relatively low cost, ease of use, ready acceptance by patients, and good hydrocolloid properties [1]. Impression materials must have an adequate setting time in order to produce an accurate impression of the teeth and their surrounding tissues. The whole process of alginate manipulation, including the mixing, placing in the tray, and insertion into the patient’s mouth, must be conducted before the setting time elapses. Two types of alginate material are available on the market: a fast setting type and a normal setting type. The fast setting type alginate was produced to enhance the patient’s comfort by reducing the working time. This type of alginate is especially useful for some cases, such as impression taking in patients with a high gag reflex. Despite its many advantages, alginate also has some disadvantages. It is hygroscopic, which means it can absorb moisture from surrounding humidity [2]. The shelf life of alginate also strongly depends on its stability during storage, which in turn depends on the storage conditions and duration [2]. ANSI/ADA specification no. 33 (2003) defines the shelf life as the period during which a material maintains its physical and mechanical properties required to perform its functions [3]. The shelf life of a material will progressively decrease with increasing duration of the storage time. Ideally, the shelf life will end at precisely the same time as the expiry date set by the manufacturer. However, conditions during the
storage and delivery of the material that do not fulfill the standards could cause deterioration or reduction in the material’s quality.

The main factors considered to affect the shelf life of alginate are the storage temperature and moisture contamination from the surrounding air [4]. Moisture contamination should be prevented because it can cause premature setting of the alginate [1]. Packaging that is left open or packaging that is not airtight could cause moisture contamination. The storage temperature should also be considered, since high temperature can cause depolymerization of the alginate polymer [1].

Nevertheless, many dentists and dental material distributors do not pay attention to the material’s storage standards. Commonly, packaging may not be airtight, storage locations may lack air conditioning, and delivery processes might allow exposure to heat and the surrounding air. In addition, the storage of alginate is not yet ideal in many dental practices. Many practitioners, after opening the package, are accustomed to transferring the powder into another container or closing the package with only a rubber band. This storage method is maintained for weeks until all the powder has been used. In these cases, in addition to not protecting the alginate from outside conditions, the expiry date might also no longer be evident, leaving the quality of the material questionable. Furthermore, in order to attract customers, many distributors are willing to give discounts for products close to their expiry dates. For these reasons, the purpose of this study was to use the setting time to compare the quality of alginate materials from a package opened for about three weeks but not past its expiry date and to the quality from a similarly opened package that had passed its expiry date.

2. Materials and Methods

Alginate specimens consisted of two groups with different expiry dates. The first group consisted of 11 specimens with an expiry date 6 months after the time of the study, and the second group was consisted of 11 specimens with an expiry date had already passed two years at the time of the study. The alginate used in this study was the Alginoplast® (Heraeus Kulzer, Sidney, Australia) type 1 and the packaging had been opened for 24 days. This duration of 24 days assumed that the average alginate package is opened for 24 days until all the contents have been used.

All tools and materials for the testing were moved into the testing room ten hours prior to the test. During the testing, the room condition was controlled with an average humidity of 52.5% and temperature of 24.7 °C. The setting time of the alginate was counted from the beginning of the mixing until the material had fully set, with the clinical sign of the loss of the material’s stickiness. The first procedure was mixing the alginate powder with distilled water with the ratio indicated in the manufacturer’s instructions (23 grams of powder with 50 mL of distilled water) and then mixed for 1 minute. In this study, the amounts of powder and distilled water were reduced, but kept in the same ratio (5.75 grams of powder with 12.5 mL of distilled water) in accordance with the volume of the metal rings used for molding. The mixture was then poured into these metal ring molds (3 cm in diameter and 16 mm high), and the setting time was counted every 10 seconds by placing the surface of a polished rod of poly-methyl methacrylate in contact with the alginate mixture. When no alginate was present on the testing rod, this indicated that the alginate had reached its setting point. The setting time measurement was counted in seconds using a stopwatch from the beginning of mixing until the setting point. After conducting the test, the data for the setting points of both groups were tabulated and analyzed by comparing two independent means value (Independent Samples T Test).

3. Results and Discussion

3.1 Results

Table 1 shows a decrease in the setting time for the alginate that had been expired for 9 months (Group II). The setting time for that group was 13 seconds faster (8.2% faster) than the setting time for the other alginate that had not expired.
Table 1. Mean setting times for type I alginate

| Group                     | Total specimens | Setting time means (minute)          |
|---------------------------|-----------------|--------------------------------------|
| I                         | 11              | 2 minutes 37 seconds ± 3 seconds     |
| II                        | 11              | 2 minutes 24 seconds ± 2 seconds     |
| Manufacturer’s Instructions| 11              | 2 minutes 30 seconds                  |

Group I: Type I alginate impression material with an expiry date of April 2016
Group II: Type I alginate impression material with an expiry date of December 2014

The Shapiro Wilk normality test Q-Q Plot distribution table indicated that the numbers of significance for Group I and II were 0.70 and 0.096, respectively, with a coincidence interval (α) of 0.05. This result showed that the distribution of setting time of both groups are normal towards the means (p>0.05). A homogeneity test was then conducted to clarify the variance of each group. The variance number was 0.201 (p>0.05), which means that the variance for each group’s data was the same. The mean of both groups was then tested to show the statistical significance of the difference. Since both groups had normal distributions, the data were assessed with an independent-samples T test. The confidence interval (α) was set at 0.05. Based on the results, the significance level between the alginate that had not passed its expiry date and the one which had passed its expiry date was 0.00, which means that a significant difference existed between the two groups (p<0.05).

3.2 Discussion
This research showed a statistically significant decrease in setting time (p<0.05) for alginate that had passed its expiry date. Alginate that was nine months past its expiry date set in 2 minutes and 24 seconds, or 13 seconds faster than alginate that was still within its shelf life period (2 minutes and 37 seconds). ISO standard no. 1563 (1990) and ADA specification no. 18 (1992) indicate that the setting time of alginate should not be less than the setting time set by the manufacturer, nor should it exceed the setting time set by the manufacturer by more than 10% [5,6]. The setting time set by the manufacturer of the product used in this study was 2 minutes and 30 seconds. This meant that the setting time of the alginate that had not passed its expiry date still met the standard, whereas the alginate that was past its expiry date by 9 months, or had undergone 45 months of storage time, no longer met the standard. These results were in agreement with previous research conducted by Hondrum, which showed a reduction of some alginate properties after the expiry date when maintained either in a controlled storage condition or an extreme storage condition [7]. This previous research showed that alginate kept in storage for 40 months showed a continuous decline in the working time until the 78th month [7].

The stability during storage, including the duration and conditions of the storage, is a critical factor in alginate shelf life that contributes to the reduction in setting time of alginate that has passed its expiry date [7,8]. According to Hondrum, the physical, mechanical, and chemical properties of alginate could be affected by storage duration and the storage and delivery conditions for the material [7].

The reduced setting time of alginate that has passed its expiration date can be due to external environmental factors, namely moisture contamination and exposure to high temperatures [8,9]. In this study, moisture contamination was possible due to exposure of the alginate material to the air for 24 days. Moisture contamination was observed as the clumping of powder inside the package. Moisture contamination led to premature or spontaneous setting of the material inside the package [10]. The water content of moist air induces a spontaneous chemical cross-linking reaction of the alginate polymer chain, which then reduces the alginate setting time as parts of the powder have set inside the package [8]. Clumping of the powder also led to inaccuracy in the ratio of powder to water. Clumped powder would have a higher density; hence, the powder-to-water ratio would increase. This condition would lead to faster setting time [1].
The study done by Sunarintyas and Irnawati indicated that moisture contamination significantly influenced the setting time of the alginate. In this previous study, alginate powder was transferred into a small plastic compartment and tied with rubber band, a storage condition that induced moisture contamination. The alginate was left in this condition for 3 weeks, and its subsequent setting time decreased by approximately 17 seconds (i.e., it set 25% faster) when compared to a newly opened package. The setting time continued to fall during 5 weeks of storage time, with a decrease in the setting time of 21 seconds (or about 33% faster) compared to a newly opened package [8].

In the present study, both groups of alginate were contaminated by moisture, but only the group that had passed its expiry date showed a decreased setting time. This indicates that another factor was causing the decrease in setting time; this is likely the decreasing functionality of the retarder. Alginate formulations contain Na3PO4 as a retarder to establish the alginate setting time. Calcium alginate in gel form will only polymerize when all the phosphate ions from the Na3PO4 have reacted with the calcium ions from calcium sulfate dehydrated. The aging caused by storage in a moist atmosphere could lower the effectiveness of the retarder [1]. Hence, the retarder in alginate that had passed the expiry date is suspected to have decreased in function when compared to the retarder in alginate that had not passed its expiry date. In this condition, the reaction between the retarder and calcium is more rapid and results in faster alginate gelation [1]. This is the cause of the decrease in the alginate setting time in alginate that has exceeded its shelf life. Further research is needed for a more in depth investigation of the changes in properties of alginate preparations with different expiry dates that are still within their expiry dates, to determine if changes occur in the quality of the alginate while it is still within its allotted shelf life.

4. Conclusion
The shelf life influences the setting time of type 1 (fast-setting) alginate in an opened package condition. Alginate that is within its shelf life has a faster setting time when compared with alginate that has exceeded its shelf life.

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