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Irreversible Hydrocolloid as a Test Food in Complete Denture Wearers

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This paper was presented to the 20th Annual Scientific Meeting of the South East Asian Division of IADR in September 2005, at Malacca, Malaysia.

Abstract - *The aim of this study was to investigate the suitability of irreversible hydrocolloid impression material (alginate) as a test food to measure the chewing performance of complete denture wearers. Twenty edentulous subjects participated, 11 of whom were re-tested after new dentures were provided. A gravimetric sieving method was used. The particle size distribution was measured after 10 chewing strokes and again after 20 chewing strokes. It is concluded that alginate pellets are suitable as test food for edentulous subjects, 20 chewing strokes are appropriate and an additional mesh size greater than 2mm should also be used.*

KEY WORDS: Irreversible hydrocolloid, chewing performance, complete dentures, sieves, mastication.

INTRODUCTION

Masticatory performance is difficult to assess objectively, but assessment is necessary to evaluate the effect of different treatment methods and for research purposes. Subjective assessment (individual perception), which is often obtained by questionnaire[1], is not sufficient for evaluation of masticatory performance for a variety of reasons[2], particularly with complete denture wearers. Chewing tests are one way of providing an objective measure of masticatory ability[3] and a variety of test foods have been used in dentate subjects, such as peanuts, carrots, apple, almonds and soya beans. Artificial tests foods have also been used, such as gelatine, silicone impression material and chewing gum.

The size, shape and type of the test food, the number of chewing strokes and the method used to quantify the sieved particles are all important[4]. Sticky food (for example, soft bread and pancakes) and tough food cause difficulty in chewing while soft, firm, and brittle substances are comparatively easy to chew. Artificial test food has the advantage that it can be more consistent in terms of size, shape and texture[5]. Some artificial test food also has the advantage that it does not clump after being chewed, the particles remaining separate and therefore more easily washed and quantified. However, artificial test food with a high fracture strength in proportion to the maximum bite force of subjects with fewer teeth (or no teeth) may impair the measurement of their masticatory ability[6] as excessive effort will be required simply to break the food. Therefore the test food should have a low fracture resistance for edentulous subjects, be acceptably palatable and should be consistent in size and texture. Complete denture wearers are known to be very much restricted in their masticatory ability[7] and so the choice of test food is particularly important in experiments with these subjects. Irreversible hydrocolloid impression material (alginate) was used with dentate subjects by Ohara et al (2003)[8] but to the best of our knowledge this has not been used with edentulous subjects. Alginate is easy to prepare in a standardised manner, is inexpensive and would appear to have an ideal consistency for a test food. However, a test food that performs well in dentate subjects will not necessarily do so in complete denture wearers. The aim of this study, therefore, was to investigate the use of alginate as a test food in the measurement of the chewing performance of complete denture wearers, using a simplified sieve method.

MATERIALS AND METHODS

Subjects were recruited from patients who had been provided with complete dentures in the undergraduate Prosthodontic clinic, Glasgow Dental Hospital and School. Inclusion criteria were that they should have presented for complete denture replacement (i.e. they should have had at least one set of complete dentures previously) and have no temporomandibular disorder. Ethical approval was obtained from the Area Dental Ethics Committee, North Glasgow University Hospitals NHS Trust. Although no power calculation was performed, twenty subjects (10 men, 10 women, age range 64-83 years) were recruited for this study and informed consent was obtained.

The alginate chosen for this investigation[b] was relatively brittle, so did not clump after having been chewed and the consistency was neither too hard nor too soft for edentulous subjects to chew. The alginate complied with ISO 1563 (Dentistry - Alginate Impression Material), with an elastic recovery of at least 95% and a tear strength of at least 0.38 N/mm. The alginate was prepared in pellets of a columnar shape with a 12mm diameter and 12mm height, as suggested by Ohara et al (2003)[8]. Eight clear plastic tubes

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were used to prepare fresh pellets approximately 5 minutes before the subjects began the chewing test. Eight test pellets were prepared for each subject: 1 for familiarization chewing, 6 for the chewing tests and 1 spare. The preparation of the test pellets was quick and straightforward, using a standardized water/powder ratio and hand spatulation as recommended by the manufacturer.

Experimental procedure

The following experimental procedure was carried out initially with all 20 subjects wearing their existing (old) dentures. The whole test procedure was then repeated on 11 of these subjects after they had been fitted with new dentures and when initial difficulties had been resolved. This period varied between subjects from 2-4 weeks, as some overcame their difficulties more quickly than others.

Each subject was asked to sit upright, chew as normally as possible and not to swallow the particles. The subject then chewed one alginate pellet for a trial and was asked if he/she was comfortable and still happy to proceed with the experiment. The subject was then instructed to chew another alginate pellet for 10 chewing strokes; this was repeated three times. After a rest, the subjects then chewed another alginate pellet for 20 chewing strokes and this was repeated 3 times. The subjects counted the chewing strokes themselves. At the end of every 10 or 20 chewing strokes, the subjects were asked to rinse and expectorate into a collecting dish until it was clear that no particles remained in the mouth or on the dentures.

The collected chewed particles were rinsed and placed in disinfecting agent[c] for five minutes prior to removal from the clinic. The particles were then placed in a labeled polyethylene bag for transport to the laboratory.

Weighing

A gravimetric sieving method was used to grade the size of the chewed particles. The sieve mesh sizes were 2.00 mm, 1.70 mm, 1.40 mm and 1.00 mm[a]. The chewed particles were washed through the stack of four sieves, in decreasing order of mesh size, with approximately 400ml of water. Underneath the last sieve, filter paper was placed to collect any residual particles that had passed through all the sieves. The particles collected on each sieve (e.g. Figure 1) were rinsed with absolute alcohol[9] using a small paintbrush to facilitate drying of the particles, which were then immediately placed on dry filter paper for 5 minutes. There was no need for the particles to be stirred while washing through the sieves, as they did not clump (Figures 2 and 3). The collected particles on each sieve were weighed on a calibrated weighing machine (Sartorius®) with a sensitivity of 0.0001g.

Statistical Analysis

Differences were tested using the Wilcoxon Signed Rank Test for non-parametric distributions with Bonferroni corrections for multiple comparisons. The Bonferroni correction was achieved by setting the significance level at $p<0.01$, as the correction factor was 5. A correction was required because the quantity of material collected on one sieve was not only related to the particle size but also to the quantity of material collected on the previous sieve.

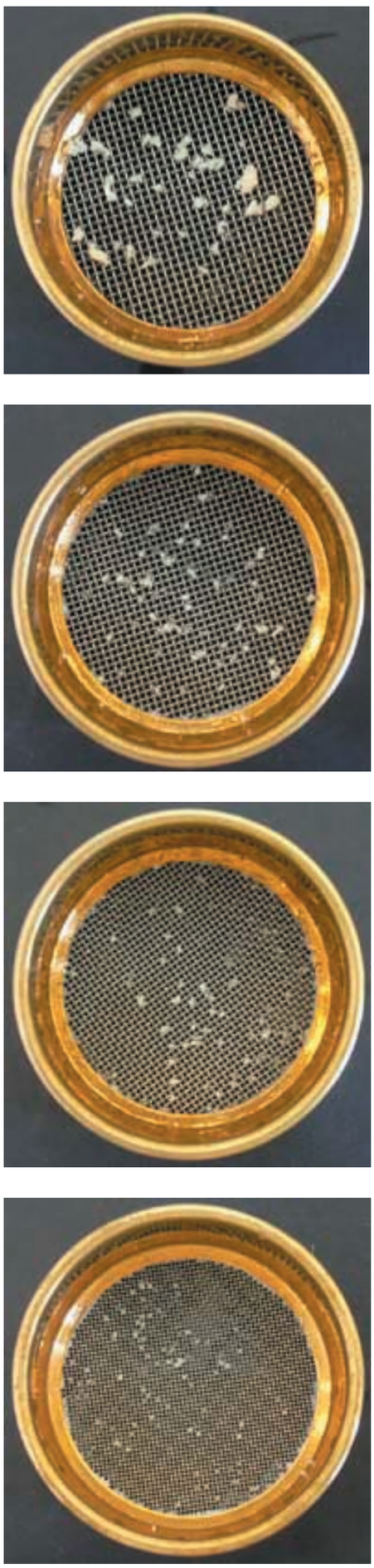

Figure 1. *Chewed alginate particles on sieves of different mesh sizes. Mesh sizes from top: 2.00mm, 1.7mm, 1.40mm and 1.00mm.*

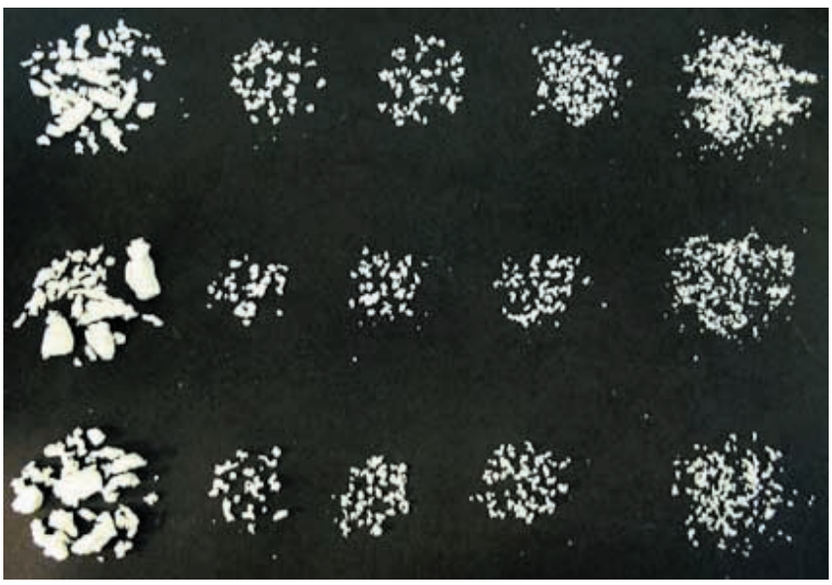

Figure 2. *Particles collected from a subject with a good masticatory performance after 10 chewing strokes, 3 trials from top to bottom. From left, particles collected on sieve 2.00mm, 1.70mm, 1.40mm, 1.00mm and filter paper.*

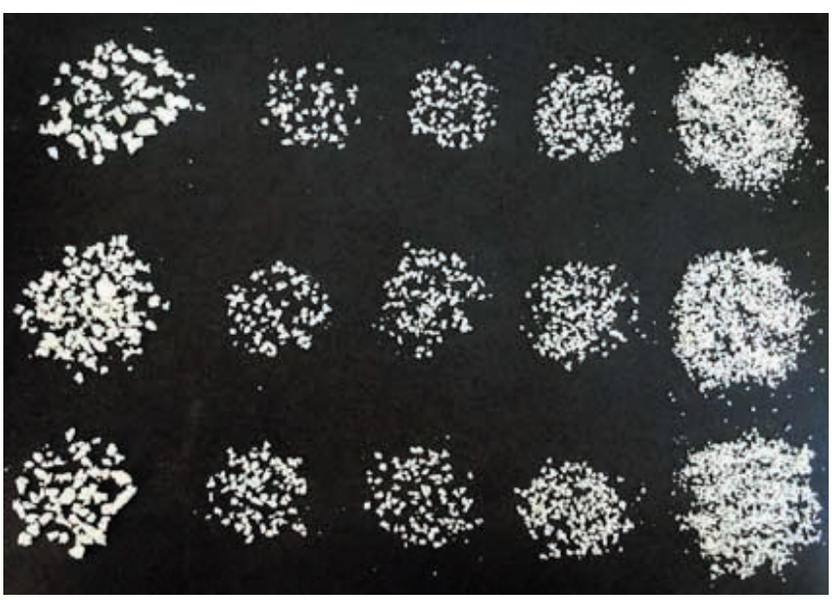

Figure 3. *Particles collected from a subject with a good masticatory performance after 20 chewing strokes, 3 trials from top to bottom (the same subject as shown in Figure 2). From left, particles collected on sieve 2.00mm, 1.70mm, 1.40mm, 1.00mm and filter paper.*

RESULTS

The weight of the particles collected on each sieve was expressed as a percentage of the total weight of particles recovered from each chewing test. Intra-individual and inter-individual variations may be seen in Figures 4 and 5. Median values for all patients and sieve sizes were calculated and may be seen in Table 1. There were no significant differences in the weight of material collected on each sieve between subjects wearing their old dentures and when wearing their new dentures.

1. Particles collected on sieve mesh size 2.0mm

The majority of the chewed particles were collected on this sieve. After 10 chewing strokes, the percentage of weight accumulated on this sieve varied from 80% to 100% (median 98.60%) for the old dentures and 89% to 99% (median 97.94%) for the new dentures. After 20 chewing strokes, all subjects had produced smaller particles than after 10 chewing strokes ($p<0.001$) and the percentage of weight accumulated ranged from 50% to 99% (median 95.37%) for the old dentures and 80% to 99% (median 93.07%) for the new dentures.

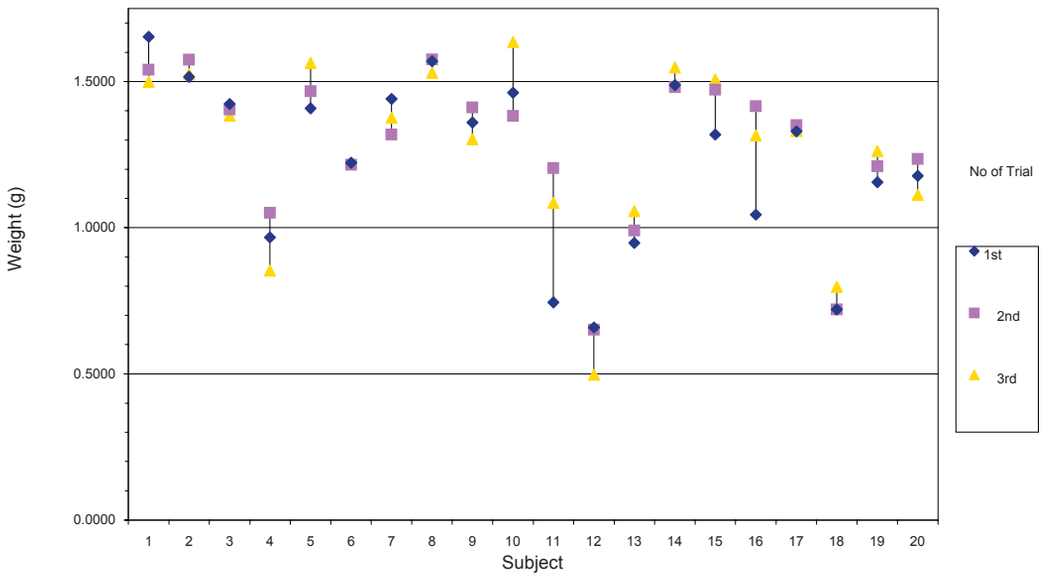

Figure 4. *Intra-individual and inter-individual variation observed after 20 chewing strokes on 2.00mm sieve (N=20).*

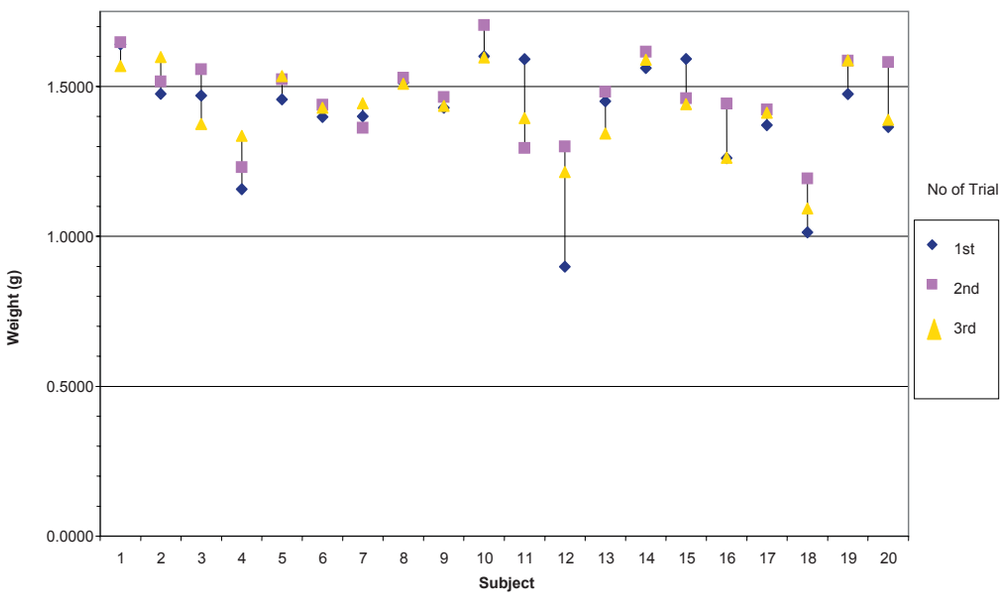

Figure 5. *Intra-individual and inter-individual variation observed after 10 chewing strokes on 2.00mm sieve (N=20).*

Table 1. *Median values of the mean weight (expressed as a percentage of the total weight of particles recovered) collected on each sieve, for all subjects, all sieve sizes and for 10 and 20 chewing strokes.*

		10 chewing strokes					*20 chewing strokes*				
Group	*n*	*2.0 mm*	*1.7 mm*	*1.4 mm*	*1.00 mm*	*Filter*	*2.0 mm*	*1.7 mm*	*1.4 mm*	*1.0 mm*	*Filter*
All old dentures	20	98.6	0.54	0.28	0.33	0.42	95.37	1.37	1.02	0.88	1.56
Old dentures*	11	97.55	0.63	0.37	0.7	0.77	89.41	2.62	2.1	2.3	3.57
New dentures	11	97.94	0.55	0.23	0.44	0.46	93.07	1.91	1.47	1.44	1.95
Probability**		0.756	0.721	0.415	0.657	0.721	0.155	0.328	0.213	0.041	0.091

* "Old dentures" represents the 11 subjects of the overall 20 who were provided with new dentures and subsequently tested again when wearing these new dentures. ** "Probability" refers to the difference between the old and the new dentures in these 11 subjects (Wilcoxon Signed Ranks Test). The significance level was set at $p<0.01$ (to incorporate a Bonferroni Correction of 5 to adjust for multiple comparisons). Thus none of the differences were significant.

2. Particles collected on sieve mesh size 1.7mm

A smaller percentage of weight was collected on this sieve compared to mesh size 2.0 mm. After 10 chewing strokes, 0 to 5% (median 0.54%) was collected with the old dentures and 0 to 3% (median 0.55%) with the new dentures. After 20 chewing strokes, 0 to 11% (median 1.37%) of weight was collected with the old dentures and 0.03% to 10% (median 1.91%) with the new dentures. With the old dentures, 7 out of the 20 subjects did not produce any particles on this sieve after 10 chewing strokes but 4 of them produced some particles after 20 strokes. The difference between 10 and 20 chewing strokes with the old dentures was significant ($p<0.001$). With the new dentures, only 1 out of the 11 subjects did not produce any particles on this sieve after 10 chewing strokes and all subjects produced some particles after 20 chewing strokes. The difference in particle distribution between 10 and 20 chewing strokes with the new dentures was also significant ($p<0.005$).

3. Particles collected on sieve mesh size 1.4mm

With the old dentures, 6 subjects did not produce any particles after 10 chewing strokes and the weight ranged from 0 to 3.8% (median 0.28%), whereas only 2 subjects did not produce any particles with the new dentures and the weight ranged from 0 to 1.5% (median 0.23%). After 20 chewing strokes, the weight had increased to 0 to 7.6% (median 1.02%) with the old dentures (significantly different to that after 10 chewing strokes, $p<0.001$) and 0 to 8.8% (median 1.47%) with the new dentures (significantly different to that after 10 chewing strokes, $p<0.005$).

4. Particles collected on sieve mesh size 1.0mm

The weight of the particles collected after 10 chewing strokes ranged between 0 and 3.9% (median 0.33%) with the old dentures and 0 to 2% (median 0.44%) with the new dentures. After 20 chewing strokes, only two subjects did not produce any particles on this sieve and the range increased to between 0% and 10% (median 0.88%) with the old dentures (significantly different to that after 10 chewing strokes, $p<0.001$) and 0.1% to 3.1% (median 1.44%) with the new dentures (significantly different to that after 10 chewing strokes, $p<0.005$).

5. Particles collected on the filter paper

Three of the subjects did not produce any fine particles after 10 chewing strokes with the old dentures and the weight collected ranged from 0 to 6.6% (median 0.42%). With the new dentures, the weight ranged from 0.01% to 3.1% (median 0.46%). When chewed for 20 chewing strokes, the weight collected with the old dentures ranged from 0.02% and 21.5% (median 1.56%), which was significantly different to that after 10 chewing strokes ($p<0.001$) and all the subjects managed to produce some fine particles. With the new dentures, the weight collected ranged from 0.1% to 4.1% (median 1.95%), which was significantly different to that after 10 chewing strokes ($p<0.005$).

DISCUSSION

Ohara et al (2003)[8] concluded that mesh sizes 1.18 mm and 1.40 mm were sufficient for dentate individuals, but four mesh sizes were used in this present study to gain more information on particle size distribution for edentulous subjects.

Counting the number of particles is reliable when a single sieve is used but, the sieve aperture size must be within the range of particle sizes produced by a particular group of subjects with a particular test food [10, 11]. Therefore, before a specific size of sieve can be used, investigations with a series of sieves should be done to establish the relevant particle size. The masticatory performance of edentulous subjects is not as efficient as dentate subjects[7] and so the sieve sizes suggested by Ohara et al (2003)[8] need to be larger for edentulous subjects. Mesh sizes between 5.00 mm and 1.00 mm would seem to be appropriate for complete denture wearers, but more studies need to be done to confirm this assumption. The results of this study show that a large proportion of the material remained on the 2mm sieve, confirming that larger sieve mesh sizes are required. When compared to the dentate study of Ohara et al[8], dentures appear to be considerably less efficient than the natural dentition, thus confirming previous studies[7]

In this study, some subjects could not chew the alginate pellet sufficiently to produce particles smaller than 2mm after 10 chewing strokes whereas all subjects could chew the pellet sufficiently to produce finer particles after 20 chewing strokes. Therefore the 20 chewing strokes suggested by Ohara et al (2003)[8] would appear to be appropriate for edentulous subjects. This is also in agreement with the results of Edlund and Lamm (1980)[5].

Even though the size, shape and texture of the alginate were constant, further investigations on the appropriate size of alginate pellet are required because the size and shape of the test food has been found to have an influence on masticatory performance[4, 12, 13]. The appropriate range of sieve mesh sizes is also important. As discussed earlier, the counting method of quantifying chewed alginate particles described by Ohara et al (2003)[8] appears to be reliable if the correct mesh size is chosen. The advantage of this method is that it eliminates the necessity to disinfect the materials (prior to weighing in the laboratory) because counting can be done in the clinic; this will save the considerable time and effort of weighing.

The intra-individual and inter-individual variations that were seen (Figures 4 and 5) could be expected. It is likely in this type of experiment that there will be a variation in the motivation of subjects and therefore a variation in effort of chewing. Subjects were instructed to chew the test food at their own pace and it is possible that different chewing rates produced a difference in particle size. It is probable that when subjects chewed more slowly, they were more likely to place the test food properly on the occlusal table. It was also observed that subjects chewed better as the test progressed. As the tests were all carried out in the same order, this might be an additional reason that subjects produced finer particles after 20 chewing strokes, apart from being simply due to the increase in the number of chewing strokes. Subjects with faulty dentures had to chew more carefully and applied less force as they indicated that they could not chew vigorously.

Although 20 subjects participated in the experiment when wearing their existing dentures, only 11 were available for re-testing with new dentures. This was mostly due to the rather extended time that the remaining 9 subjects required to overcome initial difficulties with their new dentures. In order to avoid this problem, it would seem sensible to select subjects with a history of successful accommodation to new dentures.

Some small loss of fine particles occurred from subjects with good chewing performance when washing the particles prior to disinfection. This was due to the practical difficulty of thorough washing yet preventing loss of particles, as sufficient water flow was required to clear saliva but this was sometimes a little too fast for the filter paper to catch all of the fine particles. As a result, the weight of particles on the filter paper and the total weight collected from those subjects were reduced compared to subjects with lower chewing performance (and hence larger particle size). It is, of course, possible that the loss of some fine particles was due to accidental swallowing or to retention in the mouth. However, no previous reports have been found that describe any method of disinfecting the chewed test food prior to investigation in the laboratory.

The chewed alginate particles did not clump while washing, disinfecting or when passed through the stack of sieves. This was a particular advantage as less washing was required and so there was less inadvertent loss of fine particles. The drying and sieving procedures were also easier without clumping. The sieve with the largest mesh size (2 mm) was not large enough to be fully discriminatory, as sometimes several large particles accumulated and this clearly was a difference in mastication which was not measured. It would be advisable, therefore, to use an additional sieve with a larger mesh size and also to use a smaller pellet size to facilitate control of the pellet by complete denture wearers. Although the weight collected on each sieve was small, it demonstrated that the consistency and the texture of the alginate was suitable as a test food for complete denture wearers as it did not adhere to the dentures, did not clump, was not unpleasant and was manageable with dentures.

CONCLUSIONS

Within the limitations of this experiment, it seems clear that alginate pellets are practical and appropriate as a test food for chewing tests in edentulous denture-wearing subjects if the appropriate sieve sizes and pellet sizes are used.

MANUFACTURERS DETAILS

- Endecotts, London; ISO3310-1: 9001, BS 410
- Kromogel®, Wright Health Group Ltd., Dundee, UK.
- Virkon®, Antec International Ltd, Sudbury, UK.

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