Analysis of Masticatory Cycle Efficiency in Complete Denture Wearers

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Abstract

Purpose: This study assessed masticatory efficiency and duration of the masticatory cycle in 14 asymptomatic patients with severe bone resorption. All patients had worn complete dentures for over 10 years. Recall visits were scheduled at 5 months and 1 year after receiving new dentures.
Materials and Methods: Fourteen patients were evaluated in this study. The Research Diagnostic Criteria questionnaire and tests of the efficiency and duration of the masticatory cycle were performed with artificial food before, 5 months after, and 1 year after new dentures were delivered. Masticatory efficiency was assessed using a sieve system; artificial food was ground for 35 masticatory cycles and monitored by the operator.
Results: Masticatory efficiency at 5 months was significantly improved for the 0.42-mm mesh. An improvement in masticatory efficiency and a reduction in mastication time were observed with the new dentures after 1 year.
Conclusion: The results of this study indicated that 5 months did not allow enough time to demonstrate improved muscular capacity and ability after receiving new dentures. After 1 year, the duration of the masticatory cycle was reduced, and masticatory efficiency was significantly improved.

Atrophy of denture-supporting tissues, poor adaptation, reduced masticatory efficiency, and psychosocial embarrassment are major complaints of edentulous patients wearing conventional dentures.[1] Such problems, even with the best possible prosthodontic care, have often been insurmountable with conventional denture techniques.[2] In addition, the complex neuromuscular skills required to overcome the limitations of dentures diminish with aging.[2–5] Although there has been an increase in rehabilitation with osseointegrated implants,[6,7] treatment with conventional complete dentures still remains the most common treatment for edentulous patients.[1,8]

The loss of natural teeth leads to bone resorption, temporomandibular dysfunction,[8] and muscular hypotonicity, which may affect structures involved in mastication.[9] Furthermore, treatment success depends not only on management or preparation of the patient, but also on the clinical quality of the dentures.[10–14]

Food is generally eaten in mouthfuls, and the processing of a mouthful has been reported to involve a mastication sequence of 10 to 40 chewing cycles.[15,16] Some studies have reported findings in which subjects were generally represented by a point regarding age and number of cycles required to chew and swallow the model food with both natural dentition[17–20] and dentures.[4,18–25] Some researchers have reported that edentulous individuals, when provided with optimal complete dentures, presented with masticatory efficiency lower than in those with natural teeth, with fixed prostheses on natural teeth, or with osseointegrated oral implants.[18,26]

The aim of this study was to assess efficiency and duration of masticatory cycles in patients wearing dentures for 10 years in comparison to the evaluations performed 5 months and 1 year following fabrication and insertion of new dentures.

Material and methods

Fourteen edentulous patients wearing maxillary and mandibular complete dentures for over 10 years were selected based on health history and clinical evaluations. All patients presented with reduced occlusal vertical dimension (OVD) with complete dentures showing worn teeth, alterations of anatomical occlusal form, and reduction in cuspal heights. Eight women, with a mean age of 74 years and six men, with a mean age of 71 years, were selected for the study. All patients presented with severe bone resorption in accordance with Ortman et al[27] particularly in the mandibular arch. Individuals presenting with diabetes,

cardiovascular or articular alterations, hypertension, cancer, or history of temporomandibular disorders (TMD) were excluded from the study according to exclusionary criteria.

All patients were asymptomatic and presented no signs or symptoms of TMD, as defined by the Dworkin and Leresche Research Diagnostic Criteria (RDC) questionnaire.[28] The questionnaires were administered by two examiners before the new dentures were inserted and again 5 and 12 months after denture insertion. Two examiners, calibrated according to RDC/TMD standards, performed the clinical evaluations in accordance with RDC/TMD standards.

The subjects with their old dentures were defined as the control group. Data from the control group were compared to the post-treatment data, which allowed within-subject comparisons. The selected subjects were informed about the treatment and signed an informed consent form in accordance with the recommendations of the Human Research Ethics Committee.

Clinical evaluations revealed the following conditions: severe decrease in lower face height yielding poor facial esthetics, inadequate fit of complete dentures, worn denture teeth, clinically perceptible deficiency in OVD, acquired protrusive maxillomandibular relationships secondary to resorption, or angular cheilitis.[29] The deficiencies in the preoperative OVD were corrected by adding increments of acrylic resin to the occlusal surfaces[30] of the teeth in the old mandibular dentures. The new complete dentures were made according to the procedure recommended by Zarb et al.[31]

The technique for denture fabrication consisted of preliminary impressions using stock trays and condensation silicone impression material (Zetaplus, Zhermack, Rovigo, Italy). The preliminary casts were fabricated to make custom trays for definitive impressions. Border molding was performed with heavy body condensation silicone (Zetalabor, Zhermack), and the definitive impressions were made with rubber base impression material (Pasta Lysanda Zincoenólica, Lysanda, São Paulo, Brazil) syringed around the borders of the trays until the trays were completely covered. The definitive impressions were poured with dental stone type IV (Durone, Dentsply, Rio de Janeiro, Brazil) to obtain the master casts.

The maxillary cast of each patient was mounted in a semiadjustable articulator (Whip Mix Corporation, Louisville, KY) using a face bow. OVD was established using the physiological rest positions associated with phonetic and esthetic techniques.[31]

Centric relation was established according to dynamic records based on physiological movements of the jaws, including opening, closing, and lateral movements performed by the patient.[31] These records were performed to position the mandibular casts on the articulators. Artificial teeth were selected, and bilateral balanced occlusion was obtained. The dentures were waxed, processed, finished, and polished for insertion and follow-up.[31] The new dentures showed improved facial esthetics, adequate fit, correct maxillomandibular relationships, and anatomical teeth with cusp inclination of 20°.

Mastication tests were performed using artificial food in accordance with Optocal ATF.[32] The food was fragmented as recommended by Slagter et al.[33] Each patient received an aliquot of artificial food fragments weighing a total of 3 g. The food was chewed for 35 cycles[15] and monitored by an examiner. The patients were instructed to chew the artificial food with slight movements and not to swallow the food. The number of cycles was determined to be close to the moment of natural swallowing.[15] The cycles were monitored by an examiner and timed in seconds by a digital watch (Ikea, Hong Kong). Patients were allowed to select the chewing side. After mastication, the chewed particles were expelled into a set of four sieves. The prostheses were washed with water, and patients were asked to rinse the oral cavity to eliminate any remaining particles, expelling them into the same receptacles. At the end of the test, intraoral inspection was performed to certify that no residual food fragments remained in the oral cavity.

The particles contained in the sieve were washed with water and dried in an autoclave at 50°C for 1 hour. After drying, the sieve system was put into a vibrator for 60 seconds, and the food particles were separated according to granulometric meshes with openings of 2.0, 1.08, 0.42, and 0.20 mm, sequenced in decreasing order of size. Each mesh was weighed separately on an analytical balance (BEL Equipamentos Analítico, São Paulo, Brazil) with a precision of 0.001 g.[34,35]

The masticatory efficiency analysis was performed three times for each patient: (1) with the original denture, (2) 5 months following treatment, and (3) 1 year following treatment. Statistical analysis was performed by comparison of variance tests to compare masticatory cycles and efficiency, followed by the normal data distribution test, ANOVA, and Tukey's student range (HSD) ($p < 0.05$).

Results

Denture replacement reduced the amount of artificial food retained in the 2.0-mm sieve at 5 months and 1 year after insertion of the new dentures. Food weight in the other sieve granulations (1.08, 0.42, and 0.20 mm) increased at 5 months, with further increase at 1 year (Table 1). With the original dentures, 9.93% of the material passed through the 2.0-mm sieve. With the new dentures, 14.2% passed through the 2.0-mm sieve at 5 months, and 21.4% passed through the 2.0-mm sieve at 1 year (Table 2). Five months postinsertion, masticatory efficiency was significantly improved for the small particles (0.42-mm mesh) (Table 1).

One patient reported difficulty in adapting to the new mandibular denture at the 5-month recall visit, without further improvement 1-year postinsertion. The time required to perform 35 masticatory cycles was significantly reduced only after 1 year with the new dentures (30.5 seconds), (Table 3); however, the mean amount of food that passed through the 2.0-mm sieve during masticatory cycles was statistically significant for all periods of evaluation.

Discussion

In this study, there was no statistically significant improvement in masticatory efficiency and duration of masticatory cycles 5 months after denture replacement (Tables 1–3). Other authors have affirmed that patients with new dentures increased masticatory efficiency,[18,19,21,26] even with poor muscular adaptation and reduced electrical activity in the masticatory muscles.[1,8]

Table 1 Mean weight (g) and standard deviation (SD) of chewed artificial food retained in graduated sieve meshes before, after 5 months, and after 1 year of wearing new dentures (N = 14)

Period/mesh	Old dentures (SD)	After 5 months with new dentures (SD)	After 1 year with new dentures (SD)
2.00 mm	2.7008 ± 0.1633 A,a	2.5741 ± 0.1521 A,ab	2.358 ± 0.134 A,b
1.08 mm	0.1351 ± 0.0650 B,a	0.1822 ± 0.0601 B,a	0.234 ± 0.083 B,b
0.42 mm	0.0932 ± 0.0531 BC,a	0.1465 ± 0.0484 B,b	0.211 ± 0.067 B,c
0.20 mm	0.0700 ± 0.0557 C,a	0.0830 ± 0.0512 C,a	0.197 ± 0.00412 B,b

Different uppercase letters indicate statistically significant difference (5%) in rows (groups).
Different lowercase letters indicate statistically significant difference (5%) in columns (reading).

This small increase may be related to reestablishment of OVD[1] and presence of cusps;[6,22] however, this increase was not statistically significant—perhaps due to lack of muscular capacity and ability,[22] as well as the complex neuromuscular skills required to overcome the limitations of dentures.[1] These characteristics make occlusal adjustment of dentures difficult, perhaps permitting premature occlusal contacts that may destabilize the dentures and complicate mastication;[3] however, all but one of the patients presented significant improvement in masticatory efficiency following 1 year of treatment. This increased masticatory efficiency may have developed from muscular adaptation,[2,5,9] establishment of bilateral balanced occlusion,[18,19,21,26] presence of teeth with cusps,[6,22] and reestablishment of OVD and occlusal surfaces.[1] The new dentures with correctly positioned cusps facilitated intercuspation and perhaps required a lower amount of force to chew the food.[26] This could lead to greater chewing of food and a better quality diet.[15,16] The mean time to perform the 35 mastication cycles decreased with longer periods of new denture wear. These results are in agreement with those of Bakke et al,[10] Wilding,[11] Julien et al,[12] Christensen and Mohamed,[13] and Honma et al.[14] An additional possible explanation for improved masticatory efficiency may be explained by enhanced bilateral balanced occlusion obtained with the new dentures.

Table 2 Percentage means of ground artificial food passing through a 2.0-mm sieve before, after 5 months, and after 1 year of wearing new dentures

Period-granulation	With original dentures	After 5 months with new dentures	After 1 year with new dentures
First-2.0 mm	9.93%	14.20%	21.4%

Table 3 Mean time (seconds) and standard deviation (SD) of chewing cycles before, after 5 months, and after 1 year of wearing new dentures (N = 14)

Cycles/period	Time (SD)
Old denture	36.5 ± (0.52) A
After 5 months with new dentures	34.5 ± (0.45) A
After 1 year with new dentures	30.5 ± (0.40) B

Different letters indicate statistically significant difference (5%) in columns (reading).

In the present study, the reduction in the number of cycles occurred mainly at the end of mastication. The reduction of cycles in this specific chewing period may have occurred due to a greater capacity of patients to chew food in the beginning of chewing[4,17,20,23-25] associated with adaptation to new dentures,[2,5,9] establishment of bilateral balanced occlusion,[18,19,21,26] and/or presence of teeth with cusps.[6,22]

Significant improvement in masticatory efficiency has been reported to occur after 5 months with implant overdentures.[7] Geertman et al[7] speculated that this occurred due to improved adaptation and muscular capacity. The number of chewing strokes needed to pulverize the material was reduced more than with conventional dentures;[7] however, in this study, 5 months was not enough time to observe increased efficiency or change the number of masticatory cycles with the new complete dentures (Table 3).

Nevertheless, positive outcomes occurred in the majority of the patients, possibly due to reestablishment of the artificial tooth cusps with anatomic teeth and conventional balanced occlusion.[18,19,21,26] Further studies should clarify the association among masticatory efficiency and alterations in anatomical occlusal form.

Conclusion

In this study, patients experienced improved masticatory efficiency after 1 year with their new dentures. There were also significant decreases in particle size and number of masticatory cycles required to chew the test foods with the new complete dentures as compared to the original dentures. These results suggest that 5 months was not a long enough time to evaluate patient adaptation and functional capacity with new complete dentures.

References

1. Goiato MC, Garcia AR, dos Santos DM: Electromyographic activity of the mandible muscles at the beginning and end of masticatory cycles in patients with complete dentures. Gerontology 2008;54:138-143
2. Gunne HS, Bergman B, Enbom L, et al: Masticatory efficiency of complete denture patients. Acta Odontol Scand 1982;40:289-297

3. Miralles R, Bull R, Manns A, et al: Influence of balanced occlusion and canine guidance on electromyographic activity of elevator muscles in complete denture wearers. J Prosthet Dent 1989;61:494-498
4. Karkazis HC, Kossioni AE: Surface EMG activity of the masseter muscle in denture wearers during chewing of hard and soft food. J Oral Rehabil 1998;25:8-14
5. Piancino MG, Farina D, Talpone F, et al: Surface EMG of jaw-elevator muscles and chewing pattern in complete denture wearers. J Oral Rehabil 2005;32:863-870
6. Khamis MM, Zaki HS, Rudy TE: A comparison of the effect of different occlusal forms in mandibular implant overdentures. J Prosthet Dent 1998;79:422-429
7. Geertman ME, Slagter AP, van't Hof MA, et al: Masticatory performance and chewing experience with implant-retained mandibular overdentures. J Oral Rehabil 1999;26:7-13
8. Goiato MC, Garcia AR, Santos DM: Electromyographic evaluation of masseter and anterior temporalis muscles in resting position and during maximum tooth clenching of edentulous patients before and after new complete dentures. Acta Odontol Latinoam 2007;20:3-8
9. Gunne HS, Wall A: The effect of new complete dentures on mastication and dietary intake. Acta Odonto Scand 1985;43:257-268
10. Bakke M, Holm B, Jensen BL, et al: Unilateral, isometric bite force in 8-68-year-old women and men related to occlusal factors. Scand J Dent Res 1990;98:149-158
11. Wilding RJ: The association between chewing efficiency and occlusal contact area in man. Arch Oral Biol 1993;38:589-596
12. Julien KC, Buschang PH, Throckmorton GS, et al: Normal masticatory performance in young adults and children. Arch Oral Biol 1996;41:69-75
13. Christensen LV, Mohamed SE: Bilateral masseteric contractile activity in unilateral gum chewing: differential calculus. J Oral Rehabil 1996;23:638-647
14. Honma K, Kohno S, Honma W, et al: A study on the differences in function of free-sided and unilateral chewing. Nihon Hotetsu Shika Gakkai Zasshi 2005;49:459-468
15. Woda A, Mishellany A, Peyron MA: The regulation of masticatory function and food bolus formation. J Oral Rehabil 2006;33:840-849
16. Shinkai RS, Hatch JP, Rugh JD, et al: Dietary intake in edentulous subjects with good and poor quality complete dentures. J Prosthet Dent 2002;87:490-498
17. Peyron MA, Blanc O, Lund JP, et al: Influence of age on adaptability of human mastication. J Neurophysiol 2004;92:773-779
18. 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. J Gerontol 1984;39:284-289
19. Fontijn-Tekamp FA, Slagter AP, Van Der Bilt A, et al: Biting and chewing in overdentures, full dentures, and natural dentitions. J Dent Res 2000;79:1519-1524
20. Shikano Y: Clinical study of evaluation on masticatory function in complete denture wearers. A comparison of masticatory movements between normal natural dentition and complete denture wearers. Nihon Hotetsu Shika Gakkai Zasshi 1990;34:318-332
21. Michael CG, Javid NS, Colaizzi FA, et al: Biting strength and chewing forces in complete denture wearers. J Prosthet Dent 1990;63:549-553
22. Brills N: Reflexes, registrations and prosthethic therapy. J Prosthet Dent 1957;7:341-360
23. Lucas PW, Luke DA: Methods for analysing the breakdown of food in human mastication. Arch Oral Biol 1983;28:813-819
24. Rissin L, House JE, Manly RS, et al: Clinical comparison of masticatory performance and electromyographic activity of patients with complete dentures, overdentures, and natural teeth. J Prosthet Dent 1978;39:508-511
25. Van Der Bilt A, Ottenhoff FA, Van Der Glas HW, et al: Modulation of the mandibular stretch reflex sensitivity during various phases of rhythmic open close movements in humans. J Dent Res 1976;76:839-847
26. Slagter AP, Bosman F, Van Der Glas HW, et al: Human jaw-elevator muscle activity and food comminution in the dentate and edentulous state. Arch Oral Biol 1993;38:195-205
27. Ortman LF, Hausmann E, Dunford RG: Skeletal osteopenia and residual ridge resorption. J Prosthet Dent 1989;61:321-325
28. Dworkin SF, LeResche L: Research diagnostic criteria for temporomandibular disorders: review, criteria, examinations and specifications, critique. J Craniomandib Disord 1992;6:301-355
29. Wagner AG: Complete dentures with an acquired protrusive occlusion. Gen Dent 1989;37:56-57
30. Mays KA: Reestablishing occlusal vertical dimension using a diagnostic treatment prosthesis in the edentulous patient: a clinical report. J Prosthodont 2003;12:30-36
31. Zarb G, Bolender C, Eckert S, et al: Prosthodontic Treatment for Edentulous Patients (ed 12). St. Louis, Mosby, 2004
32. Olthoff LW, Van Der Bilt A, de Boer A, et al: Comparison of force deformation characteristics of artificial and several natural foods for chewing experiments. J Texture Stud 1986;7: 275-289
33. Slagter AP, Van Der Glas HW, Bosman F, et al: Force-deformation properties of artificial and natural foods for testing chewing efficiency. J Prosthet Dent 1992;68:790-798
34. Gavião MB, Raymundo VG, Sobrinho LC: Masticatory efficiency in children with primary dentition. Pediatr Dent 2001;23:499-505
35. Gavião MB, Raymundo VG, Rentes AM: Masticatory performance and bite force in children with primary dentition. Braz Oral Res 2007;21:146-152

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