Original Article

Evaluation of oral stereognosis, masticatory efficiency, and salivary flow rate in complete denture wearers

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Abstract

Aim: The aim of the present study was to evaluate the improvement in oral stereognostic ability, masticatory efficiency, and difference in salivary flow rate in nonexperienced denture wearers, before, after, and 6 months after rehabilitation with complete dentures.

Settings and Design: Invivo – Observational study.

Materials and Methods: Seventy edentulous subjects were selected who came for rehabilitation with complete dentures for the first time. The study was conducted in three stages–before denture insertion, after denture insertion, and 6 months after denture insertion. Oral stereognostic ability was evaluated by asking the subjects to identify six heat cured acrylic resin samples by oral manipulation without seeing it. The unstimulated salivary flow rate was estimated by measuring the time taken to collect 5 ml of the whole saliva. Masticatory efficiency of the subjects was assessed with the help of preweighed chewing gums. The chewing gums were desiccated after the chewing strokes and weighed again.

Statistical Analyses Used: Data were tabulated and analyzed statistically using pairedt-test, one-way ANOVA test, and the *post hoc* test.

Results: Oral stereognostic ability increased immediately on insertion of complete dentures and was still higher 6 months post insertion of dentures. Comparison of the means of masticatory efficiency after denture insertion and 6 months after denture usage gave highly significant values ($p<0.001$). The salivary flow which increased immediately following denture insertion returned to almost normal 6 months after denture insertion.

Conclusion: The study support the hypothesis that the presence of dentures improve oral sterognostic ability and masticatory efficiency.

Keywords: Masticatory efficiency, oral sensorimotor function, oral stereognosis, proprioception,unstimulated salivary flow

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INTRODUCTION

Stereognosis may be defined as the ability to recognize the form of an object by means of manual palpation, without the use of eyesight, using only tactile sensation. Oral stereognosis is the ability of the oral mucous membrane to recognize and discriminate the forms of objects in the oral cavity. Stereognostic tests have been used to evaluate

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the integrity of sensory feedback from the oral mucosa following teeth loss and rehabilitation with complete dentures. Berry and Mahood were the first to introduce oral stereognosis test by placing objects into the mouth without being seen by the patient and having the patient identify the form.[1] Improvement in oral stereognosis is considered to be an indicator of success following complete denture therapy.[2]

The replacement of missing natural teeth is expected to achieve an acceptable masticatory function.[3] Furthermore, salivary wetting mechanisms are necessary for denture-wearing population to create adhesion, cohesion, and surface tension that ultimately lead to increased retention of the prosthesis.[4]

This study is done to assess the improvement in oral stereognosis and difference in salivary flow rate before denture insertion, at the time of insertion, and 6 months after denture insertion in patients who are wearing complete dentures for the first time. Improvement in masticatory efficiency is assessed in the same patients at the time of denture insertion and 6 months after denture insertion.

MATERIALS AND METHODS

The present *in vivo* study was conducted on seventy edentulous subjects in the age group of 50–70 years reported to the Department of Prosthodontics for rehabilitation with a complete denture. All the subjects involved in this study were free from oral diseases and significant medical conditions. The study was conducted only in patients with Class I ridge relation and adequate ridge height.

Inclusion criteria

1. Patients in the age group of 50–70 years.
2. Patients who will visit the college for follow-up checkup after 6 months.
3. Patients would receive new dentures and he or she would not have any past experience of denture usage.
4. All the patients involved in this study would be free from oral symptoms and pathologies and significant medical conditions.
5. No history of temporomandibular joint disorders.

Exclusion criteria

1. Uncooperative patients.
2. Patients with diseases of the tongue, tongue surgery, trauma or inflammatory condition of the tongue, xerostomia, cleft lip/palate, abnormal palatal vault, systemic diseases, and temporomandibular disorders were not included in the study.
3. Patients with neurological disorders, under the influence of neurological drugs, under intoxications, and having any psychological problems or deliterious habits.
4. Those who do not or not willing to sign the consent form.
5. Any past experience of denture usage.

Institutional ethical committee approval and informed consent from the experimental subjects were obtained. Ethical committee approval number IEC/14/2014/MBDC. Each edentulous subject received maxillary and mandibular dentures on the same day of the test. The clinical and laboratory steps required for the fabrication of the prosthesis were entirely done by the principal investigator following the standard treatment protocol. The material used for the fabrication of prosthesis was heat cure acrylic resin (Dental Products of India heat cure) using standard acrylization method followed in the institution. All the patients had routine postinsertion review appointments in the 1st week, and correction was done for those who needed. Stereognostic test was not done in this appointment since previous studies have shown a mininum of one month for noticeable improvement. Measurement of oral stereognostic ability and salivary flow rate assessment were done on the day of denture delivery, before and after insertion, and after 6 months. Measurement of masticatory efficiency was done after the insertion of dentures and after 6 months.

The various forms used to evaluate stereognostic ability were square, rectangle, triangle, star, circle, and oval [Figure 1]. These test forms were chosen in accordance with the guidelines provided by the National Institute of Dental Research which developed a range of 20 shapes to assess oral stereognosis.[5] The test forms used were of 5 mm in thickness and 10 mm in diameter. Six forms were used to prevent fatigue. The test pieces were made of heat cure acrylic resin to which dental floss was attached to prevent accidental aspiration of the test pieces. Test pieces were autoclaved at 121°C at 15 psi for 30 min. For identification purposes, similar but 5–6 times oversized test forms were fabricated with plaster of Paris [Figure 2].

The test was conducted before denture insertion, after denture insertion, and after 6 months of denture insertion.

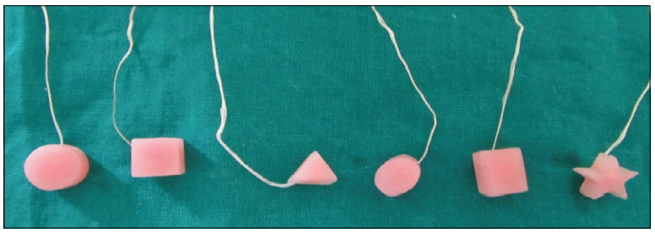

Figure 1: Test forms used in the study

The tests were performed in a calm and quiet environment with the subject seated comfortably in the dental chair in an upright position. Oversized test forms fabricated with plaster of Paris of all six test specimens were shown to the subject and given adequate time to get acquainted with these shapes. Then, the six acrylic forms were introduced to the patient in random order, with each form used only once. The subjects were asked to close their eyes when the test forms were placed on the mid-dorsum of the tongue by the investigator. The subject was allowed to manipulate it freely in the mouth [Figure 3]. Then, the subject was asked to identify the shape which he/she thought was correct by pointing at the corresponding plaster model [Figure 4].

A 3-point scale (0, 1, and 2) was used for recording the oral stereognostic analysis score.[6] The scale used was as follows:

0 – For not identifying the test sample

1 – For incorrect identification within the same group of forms. For example, if the subject answered incorrectly oval for a presented circular form, it was scored as 1 point

2 – For correct identification of the test sample, if all answers were correct, a full 12 points was scored. Thus, the higher the score, the better is an individual's stereognostic ability.

For evaluating masticatory efficiency, Wrigley's Orbit White Sweet Mint Sugar-free Pellet Form Chewing Gum was used. The weight lost from gum during chewing can be measured by a simple test for masticatory effectiveness (ME) of viscoelastic foods.[7] Weight of the chewing gum was measured by electronic weighing balance (American Weigh Scales AWS-1KG-BLK Signature Series Black Digital Pocket Scale 1000 by 0.1 G) which weighs items up to 1000 g in 0.1 g increments. Each subject was allowed to chew the chewing gum for 5 strokes. The chewing gum was then desiccated in a plain desiccator for 24 h and weighed again [Figures 5 and 6]. Since the sweetener was chewed out, the weight of the chewing gum was reduced. Similarly, the procedure was repeated for 10, 15, and 20 strokes. The same procedure was followed after a period of 6 months. Thus, the weights of the chewing gums were recorded at the time of insertion and 6 months after denture usage.

Unstimulated salivary flow rate was estimated by measuring the time taken to collect 5 ml of the whole saliva. Saliva is said to be "unstimulated" when no exogenous stimulation by mechanical or pharmacological agents is present. The saliva was collected using the spitting method, as this is considered the most reproducible method.[8] After rinsing the mouth with water, saliva was allowed to accumulate in the floor of the mouth and repeatedly expectorated into a graduated measuring jar to collect 5 mL [Figure 7]. The

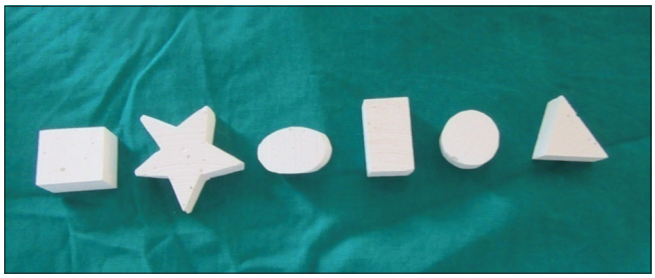

Figure 2: Over-sized plaster models for identification

Figure 4: The subject is identifying the correct shape

Figure 3: Introduction of test forms to the subject

Figure 5: Chewed gums kept in a desiccator for 24 h for drying

Figure 6: Chewed gum weighed after desiccation

Figure 7: The subject with a collected saliva sample

collection time was recorded using a stopwatch. The test was repeated in the same manner after 6 months.

Improvement in stereognosis, masticatory efficiency, and salivary flow rate were assessed using paired *t*-test. One-way repeated-measure ANOVA test was used to find whether the variations in oral stereognostic ability and salivary flow rate at different stages were significant or not. *Post hoc* test was used to compare the mean oral stereognostic ability and salivary flow rate at different time intervals to assess where a significant mean difference exists.

Sample size calculation method

Comparison of masticatory efficiency after 6 months of denture usage was calculated using the formula:

$$N = \frac{2 \times (Z\alpha + Z\beta)^2 \sigma^2}{\Delta}$$

Where $Z_{\infty} = 1.96$ for $\infty = 0.05$

$Z_{\beta} = 0.84$ for $\beta = 0.20$

$\Delta = \mu_T - \mu_C$ (difference in mean)

σ = Standard déviation

In this study:

Standard deviation of masticatory efficiency (σ) = 0.35

Difference in masticatory efficiency after 6 months of denture usage (Δ) = 0.183

$$N = \frac{2 \times (1.96 + 0.84)^2 \times (0.35)^2}{(0.183)^2}$$

= 31.

Hence, the minimum sample size required at 6 months after denture usage is 31. Expecting 50% dropout at 6 months after denture usage, the sample required initially is 62 rounded to 70.

RESULTS

Of the 70 subjects, only 38 subjects returned after 6 months of denture usage, and hence, the study was continued with 38 subjects only. Data were tabulated and analyzed statistically using paired t-test, one-way ANOVA test, and the *post hoc* test. One-way repeated-measure ANOVA test was used to find whether the variation in oral stereognostic ability at different stages is significant or not. The value of F (187.49, $P < 0.01$) shows that the variation in oral stereognostic ability score at different intervals of time is significant at 0.01 level [Table 1]. The mean difference between before denture insertion and after denture insertion assessment is 2.55, and the pairwise comparison using *post hoc* test with Bonferroni correction shows that the difference is statistically significant. A similar result can be observed for the difference between before denture insertion and 6 months after denture insertion (4.34) and difference between after denture insertion and 6 months after denture insertion score (1.79). It means that the denture insertion is effective in increasing oral stereognostic ability. After 6 months of intervention, the oral stereognostic ability is further increased and that increase is statistically significant.

The mean value for salivary flow rate before denture insertion, after denture insertion, and after 6 months of denture insertion was 2.7 ± 0.8, 1.7 ± 0.7, and 2.9 ± 0.7, respectively [Table 2]. The value of F (78.02, $P < 0.01$) shows that the variation in salivary flow rate at different intervals of time is significant at 0.01

level. The pairwise comparison using *post hoc* test with Bonferroni correction shows that the mean difference between before denture insertion and after denture insertion (1.15) and between after denture insertion and 6 months after denture insertion (1.28) is statistically significant. However, the mean difference between before denture insertion and 6 months after denture insertion (0.13) is not significant.

Masticatory efficiency of the 38 denture subjects who returned after 6 months of denture usage was evaluated after denture insertion and 6 months after denture insertion. The mean value of the weight of the chewing gum after 5 strokes at the time of denture insertion was 1.09 ± 0.02 and that after 6 months of denture usage was 0.93 ± 0.08. There was a decrease in value after 6 months of denture usage with a mean difference of 0.17, which is highly significant ($P < 0.001$) [Table 3]. Similarly, the values for 10 strokes, 15 strokes, and 20 strokes showed a reduction after 6 months of denture usage with a mean difference of 0.32, 0.43, and 0.52, respectively, all being highly significant ($P < 0.001$) [Tables 4-6].

DISCUSSION

Oral stereognosis is the neurosensorial ability of the oral mucous membrane to recognize and discriminate the forms of objects in the oral cavity. Sensory function of the mouth includes the ability to assess shape, size, surface

Table 1: Comparison of oral stereognostic ability in complete denture patients before denture insertion, after denture insertion, and 6 months after denture insertion (for comparison of means using one-way ANOVA)

Oral stereognostic ability	Mean±SD	*n*	*F*#	*P*	Pair	Mean difference	*P*$
Before denture insertion (A)	6.5±2.2	38	187.49**	0.000	A and B	2.55*	0.000
After denture insertion (B)	9.1±1.9	38			A and C	4.34*	0.000
6 months after denture insertion (C)	10.8±1.2	38			B and C	1.79*	0.000

**Significant at 0.01 level, *Significant at 0.05 level, #One-way repeated-measures ANOVA, $Pairwise multiple comparison with Bonferroni correction. SD: Standard deviation

Table 2: Comparison of salivary flow rate in complete denture patients before denture insertion, after denture insertion, and after 6 months (for comparison of means using one-way ANOVA)

Salivary flow rate	Mean±SD	*n*	*F*#	Significant	Pair	Mean difference	*P*$
Before denture insertion (A)	2.8±0.9	38	78.02**	0.000	A and B	1.15*	0.000
After denture insertion (B)	1.6±0.8	38			A and C	0.13	0.989
6 months after denture insertion (C)	2.9±0.7	38			B and C	1.28*	0.000

**Significant at 0.01 level, *Significant at 0.05 level, #One-way repeated-measures ANOVA, $Pairwise multiple comparison with Bonferroni correction. SD: Standard deviation

Table 3: Comparison of weight of chewing gum after 5 strokes after denture insertion and after 6 months

Weight of chewing gum after 5 strokes	Mean±SD	*n*	Mean difference	Paired *t*	*P*
After denture insertion	1.09±0.02	38	0.17	13.09**	0.000
6 months after denture insertion	0.93±0.08	38			

**Significant at 0.01 level, SD: Standard deviation

Table 4: Comparison of weight of chewing gum after 10 strokes after denture insertion and after 6 months

Weight of chewing gum after 10 strokes	Mean±SD	*n*	Mean difference	Paired *t*	*P*
After denture insertion	1.07±0.05	38	0.32	14.68**	0.000
6 months after denture insertion	0.76±0.15	38			

**Significant at 0.01 level, SD: Standard deviation

Table 5: Comparison of weight of chewing gum after 15 strokes after denture insertion and after 6 months

Weight of chewing gum after 15 strokes	Mean±SD	*n*	Mean difference	Paired *t*	*P*
After denture insertion	1.02±0.06	38	0.43	17.3**	0.000
6 months after denture insertion	0.59±0.16	38			

**Significant at 0.01 level, SD: Standard deviation

Table 6: Comparison of weight of chewing gum after 20 strokes after denture insertion and after 6 months

Weight of chewing gum after 20 strokes	Mean±SD	*n*	Mean difference	Paired *t*	*P*
After denture insertion	0.95±0.08	38	0.52	22.96**	0.000
6 months after denture insertion	0.43±0.17	38			

**Significant at 0.01 level, SD: Standard deviation

texture, and temperature. Tactile sensory feedback is elicited by physical contact between some entities such as food particles and mechanoreceptors present in the oral mucosa and periodontal ligament (e.g., Merkel discs and Ruffini endings). This low-level sensory information is processed in the cerebral cortex, compared with previous sensory memories, and then transformed into higher level information like extracting shapes of objects or developing the best chewing strategy that minimized stresses on teeth and other structures. This perception together with proprioception, which provides information about the relative spatial position and movements of the jaw, programs the physiologic function of the masticatory system. Edentulism and age diminish oral stereognostic ability of an individual.[9] Improvement in oral stereognosis is considered to be an indicator of success following complete denture therapy, and hence, oral stereognostic tests can be used to predict the patients' adaptation to complete dentures.

Oral stereognosis ability testing can also be done with other materials like carrots and metal alloy. In this study, heat cure acrylic resin was used since the denture to be given to the patient will be made of heat cure acrylic resin. The test items should have a wide variety of characteristics such as straight lines, angles, and concave and convex curves, and easily perceived ratios of length and width. Two equally important factors are the intelligibility (ease of recognition) and confusability (degree of confusion with regard to form similarity) of every individual form.[10]

According to Oliveira *et al.*, masticatory performance is defined as the ability to grind a certain portion of food with a determined number of masticatory cycles, while the term masticatory efficiency (ME) is related to the amount of chewing necessary to achieve a given degree of grinding of test food, independently of the number of masticatory cycles.[11] Chewing efficiency decreases as the natural dentition deteriorates, and the ME of complete denture wearers is only 16%–50% that of dentate subjects.[7,12] Loss of teeth can lead to a diminished chewing efficiency, and there is evidence of restricted dietary choice with resultant systemic effects.[13-15] However, the replacement of missing natural teeth improves masticatory function but to a lesser extent than that of previous natural dentition.

Most of the literatures that evaluated masticatory efficiency used food particles like peanuts along with the sieve method for assessment. Heath proposed a novel method of measuring ME using chewing gum, the principle being the percentage of sweeteners chewed out during a defined number of chewing strokes. A wide variety of test foods are being in use like standard sizes of formalin hardened gelatin, round tablets of silicone impression materials. Japanese investigators preferred a fishcake called "kamaboko," while European and American investigators preferred carrots, peanuts, and almonds. Manufactured chewing gums have the major advantage that they are carefully standardized; chances of food particle getting trapped under the denture are negligible compared to the other test foods.[7]

Furthermore, salivary wetting mechanisms are necessary to create adhesion, cohesion, and surface tension that lead to increased retention of the prosthesis. Salivary flow rate is thus an important factor contributing to the retentive properties of complete denture.

Oral stereognostic ability increased immediately following insertion of complete dentures and was still higher after 6 months post insertion of dentures. The results obtained were in accordance with Bhandari *et al.* and Meenakshi *et al.* who suggested that the improvement in stereognostic ability in part is due to their increased ability to manipulate objects with their complete denture.[16,17] As reported by van Aken *et al.*, large test pieces showed higher obstructive sleep apnea score than small pieces, and test pieces with corners were recognized more correctly than those without corners.[19-21] This observation is justified in our study also, as most subjects made the least error with identification of star forms.

Several studies have shown that saliva has an important role in masticatory function.[4] The values for the whole salivary flow rate after 6 months remained significantly high when compared with the values obtained before the complete denture placement, suggesting the importance of stimulation, where the dentures themselves act as mechanical stimulants. There was an increase in salivary flow immediately following denture insertion which is considered to be normal. The results further showed that the salivary flow which increased immediately following denture insertion returned to normal during 6-month postdenture insertion period.[11,18]

Masticatory efficiency of the 38 denture subjects who returned after 6 months of denture usage was evaluated after denture insertion and 6 months after denture insertion. For each subject, Orbit chewing gums were used for 5, 10, 15, and 20 strokes. The chewing gums were then desiccated and weighed again. Since the sweetener was chewed out, the weight of the chewing gum was reduced. This reduction in weight of the chewing gum is

a measure of masticatory efficiency. The same procedure was followed after a period of 6 months. Comparison of the means of masticatory efficiency after denture insertion and 6 months after denture usage gives highly significant values. This indicates a highly significant improvement in masticatory efficiency following rehabilitation with a complete denture. According to Bhandari *et al.*, this improvement in masticatory efficiency may be due to patient's adaptation to the new denture.[16]

CONCLUSION

The present study evaluated the functions of the masticatory system like oral stereognosis and salivary flow rate before denture insertion, after denture insertion, and after 6 months of insertion in nonexperienced denture wearers. It also evaluated the masticatory efficiency after denture insertion and 6 months after denture insertion. In light of the results of this investigation and statistical analysis paired t-test, one-way ANOVA test, and the post hoc test, the following conclusions can be derived:

1. Oral stereognostic ability increased immediately on the insertion of complete dentures and was still higher after 6 months post insertion of dentures. This improvement may be due to improved adaptability with the dentures with due course of time. As the oral stereognostic ability score was statistically significant, the results of this study support the hypothesis that rehabilitation with dentures improves oral stereognostic ability
2. Comparison of the means of masticatory efficiency after denture insertion and 6 months after denture usage gives highly significant values. This indicates a highly significant improvement in masticatory efficiency following rehabilitation with a complete denture
3. The salivary flow which increased immediately following denture insertion returned to normal during 6-month postdenture insertion period.

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Conflicts of interest
There are no conflicts of interest.

REFERENCES

1. Berry DC, Mahood M. Oral stereognosis and oral ability in relation to prosthetic treatment. Br Dent J 1966;120:179-85.
2. Jacobs R, BouSerhal C and Steenberghe D. Oral stereognosis: A review of the literature. Clin Oral Invest 1998;2:3-10.
3. Kapur KK, Soman SD. Masticatory performance and efficiency in denture wearers. 1964. J Prosthet Dent 2006;95:407-11.
4. Ishijima T, Koshino H, Hirai T, Takasaki H. The relationship between salivary secretion rate and masticatory efficiency. J Oral Rehabil 2004;31:3-6.
5. Jacobs R, van Steenberghe D. Role of periodontal ligament receptors in the tactile function of teeth: A review. J Periodontal Res 1994;29:153-67.
6. Smith PW, McCord JF. Oral stereognostic ability in edentulous and dentate individuals. Eur J Prosthodont Restor Dent 2002;10:53-6.
7. Anastassiadou V, Heath MR. The development of a simple objective test of mastication suitable for older people, using chewing gums. Gerodontology 2001;18:79-86.
8. Navazesh M. Methods for collecting saliva. Ann N Y Acad Sci 1993;694:72-7.
9. Rossetti PH, Bonachela WC, Nunes LM. Oral stereognosis related to the use of complete dentures: A literature review. Int J Oral-Med Sci 2004;2:57-60.
10. Jacobs CB, van Steenberghe SD. Oral stereognosis: A review of the literature. Clin Oral Invest 1998;2:3-10.
11. Oliveira NM, Shaddox LM, Toda C, Paleari AG, Pero AC, Compagnoni MA. Methods for evaluation of masticatory efficiency in conventional complete denture wearers: A systematized review. Oral Health Dent Manag 2014;13:757-62.
12. Thumati P. Mastication analysis. J Indian Prosthodont Soc 2018;18;61-2.
13. Sharma AJ, Nagrath R, Lahori M. A comparative evaluation of chewing efficiency, masticatory bite force, and patient satisfaction between conventional denture and implant-supported mandibular overdenture: An *in vivo* study. J Indian Prosthodont Soc 2017;17;361-72.
14. Muddugangadhar BC, Rajashekar S, Rudraprasad IV, Nandeeshwar DB, Dhanya Kumar BH. A clinical study to compare between resting and stimulated whole salivary flow rate and pH before and after complete denture placement in different age groups. J Indian Prosthodont Soc 2015;15;356-66.
15. Bhat S, Chowdhary R, Mahoorkar S. Comparison of masticatory efficiency, patient satisfaction for single, two, and three implants supported overdenture in the same patient: A pilot study. J Indian Prosthodont Soc 2016;16:182-86.
16. Bhandari A, Hegde C, Krishna Prasad D. Relation between oral stereognosis and masticatory efficiency in complete denture wearers: An *in vivo* study. Braz J Oral Sci 2010;9:3.
17. Meenakshi S, Gujjari AK, Thippeswamy HN, Raghunath N. Evaluation of oral stereognostic ability after rehabilitating patients with complete dentures: *In vivo* study. J Indian Prosthodont Soc 2014;14:363-8.
18. Yurdukoru B, Terzioğlu H, Yilmaz T. Assessment of whole saliva flow rate in denture wearing patients. J Oral Rehabil 2001;28:109-12.
19. van Aken AA, de Baat C, van Rossum GM, Mulder J, Kalk W. Adjustment of complete dentures. Have oral stereognosis and denture quality a predictable value? Ned Tijdschr Tandheelkd 1996;103:122-4.
20. Litvak H, Silverman SI, Garfinkel L. Oral stereognosis in dentulous and edentulous subjects. J Prosthet Dent 1971;25:139-51.
21. Garrett NR, Kapur KK, Jochen DG. Oral stereognostic ability and masticatory performance in denture wearers. Int J Prosthodont 1994;7:567-73.