

[ORIGINAL]

A simplified sieving method for measuring masticatory performance

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Abstract

An objective and simple method for evaluating masticatory function in patients is necessary for diagnosis and outcome assessment in prosthetic treatment. The objective of this study was to simplify Kapur's chewing test using peanuts.

A mechanical peanut pulverization procedure was developed simulate a complete denture wearer's chewing performance. Corresponding to the variable B (ml) for the total volume on various sieves used to measure masticatory performance by Kapur's method, a constant K (ml) was used to simplify the method and K was determined in accordance with measurements of mechanical pulverization and the results of chewing tests by 20 complete denture wearers.

The constant K was established as 20ml. The correlation between the evaluated masticatory performance by Kapur's method and the method here was 0.998 ($p < 0.01$) by in vitro pulverization and, 0.808 ($p < 0.01$) in 20 complete denture wearers.

Key words : Masticatory performance, Sieving methods, Complete denture wearers.

Introduction

Several objective methods for evaluating masticatory function have been developed for denture wearers and TMD patients. These measure masticatory performance and efficiency¹⁻³⁾, muscle activity⁴⁾, mandibular movement⁵⁾ and masticatory force⁶⁾ to provide information for diagnosis and outcome assessments in prosthetic treatment. These methods involve complicated procedures and require special equipment and their application has been limited in clinical and laboratory conditions.

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A sieving method proposed by Kapur et. al.²⁾ has been widely used and is the most simple and practical method for evaluating masticatory function⁷⁻¹²⁾. However, this method still leaves room for improvement from the viewpoints of simplicity and validity. In Kapur's method, a subject is asked to chew 3 grams of peanuts with 20 strokes and expectorate all peanut particles into a cup. Then, the subject is asked to rinse the mouth twice with water and to pour the rinsing water into the cup. The whole procedure is repeated 3 times. The particles in the cup are then poured on a stack of #5, #10, #20, and #40 mesh sieves. The volume of particles on each sieve is measured after centrifuging for 3 minutes at 1500rpm. Masticatory performance for any particle size is determined by dividing the volume of peanuts passing through the #5 mesh sieve by the total volume of peanuts remaining on the #5, #10, #20, and #40 mesh sieves. This method is quite simple and requires no drying of pulverized peanuts. However, the collection and transfer of small particles on the #20 and #40 mesh sieves for centrifuging is tedious. If the masticatory function of a patient could be evaluated by measuring only the volume of the #5 mesh sieve, it would save time and make the test more easily applied.

The purpose of this study is to clarify the feasibility of a simplification of Kapur's method without changing the inherent validity of the method.

Materials and Methods

To simulate a complete denture wearer's chewing performance, an in vitro peanut pulverization procedure was developed with repeated trial and error. Three grams of peanuts were sandwiched between two metal plates on the flat base of a flask press with various spacers (1, 2, 3, 4mm). The peanuts were pulverized by a 20 kgf load for 10 seconds to obtain standard peanut particles (Fig.1). This procedure was repeated 3 times with each spacing, similar to

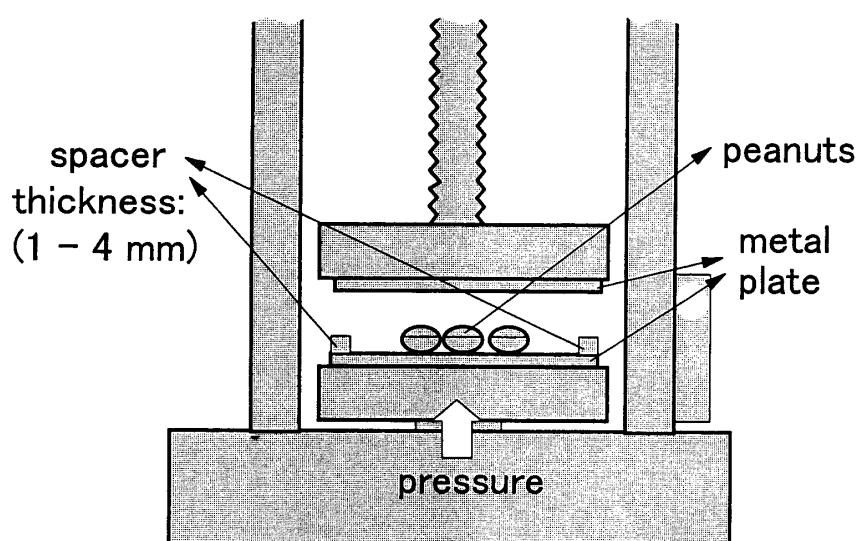


Fig. 1 Schematic drawing of the two flat metal plates with spacer, a flask press and peanuts for mechanical pulverization

Kapur's method for denture wearing patients²⁾. All pulverized peanut particles produced at each spacing were sieved by a series of #5, #10, #20, and #40 mesh sieves, and the particle volume remaining on each sieve was determined after centrifuging for 3 minutes at 1500rpm. This procedure was repeated 5 times and the mean value of the volume of peanuts particles was calculated. The masticatory performance of denture wearers was also evaluated with 20 complete denture wearers (10 female, 10 male, aged 50 to 75 years) where the upper and lower complete dentures were fabricated by one of the authors. The denture wearers were asked to chew peanuts in accordance with Kapur's method²⁾. The constant K was established using the total volume of peanut particles remaining on the #5, #10, #20, and #40 mesh sieves. To verify the utility of K, 30 fully dentate subjects with intact natural dentition (all male, aged 23 to 31 years) were asked to chew peanuts and evaluated by both Kapur's method and the simplified method using K.

The masticatory performance of the in vitro peanut pulverization, the complete denture wearers, and the dentate subjects was used to determine the MPK proposed by Kapur²⁾ ($MPK(\%) = A/B \times 100$: A is the volume of peanuts passing through the #5 mesh sieve; B is the total volume of peanuts remaining on the #5, #10, #20, and #40 mesh sieves) and the MPN proposed by the authors ($MPN(\%) = (K-C)/K \times 100$: K is a constant (ml); C is the volume of peanuts remaining on the #5 mesh sieve). The correlation between MPK and MPN were determined by regression analysis (SPSS for Windows, Tokyo, Japan).

Results

The volumes of peanut particles after in vitro pulverization remaining on the #5, #10, #20, and #40 mesh sieves after centrifuging are shown in Table 1. The mean value was 20.4 ± 2.5 ml, with no significant difference detected between the values remaining on the #5 mesh sieve at any spacer thickness.

The volumes of peanut particles remaining on the #5, #10, #20, and #40 mesh sieves after centrifuging for in vitro pulverization and from the complete denture wearers are presented in Fig. 2. The distribution of peanut particles from in vitro pulverization and from the chewing test in complete denture wearers were almost identical. The mean volumes after in vitro

Table 1 Volume of peanut particles remaining on #5, #10, #20, and #40 mesh sieves after mechanical pulverization. (n=5)

Spacer thickness	5	10	20	40 mesh	Total volume
1 mm	2.0(0.2)	7.8(0.3)	5.3(0.2)	1.3(0.1)	16.5(0.1)
2 mm	10.2(0.4)	9.8(0.3)	1.5(0.1)	0.3(0.0)	21.6(0.2)
3 mm	19.0(1.2)	2.8(0.2)	0.5(0.0)	0.1(0.0)	21.7(0.4)
4 mm	20.5(1.5)	0.5(0.1)	0.1(0.0)	0.0(0.0)	20.9(0.6)
Mean(1-4 mm)					20.4±2.5

(Mean±SD : ml)

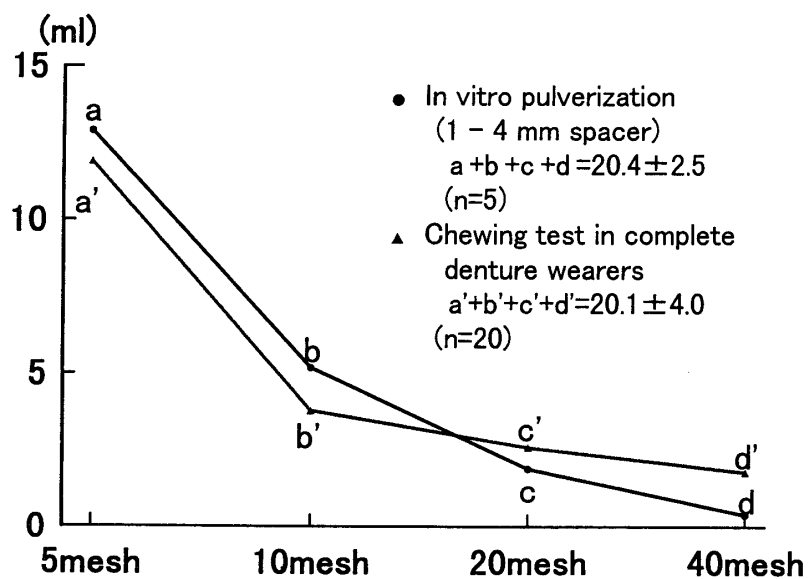


Fig. 2 The volumes of peanut particles produced by mechanical pulverization and by 20 complete denture wearers remaining on the #5, #10, #20, and #40 mesh sieves; a, a': volume on #5 mesh; b, b': volume on #10 mesh; c, c': volume on #20 mesh; d, d': volume on #40 mesh,

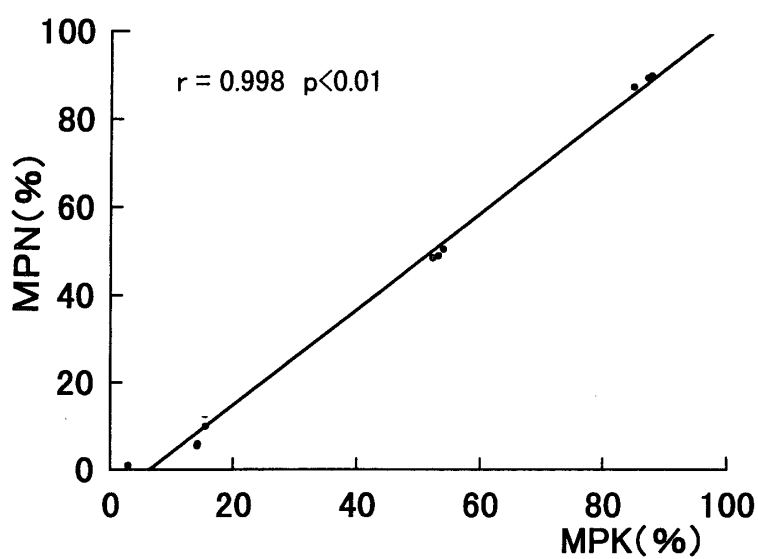


Fig. 3 MPK vs MPN for in vitro pulverization

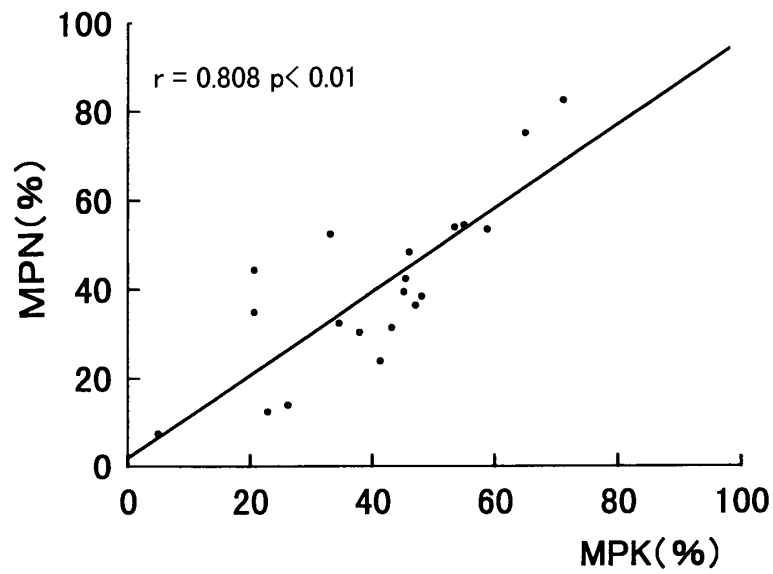


Fig. 4 MPK vs MPN for complete denture wearers

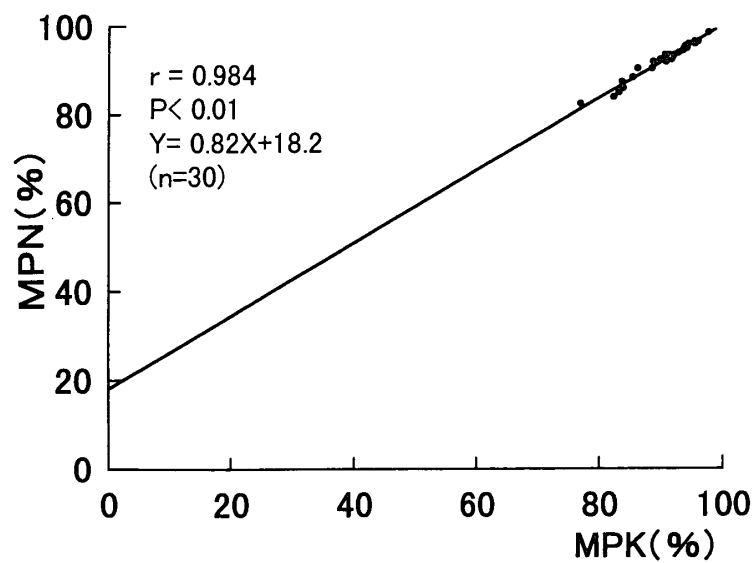


Fig. 5 MPK vs MPN for 30 adult dentate subjects

pulverization and as conshed by complete denture wearers were $20.4 \pm 2.5\text{ml}$ and $20.1 \pm 4.0\text{ml}$, respectively. Based on these results, the K constant was set to be 20ml.

The correlation between MPK and MPN for in vitro pulverization was 0.998 ($p < 0.01$) and for complete denture wearers 0.808 ($p < 0.01$) (Fig.3, 4).

The mean value of MPK and MPN in fully dentate subjects were 90.4% and 92.3%, with a statistically significant correlation coefficient of 0.984 ($p < 0.01$) (Fig.5).

Discussion

In this study, a significant statistical correlation was found between the measurements of masticatory performance by Kapur's method and by the simplified method, proposed here.

There are two sieving methods for evaluating masticatory performance. One measures the particle weight remaining on each sieve after drying^{1,3)}; the other measures the particle volume on each sieve after centrifuging²⁾. The former method is time consuming due to the time required to dry the particles. The latter method requires tedious collection and transfer of particles to a centrifuging tube, and involves some risk of lost particles. In this study, nearly identical volumes were obtained from in vitro pulverization and from complete denture wearers, and almost all particles were collected from complete denture wearers with a loss of peanut particles of about 1.5%.

Similar distribution patterns emerged for in vitro peanut particles and for particles from complete denture wearers, with the total volumes being 20.4ml and 20.1ml, respectively (Fig. 2). This finding enhances the validity of the chewing simulation with a controlled stable spectrum of particle sizes presumably similar to that of the complete denture wearing-population. This finding also validates the simplification of Kapur's method using 20ml for the constant K. Using 20ml for K the formula is modified as follows :

$$\begin{aligned}\text{MPN (\%)} &= (K - C)/K \times 100 \\ &= 100 - 5 \times C\end{aligned}$$

C : volume of peanuts remaining on the #5 mesh sieve

The validity of the constant K was examined with in vitro pulverization and in vivo complete denture wearers. Because the correlation between MPK and MPN in both situations was significant ($p < 0.01$) (Fig. 3, 4), the constant K was considered to be appropriate. This was confirmed by the significant correlation between MPK and MPN in dentate subjects (Fig. 5). Kapur's method was originally developed for complete denture wearers and may not be applicable to fully dentate people. However, if the simplified method is consistent with Kapur's method, it may be applied to compare the masticatory performance of elderly complete denture wearers to elderly dentates for research purposes¹²⁾. The significant correlation between MPK and MPN in dentate subjects with the proposed simplified method could be

applied to dentates as well as edentulous patients. In conclusion, 20 ml appears to be a valid for the constant K.

Another advantage of the simplified method is speed. Providing a quick evaluation of masticatory performance without centrifugation offers benefits for laboratory work.

Conclusion

Aiming to simplify Kapur's chewing test, mechanical pulverization and in vivo chewing tests in 20 complete denture wearers were performed to establish a constant K (ml) in place of the variable B (ml) for the total volume in Kapur's method. The effectiveness of the constant K was found by regression analysis of masticatory performance in vitro (mechanical), in complete denture wearers, and in fully dentate subjects. The constant K established in this manner was 20 ml. Statistically significant correlations were found between the measurements of masticatory performance by Kapur's method and by the method employed here.

References

1. Manly RS, Brealey LC: Masticatory performance and efficiency, *J Dent Res*, **29**: 448-462, 1950.
2. Kapur K, Soman S, Yurkstas A: Test foods for measuring masticatory performance of denture wearers, *J Prosthet Dent*, **14**: 483-491, 1964.
3. Yurkstas AA, Emerson WH: Dietary selections of persons with natural and artificial teeth, *J Prosthet Dent*, **14**: 695-697, 1964.
4. Michman J, Langer A: Clinical and electromyographic observation during adjustment to complete dentures, *J Prosthet Dent*, **12**: 922-939, 1962.
5. Hirai T, Matai N, Anzai T et al.: Masticatory rhythm analyzing method and clinical application, *Bull Tokyo Med Dent Univ*, **32**: 57-65, 1985.
6. Lundgren D, Laurell L: Occlusal forces in prosthetically restored dentition, a methodological study, *J Oral Rehabil*, **11**: 29-37, 1984.
7. Kapur KK, Glass RL, Loftus ER et al.: The veterans administration longitudinal study of oral health and disease, *Aging and Human Development*, **3**: 125-137, 1972.
8. Feldman RS, Kapur KK, Akman JE et al.: Aging and mastication: Changes in performance and in the swallowing threshold with natural dentition, *J American Geriatrics Society*, **28**: 97-103, 1980.
9. Wayler AH, Kapur KK, Feldman RS et al.: Effects of age and dentition status on measures of food acceptability, *Journal of Gerontology*, **37**: 294-299, 1982.
10. Wayler AH, Muench ME, Kapur KK et al.: Masticatory performance and food acceptability in persons with removable partial dentures, full dentures and intact natural dentition, *Journal of Gerontology*, **39**: 284-9, 1984.
11. Hirai T, Ishijima T, Koshino et al.: Age-related change of masticatory function in complete denture wearers: Evaluation by a sieving method with peanuts and a food intake questionnaire method, *Int J Prosthodont*, **7**: 454-460, 1994.
12. Koshino H, Hirai T, Ishijima T et al.: Tongue motor skills and masticatory performance in adult dentates, elderly dentates, and complete denture wearers, *J Prosthet Dent*, **77**: 147-152, 1997.