

**CLINICAL RESEARCH**

## Effect on patient satisfaction of mandibular denture tooth arrangement in the neutral zone



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Despite the growing trend of implant treatment and its proposal as the standard of care for the edentulous population, conventional complete-denture therapy remains a substantial and a more affordable treatment option for the majority of elderly edentulous patients,<sup>1,2</sup> especially those with low socio-economic status.<sup>1</sup> Although conventional dentures have been an effective treatment option for some patients, they are unsuccessful for others because of poor stability, compromised retention, inadequate facial support, poor esthetics, inefficient tongue function/posture, poor mastication or speech, gagging and general discomfort, or the patient's inability to adapt. All these factors have been classically related to physiologically inadequate contours or denture base volume and functionally inappropriate positioning of denture teeth.<sup>3</sup> Several approaches to positioning artificial teeth have been advocated,<sup>3</sup> but

superiority of one method over others is still controversial.

Positioning teeth in the neutral zone (NZ) has been a long-advocated approach. The NZ concept is to position

### ABSTRACT

**Statement of problem.** The effect of the neutral zone (NZ) technique on different functional aspects (masticatory performance, speech, and muscle activity) has been studied objectively. Subjectively, some studies reported that their participants felt that NZ dentures were more stable, retentive, and comfortable than conventionally fabricated dentures. These studies, however, lacked a measurable assessment scale or a specifically designed questionnaire.

**Purpose.** The purpose of this within-subject, crossover clinical trial was to investigate patient satisfaction levels in edentulous patients after rehabilitation with dentures fabricated using the NZ concept as compared with conventional dentures using a specific, question-oriented patient satisfaction questionnaire.

**Material and methods.** The clinical trial included 52 participants. Each received one set of conventional dentures and another fabricated based on the NZ concept with a 1-month wash-out period. Participants randomly chose 1 of 2 closed opaque envelopes with 2 denture sequences, either conventional then NZ or NZ then conventional. Hence, participants were blinded to the dentures they wore. Patient satisfaction with each denture type was assessed 6 weeks after insertion by a blinded staff member using a 5-scale questionnaire developed for the most important functional aspects (esthetics, masticatory ability, retention, stability, speech, and comfort). The Wilcoxon Signed Rank test was used to compare the satisfaction scores of the 2 denture types ( $\alpha=.05$ ).

**Results.** Patient satisfaction scores were significantly higher with the NZ dentures than with the conventional dentures in all aspects;  $P=.001$  for question 2 (opinion of denture appearance) and  $P<.001$  for all other questions.

**Conclusions.** NZ dentures offer significantly higher levels of patient satisfaction than conventional dentures in all functional aspects (retention, stability, masticatory ability, and speech) as well as in comfort and appearance. (*J Prosthet Dent* 2019;121:440-6)

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## Clinical Implications

All participants were more comfortable and more satisfied with their NZ dentures compared with their conventional dentures in all functional aspects. Fabricating complete dentures based on this concept is recommended whenever feasible, especially for challenging situations in which implant treatment is not appropriate.

teeth and contour-polished denture surfaces such that all the forces exerted by the oral and paraoral muscles are neutralized or balanced, and the denture is maintained in a state of equilibrium.<sup>4</sup> The NZ approach is by no means new as it was first described by Fish in 1931.<sup>5</sup> Since then, it has been discussed and investigated<sup>3,4,6-22</sup> and demonstrated to be beneficial, especially for edentulous patients who present a challenge for conventional denture treatment and for whom implant placement is not feasible.<sup>11,13,16</sup> Unfortunately, this approach is not widely or routinely practiced partly because of the increased chair time, increased laboratory cost, and complexity of the procedure and also because of the lack of clinician knowledge or experience.<sup>17</sup>

The effect of the NZ technique on masticatory performance,<sup>9</sup> speech,<sup>18</sup> marginal bone loss around implant-supported overdentures,<sup>22</sup> and muscle activity<sup>21</sup> has been studied objectively. However, objective assessments cannot necessarily predict patient attitudes or satisfaction with the dentures.<sup>23-25</sup> Recently, studies have focused more on participant perception and treatment satisfaction.<sup>26</sup> The effect of implant-supported prostheses,<sup>27</sup> occlusion choices,<sup>28</sup> soft liners,<sup>29</sup> impression techniques,<sup>30</sup> procedural variations,<sup>31</sup> and clinician experience<sup>32</sup> have been assessed with patient satisfaction studies in complete-denture wearers. Although some studies reported that their participants subjectively felt that NZ dentures were more stable, retentive, and comfortable with minimum problems after insertion and better esthetics than conventionally fabricated dentures,<sup>9,15,17,33</sup> none of these studies used a measurable assessment scale or a specifically designed questionnaire. To the best of the authors' knowledge, the impact on patient satisfaction of arranging teeth based on the NZ concept has not been methodically investigated.

Patient-based assessment can be carried out using an oral health-related quality of life (OHRQoL) instrument or a patient satisfaction questionnaire. OHRQoL instruments are usually directed toward the effect of a certain treatment on the patient's health condition and evaluation of their oral health from a broad perspective. Patient satisfaction scales designed with specifically oriented, in-depth questions, however, may be more

sensitive in detecting differences among treatment modalities and their influence on a wide range of functional activities of a prosthesis.<sup>34</sup> Moreover, from previous studies, a consistent positive correlation has been confirmed between self-reported satisfaction with dentures and OHRQoL.<sup>1,2,35</sup> Therefore, the purpose of this study was to investigate patient satisfaction levels in edentulous participants after rehabilitation with dentures fabricated according to the NZ concept as compared with conventionally fabricated dentures using a specific, question-oriented patient satisfaction questionnaire. The null hypothesis was that no significant differences would be found in patient satisfaction scores between the conventional and NZ dentures.

## MATERIAL AND METHODS

The study protocol was submitted to and approved by the Research Ethics committee, Faculty of Oral and Dental Medicine, Cairo University (June 9, 2014). Based on sample-size calculation (PS Program, v2.1.31) with a power of 80%, 52 edentulous participants were required. Inclusion criteria were as follows: selected participants must be free from temporomandibular disorders or any systemic diseases that could affect neuromuscular behavior, have no speech disorders or hearing disabilities, not be under any medication that could affect muscular activities, have no previous denture-wearing experience, have a class I maxillomandibular relationship, adequate interarch distance, normal tongue behavior and size, and understand and be willing to complete the satisfaction questionnaire. Individuals with xerostomia or excessive salivation and those with severe bony undercuts or bony exostoses were excluded. Fifty-two eligible participants (29 men and 23 women) with a mean age of 64.2 years were included in the study after they agreed to participate and signed an informed consent form.

The present study was a within-subject crossover clinical trial. Each participant received 2 sets of dentures: one set of conventional dentures and another set fabricated based on the NZ concept with a 1-month wash-out clearance period to try to eliminate the influence of denture adaptation. Participants were asked to randomly choose 1 of 2 closed opaque envelopes containing 1 of 2 sequences (either conventional then NZ or NZ then conventional). Participants were blinded to the dentures they wore.

All clinical steps were carried out by the same 2 calibrated clinicians (W.R.A., A.M.), and all laboratory work was done by the same dental technician in the same dental laboratory. The conventional dentures were fabricated based on the dental school's traditional standard protocol. Preliminary impressions were made using irreversible hydrocolloid (Cavex CA37; Cavex



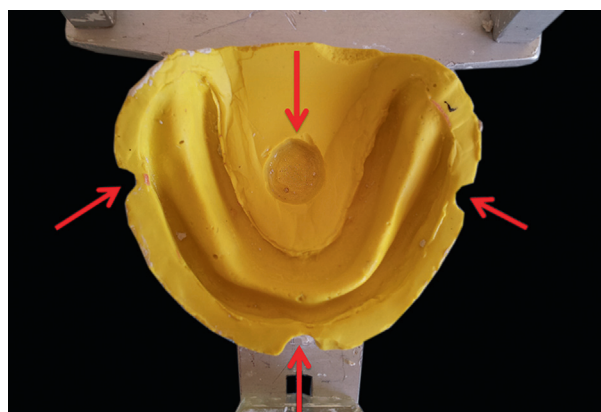
**Figure 1.** Acrylic resin denture base with wire loops.



**Figure 2.** Occlusal stops made with green modeling plastic impression compound at occlusal vertical dimension.



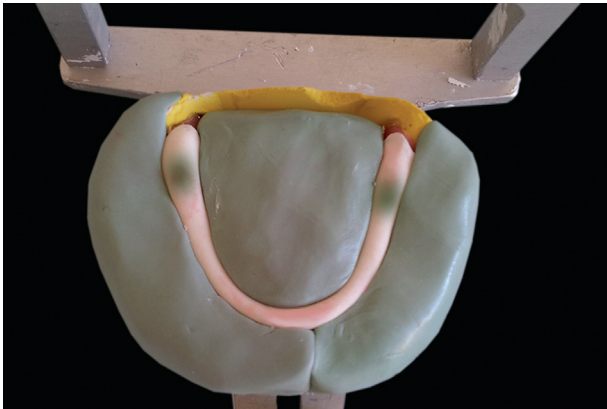
**Figure 3.** Neutral zone impression (Visco-gel).



**Figure 4.** Scoring (arrows) of base of mandibular cast to ensure stability and accurate repositioning of tongue and facial matrices.

Holland BV) in suitable and appropriately modified stock trays. Definitive impressions were made using elastomeric impression material (Speedex; Coltène) in border-molded (Impression Compound; Kerr Corp) custom trays (Cold Cure Denture Base Material; Acrostone). Impressions were boxed and poured in dental stone to obtain definitive casts on which occlusion rims were fabricated. The maxillary occlusion rim was adjusted for adequate lip support and proper occlusal plane orientation. A maxillary facebow (QuickMount; Whip Mix Corp) record was made to mount the maxillary cast on a semiadjustable articulator (8500 Series Articulator; Whip Mix Corp). The occlusal vertical dimension was determined to be 3 mm less than the vertical dimension of rest. Centric relation was recorded with wax rims related by means of a silicone occlusal registration material (Genie Bite; Sultan Healthcare) to mount the mandibular cast. Artificial teeth (Vertex Quint teeth; Vertex Dental) were arranged following a bilaterally balanced occlusal scheme, with the mandibular teeth arranged initially on the crest of the ridge. This was followed by clinical evaluation, denture delivery, and a 1-week follow-up appointment.

For the NZ dentures, all steps up to occlusal registration and mounting on the articulator were similar to those of the conventional technique. The mandibular trial denture base with its wax rim was then replaced by an acrylic resin plate with wire loops projecting upward (Fig. 1). Two occlusal finger rests (stops) were built up with green modeling plastic impression compound (Impression compound; Kerr Corp) on the wire loops at the premolar regions of both sides (Fig. 2). The stops were molded in the participant's mouth to the same and previously determined occlusal vertical dimension. The NZ impression was then made by applying tissue-conditioning material (Visco-gel; Dentsply Sirona)<sup>8,11,15,36</sup> on the acrylic resin denture base and finger rests, contouring it to an approximate rim. The participant was then asked to sit upright with the maxillary occlusion rim in place intraorally as seen in Figure 3 and to perform the following series of actions for 10 minutes: swallow mildly, take frequent sips of water, talk aloud, pronounce the vowels, count from 60 to 70, smile, grin, lick, and purse the lips. The base of the cast was scored (Fig. 4), and the NZ impression was then boxed by using silicone putty material (Labor Plus;



**Figure 5.** Neutral zone impression boxed by putty silicone material to obtain tongue and facial matrices.



**Figure 6.** Mandibular artificial teeth arranged in neutral zone defined by facial matrices and tongue matrix.

**Table 1.** Patient satisfaction scores (median and mean) in conventional and neutral zone dentures

Question	Conventional Dentures (n=52)		Neutral Zone Dentures (n=52)		P
	Median (Min-Max)	Mean	Median (Min-Max)	Mean	
Q1: How would you rate the appearance of your denture?	4.00 (2.00-5.00)	3.54	4.00 (2.00-5.00)	4.12	<.001*
Q2: How happy are you about people's opinion of your denture appearance?	4.00 (2.00-5.00)	3.65	4.00 (2.00-5.00)	4.12	.001*
Q3: How would you rate your present capacity to masticate hard food?	3.00 (2.00-4.00)	2.87	3.00 (2.00-5.00)	3.37	<.001*
Q4: How would you rate your present capacity to masticate medium food?	3.00 (2.00-4.00)	3.06	4.00 (2.00-5.00)	3.81	<.001*
Q5: How would you rate your present capacity to masticate soft food?	4.00 (2.00-5.00)	3.73	5.00 (2.00-5.00)	4.46	<.001*
Q6: How would you rate the retention of your denture?	3.00 (2.00-4.00)	3.04	4.00 (2.00-5.00)	4.29	<.001*
Q7: How would you rate the stability of your denture?	3.00 (2.00-4.00)	3.08	4.00 (2.00-5.00)	4.06	<.001*
Q8: How would you rate the comfort of your denture?	3.00 (2.00-5.00)	3.33	4.00 (2.00-5.00)	4.13	<.001*
Q9: How would you rate your capacity to speak?	3.00 (2.00-4.00)	3.17	4.00 (3.00-5.00)	4.21	<.001*
Q10: How comfortable are your muscles with the denture?	3.00 (2.00-4.00)	3.12	4.00 (2.00-5.00)	4.25	<.001*
Q11: How would you rate your denture in general?	3.00 (2.00-4.00)	3.38	4.00 (3.00-5.00)	4.25	<.001*

Min, minimum; Max, maximum. \*Statistically significant at  $P<.05$ .

Dental Line LTD) to obtain tongue and facial matrices<sup>3,15,36</sup> (Fig. 5). The conditioning material was then replaced by wax using the indices as a guide to ensure that the wax replicated the NZ record. Subsequently, mandibular artificial teeth were arranged (Fig. 6), and flanges were contoured according to the indices. The maxillary teeth were then arranged following a bilaterally balanced occlusal scheme as in the conventional dentures. This was followed by evaluation, denture delivery, and a 1-week follow-up appointment.

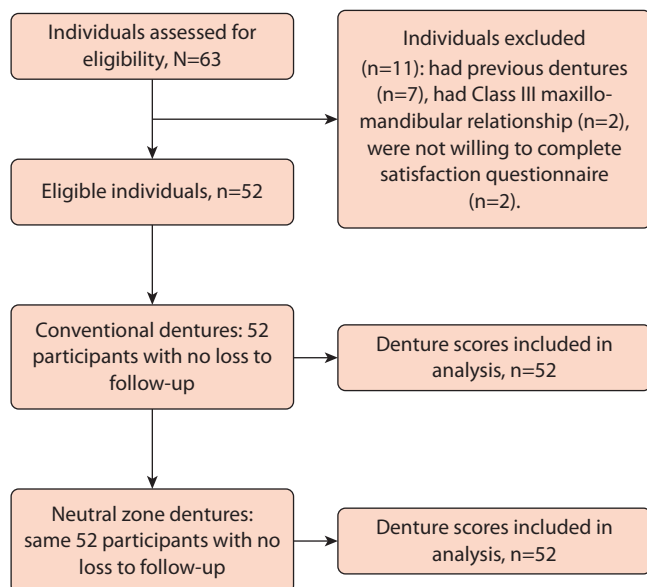
Patient satisfaction was rerecorded after the participants had worn each set for a 6-week period<sup>28</sup> by a blinded prosthodontic staff member (A.A.S.) using a questionnaire. Eleven questions (Table 1) were specifically developed for the most important aspects used to evaluate a prosthesis: esthetics, masticatory efficiency, retention, stability, speech, and comfort.<sup>37,38</sup> Participants were asked to grade their dentures on each aspect using a scale from 1 to 5, in which 1 stands for unsatisfactory, 2 for hardly satisfactory, 3 for satisfactory on average, 4 for

very satisfactory, and 5 for excellent.<sup>39</sup> Participants were blinded to their previous scores.

Statistical analysis was performed with software (SPSS v16.0 for Windows; SPSS Inc). Data were collected, tabulated, and statistically analyzed. The Wilcoxon Signed Rank test ( $\alpha=.05$ ) was used to compare the patient satisfaction scores of the 2 denture types.

## RESULTS

All participants attended until the end of the study with no dropouts (Fig. 7). Mean, median, minimum, and maximum values for satisfaction scores are presented in Table 1. For both dentures, the highest satisfaction scores were recorded for question Q5 (soft-food mastication), and the lowest scores were recorded for Q3 (hard-food mastication). The second highest scores for the NZ dentures were recorded for Q6 (denture retention) and Q10 (patient comfort). However, the second highest scores for the conventional dentures were recorded for Q1 and Q2 (appearance). Patient



**Figure 7.** Study design.

satisfaction scores were significantly higher with the NZ dentures in all aspects.

## DISCUSSION

The results of the study led to rejection of the null hypothesis as patient satisfaction scores were significantly higher in all aspects with the NZ dentures. Satisfaction with dental prostheses is multifactorial, involving technical, patient-dentist interactions<sup>1,40</sup> and patient-related variables, such as age,<sup>40</sup> sex,<sup>40</sup> educational level,<sup>40</sup> patient adaptability,<sup>1</sup> and period of denture use.<sup>40</sup> To exclude the impact of these variables, this research was designed as a within-subject crossover study where both denture types were fabricated for the same participant. This also excluded the potential impact of other patient-related factors such as period of edentulism and condition of the denture foundation area.<sup>1</sup> To exclude technical variables, all the laboratory procedures were performed by a single technician in the same laboratory. All the clinical steps were carried out by the same 2 calibrated clinicians to exclude clinician-related variables, such as the clinician's technical skill<sup>1</sup> and conduct,<sup>40</sup> and clinician-patient relationship.<sup>40</sup> The results obtained should be solely related to tooth arrangement (NZ versus conventional).

Generally, all participants were more satisfied with their NZ dentures in all aspects. Significantly, higher scores were recorded for Q6 (denture retention), Q10 (patient comfort), and Q7 (denture stability). Such findings were consistent with previous studies that reported that their participants subjectively felt that NZ dentures were more stable, retentive, and comfortable with minimum post insertion problems.<sup>9,15,17,33</sup> Feeling more

comfortable with the NZ dentures could be explained because the polished surfaces of the mandibular denture were contoured and designed to conform to the shape of the tongue, lips, and cheeks. The artificial teeth were positioned in the zone of muscle balance. The dentures were designed to harmonize with the surrounding musculature, not only during rest but also during function, providing better stability and retention. This favorable, mutual denture-musculature relationship also eliminated pain-induced discomfort related to cheek/tongue biting and that related to denture instability or looseness, which in turn made the dentures more physically comfortable. The better retention, stability, masticatory efficiency, esthetics, and speech clarity subjectively felt by the participants definitely contributed to their overall psychological comfort.

The significantly higher scores recorded for the capacity to speak with the NZ dentures are supported by an objective assessment conducted by Magaleh et al,<sup>18</sup> who reported that acoustically, speech with NZ dentures was in fact closer to normal than that with conventional ones. Speech is the most accurate and fastest mechanism of the body,<sup>41</sup> and its clarity has been directly related to patient's adaptability.<sup>42</sup> Even a small change in tooth position may affect the pronunciation of some phonemes.<sup>40</sup> Because the NZ represents the most physiological position,<sup>6</sup> it allowed the participants to adapt faster and speak more clearly with their NZ dentures. Moreover, the tongue plays an intricate role in the formation of vowels and consonant sounds.<sup>41</sup> Positioning teeth in the NZ of equilibrium and the harmonious relationship between the denture and the tongue improve speech clarity.

Masticatory ability was significantly higher with the NZ dentures for all types of food. Wright<sup>41</sup> reported that the tongue, teeth, and medial roll of the buccinator muscle are the 3 main structures of importance for mastication. The premolar buccal surface forms a point of fixation for the medial roll of the buccinator. This helps to keep food and saliva inside the mouth during mastication and provides the buccinator with sufficient leverage so that, with the aid of the tongue, it creates a peristaltic movement essential to mastication. The second premolar assists in food mastication while the first molar initiates mastication. He concluded that a harmonious relationship between these 3 structures is essential for receiving and the subsequent mastication of food. Positioning teeth in the NZ achieved this harmonious relationship. Furthermore, the enhanced retention and stability may also have been influential in the participants' masticatory efficiency. As retention increases, EMG amplitudes of masticatory muscles increase, indicating an increase in muscle force which is usually reflected in improved masticatory efficiency.<sup>43</sup> Likewise, enhanced stability decreases denture movements during function, allowing the full power of the masticatory muscles to be directed

toward crushing and grinding the food rather than partly masticating and stabilizing the denture.

Masticatory performance with NZ and conventional dentures was objectively assessed by weighting the amount of peanuts that passed through a sieve after being masticated by the participant.<sup>9</sup> It was 2.47 g for the NZ and 3.28 g for the conventional dentures. Although the conventional dentures showed a statistically better performance, the participants were unable to perceive this difference subjectively. This highlights the fact that objective assessment does not necessarily reflect how participants feel. For both dentures, the highest satisfaction scores were recorded for soft-food mastication and the lowest for hard-food mastication. Regardless of tooth arrangement, masticating hard food using artificial teeth is still challenging and cannot be compared with masticating with a natural dentition.

The NZ lies buccal to the crest of the residual ridge in many individuals, especially for those who have been edentulous for more than 2 years.<sup>10</sup> This might explain the improved esthetics with NZ dentures as they may have provided better lip and cheek support.<sup>15</sup> The second highest scores for the conventional dentures were recorded for Q1 and Q2. This implies that the functionality of these dentures was not as good as the esthetics. This is of concern for most patients, especially the elderly. A stable, retentive, comfortable denture with which they can efficiently masticate is probably more critical for them than being esthetically pleasing.

The results of the present study can be attributed to the harmonious relationship between the NZ denture and its surrounding musculature. Muscles were neither flaccid nor tense, leading to a more comfortable sensation and a more natural appearance, and when they acted during function, they tended to seat rather than displace the denture. This in turn augmented the denture's retention and stability, which was reflected in better masticatory efficiency.

A limitation of this study was that the questions included in the questionnaire have been previously published.<sup>37,38</sup> However, to the best of the authors' knowledge, the repeatability and validity of the questionnaire itself have not been tested. This point needs to be addressed in future research.

## CONCLUSIONS

Within the limitations of this clinical crossover study, the following conclusion was drawn:

1. Neutral zone dentures offer significantly higher patient satisfaction levels in all functional aspects (retention, stability, masticatory ability, and speaking) as well as in comfort levels and appearance than conventionally fabricated dentures.

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## Noteworthy Abstracts of the Current Literature

### Longitudinal assessment of denture maintenance needs in an overdenture population

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**Purpose.** To evaluate the longitudinal denture maintenance needs of a tooth-supported overdenture population.

**Material and methods.** This prospective cohort study was composed of patients who had received tooth-supported overdentures from 1974 to 1994 in the Department of Prosthodontics, University of Iowa. There were 272 persons with 662 abutments who fulfilled the inclusion criteria. To simplify analysis and reduce the number of confounding variables, only those participants wearing complete maxillary dentures and opposing complete mandibular overdentures supported by teeth #22 and #27 were included in this analysis. The denture maintenance needs of these participants were identified and related to age, gender, length of time wearing overdentures, number of medications, and denture-wearing habits. Descriptive statistics and bivariate analyses were used for the statistical analysis ( $\alpha=0.05$ ).

**Results.** Of the 91 participants (mean age=59.5  $\pm$  10.1 years; 63.7% male) who fulfilled the inclusion criteria at baseline, 48.4% took 1 to 3 medications daily, and 84.6% wore their dentures day and night. The percentages of participants who needed one or more of the following denture treatments were: 91.2% denture base adjustments, 76.9% laboratory processed relines, 61.5% denture remakes, 33% laboratory remount and occlusal adjustment, 22% repaired bases, and 19.8% needed denture teeth replaced. Bivariate analyses indicated that participants who were 65 years and older needed more denture adjustments than patients younger than 65 years ( $P=0.0343$ ). Participants who had worn overdentures for more than 5 years were more likely to require denture remakes ( $P=0.0304$ ). Participants who wore their dentures only during the day were less likely to require repairs ( $P=0.0403$ ). Participants who did not take any medications were significantly less likely to require denture base repairs ( $P=0.0258$ ). For the 35 participants who returned for recalls at all 4 time points, males were more likely to need denture teeth repaired or replaced ( $P=0.0335$ ) and those aged 50 to 64 were more likely to need 2 or more adjustments ( $P=0.0311$ ). No overdenture abutments were lost by the participants in this study.

**Conclusions.** According to the results of this study, age, medication usage, denture-wearing habits, and age of the overdentures were significant factors associated with denture maintenance needs. Persons wearing overdentures need regular recalls, because they have continuing maintenance needs.

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