

# Effect of Mandibular Ridge Height on Patients' Perceptions with Mandibular Conventional and Implant-Assisted Overdentures

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*Purpose:* This study assessed the impact of mandibular ridge height on patients' perceptions of dentures following treatment with a mandibular conventional denture (CD) or an implant-assisted overdenture (IOD). *Materials and Methods:* Evaluation of patient satisfaction in 63 participants was made with original complete dentures and 6 months after treatment completion with new dentures. Twenty-five patients received a new mandibular CD and 38 received a new mandibular IOD. The subjects were divided into 3 subgroups according to ridge height (low, moderate, or high). Two questionnaires with categorical responses were administered. Questionnaire 1 had 13 questions to determine patients' assessment of their original dentures at entry and of their study dentures at 6 months after treatment completion. Questionnaire 2, which was given at 6 months after treatment completion, had 11 questions assessing the change perceived by patients with new dentures compared to their original dentures. *Results:* No significant differences between the 2 groups were found for most of the variables in Questionnaire 1 at either time point or in regard to the difference between time points. The retrospective questionnaire 2 showed the IOD group to have significantly better perceptions than the CD group for improvement in chewing comfort, ability to eat hard foods, eating enjoyment, and denture security. The only effect of ridge height was an interaction with denture treatment for eating enjoyment, where mean improvement with the study denture was significantly less for the moderate ridge height group with the CD. *Conclusion:* The results indicate that patients in all ridge height groups had similar improvement in perceptions of dentures following treatment with either a mandibular CD or IOD and that these perceptions were not dependent on the bone height of the mandibular ridge. *Int J Oral Maxillofac Implants* 2005;20:762-768

**Key words:** complete dentures, implant-supported overdentures, mandibular symphysis height, patient satisfaction

Dental implant therapy has had a major impact on the prosthodontic treatment of the edentulous patient.<sup>1-3</sup> The implant-supported overdenture (IOD) with 2 implants is a relatively simple treatment and has been recommended for edentulous patients dis-

satisfied with conventional dentures (CDs) or having a resorbed mandibular ridge.<sup>4,5</sup> Previously, it has been reported that treatment with an IOD provides greater improvement than a CD for masticatory performance in persons with resorbed mandibular ridges, while little difference in performance was seen with adequate to-good ridges.<sup>5,6</sup> It has been indicated that clinicians should consider the degree of mandibular ridge resorption before recommending IOD therapy to improve the ability to masticate food.

However, evaluation of outcomes of prosthodontic care may include both the objective capacity to masticate and patients' subjective perceptions of the chewing experience. These different methods of assessment may lead to conflicting results when evaluating patients' chewing ability.<sup>7-10</sup> Many investigators who have analyzed patients' subjective reports of denture satisfaction and chewing ability to evaluate IOD treatment have shown improvement in

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patient perceptions of IOD treatment.<sup>11–18</sup> These improvements may be interpreted as contributing to improved quality of life (QOL) with IOD. Since these studies primarily used restrictive samples composed of people dissatisfied with their CD or patients with resorbed mandibular ridges, the benefit of IOD treatment to a broader range of patients is still unclear. Therefore, the aim of this study was to compare the effects of mandibular CD and IOD treatment on patient perceptions of denture satisfaction and function in denture wearers with low, moderate, and high mandibular ridge heights.

## MATERIALS AND METHODS

Detailed descriptions of the study design and methods have been reported previously.<sup>19,20</sup> The study sample consisted of patients who were generally satisfied with their existing prosthesis. For the study, the subjects were randomly assigned to receive either a new CD or a new IOD. Of the 102 subjects enrolled in the original study, 63 (mean age, 66.1 ± 5.5 years old) met the requirements for the present study—They had complete dentures upon entry into the study; they had a standardized cephalometric radiograph at baseline; and they completed testing at baseline with their original dentures and 6 months after treatment completion with their study dentures. On each baseline radiograph, ridge height was measured from the menton to the most superior point of the mandibular symphysis. The 25 participants in the CD group and the 38 participants in the IOD group were classified, based on these radiographic measurements, as having either (1) low (21 mm or less), (2) moderate (between 22 and 27 mm) or (3) high (at least 28 mm) ridge height. Of the 63 patients, 6 CD group subjects and 11 IOD group subjects had low ridge height, 8 CD group subjects and 14 IOD group subjects had moderate ridge height, and 11 CD group subjects and 13 IOD group subjects had high ridge height. The detailed characteristics of each group have been presented previously.<sup>6</sup>

Two questionnaires previously used in outcome studies of conventional dentures, removable and fixed partial dentures, and implant-assisted dentures, were used for assessment of dentures by patients.<sup>19,21,22</sup> Questionnaire 1 had 13 questions which probed patients' perceptions of their chewing function, speaking ability, social life, denture hygiene, self-confidence, and overall satisfaction. It was presented to the subject twice, once upon entry to the study, when it was answered with respect to the patients' original dentures, and once 6 months after treatment completion with study dentures. All ques-

- Question 1.** Do you use your dentures for eating?  
 (1) \_\_\_ I mostly eat with my dentures.  
 (2) \_\_\_ I frequently eat with my dentures.  
 (3) \_\_\_ I occasionally eat with my dentures.  
 (4) \_\_\_ I rarely eat with my dentures.
- Question 2.** Do you experience any discomfort when you chew with your dentures?
- Question 3.** How well can you chew with your dentures?
- Question 4.** Do you enjoy eating with your dentures?
- Question 5.** Do the dentures affect your choice of foods?
- Question 6.** Do you find food particles getting under the dentures?
- Question 7.** Do you feel any difference in the taste of food with your dentures?
- Question 8.** Do the dentures affect your speech?
- Question 9.** Do you experience odor with your dentures?
- Question 10.** Do you experience difficulty cleaning your dentures?
- Question 11.** After cleaning, are you satisfied with the cleanliness of your dentures?
- Question 12.** How secure do you feel with your dentures?
- Question 13.** How satisfied are you with your dentures?

**Fig 1** Questionnaire 1: Questions and example of response choices for patient assessment of original and study dentures.

tions had similar 4-response choices with the exception of overall satisfaction (question 13), which had 6 response choices. The 13 questions, along with the 4 response choices for question 1, are listed in Fig 1. Choices were similarly specified for questions 2 through 12. The 6 response categories for degree of denture satisfaction (question 13) were: completely, moderately, or slightly satisfied and slightly, moderately, or completely dissatisfied.

Questionnaire 2 comprised 11 questions evaluated on 7-point ordinal scale (+3 to -3). Participants rated the degree of change perceived with the study dentures at 6 months after treatment completion compared to the original denture in a retrospective fashion. The first question, with its 7 possible responses, and the remaining 10 questions for this comparative evaluation are given in Fig 2. A positive score indicated the degree of improvement and a negative score the degree of deterioration with study dentures compared to original dentures. A score of 0 was given for no change. An independent and trained interviewer who was not involved in the treatment or examination procedures for study dentures presented both questionnaires. Subjects were not shown their earlier responses to questions (questionnaire 1) when they assessed the study dentures. Subjects were provided the questions and responses on a card to read, while the interviewer read out loud

**Question 1.** How well can you chew with your present denture compared with your previous denture?

- |  | (Score) |
|--|---------|
| (1) ___ Extremely poorer than before             | (-3)    |
| (2) ___ Considerably poorer than before          | (-2)    |
| (3) ___ Slightly poorer than before              | (-1)    |
| (4) ___ The same as before I got the replacement | (0)     |
| (5) ___ Slightly better than before              | (1)     |
| (6) ___ Considerably better than before          | (2)     |
| (7) ___ Extremely better than before             | (3)     |

**Question 2.** Do you feel comfortable when you chew with your present dentures compared with your previous denture?

**Question 3.** What degree of difficulty do you have while eating hard-to-chew foods with your present dentures compared with your previous dentures?

**Question 4.** How have your present dentures affected your choice of foods?

**Question 5.** How much have your present dentures affected your enjoyment of eating?

**Question 6.** How difficult do you find it to clean your present denture compared with your previous denture?

**Question 7.** How satisfied are you with the cleanliness of your present dentures compared with your previous dentures?

**Question 8.** How much odor do you experience from your present denture compared with your previous dentures?

**Question 9.** How often do you experience odor with your present denture compared with your previous dentures?

**Question 10.** How secure do you feel with your present dentures compared with your previous dentures?

**Question 11.** How much have your present dentures affected your pronunciation compared with your previous dentures?

**Fig 2** Questionnaire 2: Questions and sample response choices for patient assessment of perceived functional changes with original and study dentures.

each question and the possible choices, and recorded the response. This interview approach was chosen to assure maximal participation with minimal error due to misunderstanding.

### Statistical Analysis

Two-way analysis of variance (ANOVA) tests with denture type (CD/IOD) and ridge height (low/medium/high) as factors were used to compare the mean responses with study dentures and the mean change in response from original to study denture for each item in response to questionnaire 1 between the 2 treatment groups. These change scores were made by subtracting the response at entry with the original denture from the response posttreatment completion with the study denture. The response to each item in questionnaire 2 was similarly evaluated for differences between the 2 treatment and 3 ridge

height groups with 2-way ANOVA tests. Separate comparisons were made for each item in both questionnaires. A  $P$  value of  $< .05$  was considered statistically significant. No adjustments to the  $P$  value were made for multiple tests. Analysis was completed using the StatView software, version 4.58 for Windows (Abacus Concepts, Piscataway, NJ).

## RESULTS

### Subjects' Perception Scores 6 Months After Treatment (Questionnaire 1)

Comparisons between CD and IOD mean scores for questionnaire 1 6 months after treatment completion were made for participants with low, moderate, and high ridge height (Table 1).

A significant difference was found between the CD and the IOD ( $F = 5.71, P = .02$ ) for food choices, with the IOD group reporting less restriction. The effect of ridge height and the interaction effect with denture type were not significant ( $P > .05$ ). Significant main effects for denture type ( $F = 5.18, P = .03$ ), ridge height ( $F = 8.02, P = .001$ ) and denture type  $\times$  ridge height interaction ( $F = 13.0, P = .001$ ) were seen for speech, because of a large number of CD subjects in the moderate ridge height group reporting poorer speech.

### Change in Response from Original to Study Denture (Questionnaire 1)

The mean changes  $\pm$  SDs between scores with the original dentures and scores 6 months posttreatment with the study dentures for questionnaire 1 items are presented in Table 2. Scores for the low, moderate, and high ridge height groups are presented. Speech was found to differ significantly between ridge groups, with subjects having low ridge height experiencing more improvement than those with moderate or high ridge height ( $F = 5.88; P = .004$ ). A significant interaction between ridge height and denture type ( $F = 6.98, P = .02$ ) for speech is seen with an improvement of 1.8 in the IOD group with low ridge height compared to an improvement of only 0.8 for the CD. The low ridge height group was also found to have significantly greater improvement of perceptions of denture odor ( $F = 5.58, P = .006$ ) and satisfaction with denture cleanliness ( $F = 3.38, P = .03$ ) compared to the moderate and high bone height groups, but there were no interactions with denture type. The greatest change in any category was in overall satisfaction; the change was 2.7 for patients with an IOD with low ridge height, although this was not significantly greater than the improvement of 1.8 seen with new CDs.

**Table 1 Comparisons Between CD and IOD Mean (SD) Responses to Questionnaire 1 6 Months After Treatment Completion**

	Low ridge height		Moderate ridge height		High ridge height	
	CD	IOD	CD	IOD	CD	IOD
	(n = 6)	(n = 11)	(n = 8)	(n = 14)	(n = 11)	(n = 13)
Denture use for eating	1.0 (0.0)	1.0 (0.0)	1.3 (0.7)	1.0 (0.0)	1.0 (0.0)	1.2 (0.6)
Chewing comfort	1.7 (0.8)	1.4 (0.5)	2.1 (1.0)	1.2 (0.6)	1.6 (0.9)	1.5 (0.9)
Chewing ability	1.2 (0.4)	1.3 (0.5)	1.9 (0.8)	1.2 (0.4)	1.5 (0.7)	1.2 (0.4)
Eating enjoyment	1.5 (0.5)	1.3 (0.5)	1.5 (7.6)	1.3 (0.5)	1.3 (0.6)	1.3 (0.6)
Food choices*	1.0 (0.0)	1.4 (0.5)	2.0 (1.2)	1.2 (0.4)	1.4 (0.9)	1.4 (0.7)
Particles get under dentures	2.3 (0.8)	2.9 (0.8)	2.5 (0.8)	2.4 (0.7)	2.3 (0.9)	3.0 (1.1)
Taste of food	1.0 (0.0)	1.0 (0.0)	1.3 (0.7)	1.2 (0.6)	1.2 (0.6)	1.2 (0.4)
Effect on speech <sup>†</sup>	1.3 (0.5)	1.2 (0.4)	2.6 (1.5)	1.1 (0.3)	1.0 (0.0)	1.4 (0.5)
Denture odor	1.0 (0.0)	1.1 (0.3)	1.5 (1.1)	1.1 (0.2)	1.0 (0.0)	1.2 (0.4)
Ease of cleaning dentures	1.2 (0.4)	1.0 (0.0)	1.3 (1.1)	1.2 (0.4)	1.0 (0.0)	1.3 (0.9)
Denture cleanliness satisfaction	1.0 (0.0)	1.0 (0.0)	1.4 (1.1)	1.2 (0.4)	1.2 (0.4)	1.4 (0.7)
Security with denture	1.5 (0.5)	1.2 (0.4)	1.5 (0.9)	1.3 (0.7)	1.2 (0.6)	1.4 (0.7)
Overall satisfaction	1.3 (0.5)	1.2 (0.5)	1.9 (1.0)	1.2 (0.4)	1.8 (1.5)	1.7 (1.5)

\*ANOVA for denture factor ( $F = 5.71, P = .02$ ).

<sup>†</sup>ANOVA for denture factor ( $F = 5.18, P = .03$ ), for ridge height factor ( $F = 8.02, P = .001$ ), for denture  $\times$  ridge height interaction ( $F = 13.0, P = .001$ ).

**Table 2 Comparisons of Mean (SD) Change in Responses from Pretreatment to Posttreatment Questions in Questionnaire 1**

	Low ridge height		Moderate ridge height		High ridge height	
	CD	IOD	CD	IOD	CD	IOD
	(n = 6)	(n = 11)	(n = 8)	(n = 14)	(n = 11)	(n = 13)
Denture use for eating	0.0 (0.0)	0.1 (0.3)	-0.3 (0.6)	0.2 (0.5)	0.3 (0.0)	0.1 (0.3)
Chewing comfort	0.5 (1.3)	1.4 (0.9)	0.5 (1.3)	0.7 (0.9)	0.5 (1.3)	1.2 (1.0)
Chewing ability	0.8 (0.7)	1.1 (1.1)	0.1 (1.1)	0.5 (0.7)	0.2 (1.1)	0.8 (1.1)
Eating enjoyment	0.0 (0.9)	0.9 (1.3)	0.1 (0.8)	0.4 (0.7)	0.3 (1.2)	0.9 (0.9)
Food choices	0.8 (0.9)	1.0 (1.3)	0.0 (1.4)	1.0 (0.8)	0.5 (1.6)	0.9 (1.4)
Particles get under dentures	-0.2 (1.3)	0.4 (1.2)	0.4 (0.5)	0.5 (1.0)	-0.1 (1.3)	-0.1 (1.2)
Taste of food	0.2 (0.4)	0.4 (0.9)	-0.1 (0.8)	0.1 (0.5)	-0.1 (0.3)	0.1 (0.5)
Effect on speech*	0.8 (0.7)	1.8 (0.4)	-0.6 (1.1)	0.2 (0.8)	0.1 (0.3)	0.0 (0.0)
Denture odor <sup>†</sup>	1.0 (0.6)	0.6 (0.9)	-0.3 (1.2)	0.2 (0.7)	0.2 (0.4)	0.0 (0.4)
Ease of cleaning dentures	0.0 (0.6)	0.1 (0.3)	-0.1 (0.7)	-0.1 (0.3)	0.0 (0.0)	-0.2 (0.9)
Denture cleanliness satisfaction <sup>†</sup>	0.8 (0.7)	0.4 (0.5)	-0.1 (1.2)	0.4 (0.7)	-0.1 (0.5)	0.0 (0.9)
Security with denture	0.8 (1.5)	1.0 (1.0)	0.1 (0.3)	0.5 (1.1)	0.5 (1.1)	0.9 (1.3)
Overall satisfaction	1.8 (2.1)	2.7 (2.1)	1.6 (1.4)	1.2 (1.5)	1.0 (2.0)	2.1 (2.0)

\*ANOVA for ridge height factor ( $F = 5.88, P = .004$ ), for denture  $\times$  ridge height interaction ( $F = 6.98, P = .02$ ).

<sup>†</sup>ANOVA for ridge height factor ( $F = 5.58, P = .006$ ).

<sup>‡</sup>ANOVA for ridge height factor ( $F = 3.38, P = .03$ ).

### Perceived Change with Study Denture (Questionnaire 2)

The means and SDs for subjects' perceived change with denture treatment (questionnaire 2) for low, moderate, and high ridge height groups are presented in Table 3. The IOD was found to be significantly better than the CD for perceptions of chewing comfort ( $F = 5.61, P = .02$ ), ability to eat hard foods ( $F = 4.15, P = .05$ ), eating enjoyment ( $F = 10.68,$

$P = .02$ ), and security with dentures ( $F = 8.41, P = .005$ ), and no main effects were seen for ridge height. There was a significant interaction between denture type and ridge height for the perception of eating enjoyment ( $F = 3.85, P = .03$ ). The moderate ridge height group with the CD had the lowest mean score (3.7), indicating many found the study denture to be poorer than the original denture for eating enjoyment.

**Table 3 Comparisons of Mean (SD) Change in Responses Following Study Denture Treatment to Questions in Questionnaire 2**

	Low ridge height		Moderate ridge height		High ridge height	
	CD (n = 6)	IOD (n = 11)	CD (n = 8)	IOD (n = 14)	CD (n = 11)	IOD (n = 13)
Chewing ability	6.0 (1.2)	6.0 (1.2)	4.6 (1.7)	6.1 (1.2)	5.5 (2.0)	6.2 (0.9)
Chewing comfort*	5.7 (1.3)	6.1 (1.1)	4.6 (1.7)	6.3 (1.2)	5.5 (1.8)	6.0 (1.3)
Ability to eat hard foods†	5.3 (1.5)	5.8 (1.1)	4.3 (1.9)	6.2 (0.9)	5.4 (1.7)	5.5 (2.2)
Food choices	5.1 (1.3)	5.1 (1.2)	4.2 (1.2)	6.1 (1.2)	5.1 (1.5)	4.6 (1.4)
Eating enjoyment‡	5.0 (1.3)	5.6 (1.3)	3.7 (1.7)	6.2 (1.0)	5.3 (1.2)	5.6 (1.7)
Ease of cleaning dentures	4.5 (0.8)	3.8 (0.8)	4.4 (1.5)	4.3 (1.5)	3.9 (0.3)	5.0 (1.7)
Denture cleanliness satisfaction	5.1 (1.3)	4.5 (1.0)	4.4 (1.9)	5.0 (1.4)	4.5 (1.2)	4.6 (1.7)
Intensity of denture odor	4.8 (1.3)	4.5 (0.7)	4.1 (1.6)	4.8 (1.3)	4.5 (1.0)	4.6 (1.1)
Frequency of denture odor	4.8 (1.3)	4.4 (0.7)	4.2 (1.7)	4.7 (1.3)	4.3 (0.8)	4.3 (0.8)
Security with dentures§	5.7 (1.5)	6.2 (1.2)	4.6 (1.8)	6.5 (0.6)	5.4 (1.4)	5.8 (1.4)
Effect on speech	4.7 (1.0)	4.3 (0.8)	3.8 (1.0)	5.2 (1.5)	4.5 (1.0)	5.0 (1.2)

\*ANOVA for denture factor ( $F = 5.61, P = .02$ ).

†ANOVA for denture factor ( $F = 4.15, P = .05$ ).

‡ANOVA for denture factor ( $F = 10.68, P = .02$ ), for denture  $\times$  ridge height interaction ( $F = 3.85, P = .03$ ).

§ANOVA for denture factor ( $F = 8.41, P = .005$ ).

## DISCUSSION

The results of subjects' changes in perception to study dentures compared to original dentures in each of the ridge height groups (low, moderate, and high) did not show the IOD to have a significant advantage over the CD. This is contrary to previous reports, which have largely shown significant improvements in patient satisfaction with the IOD.<sup>11-18</sup> Most of the previous studies have evaluated the effect of IOD treatment in subjects seeking implant denture treatment because of dissatisfaction with conventional dentures and/or subjects with extremely resorbed ridges who were unable to tolerate conventional dentures. In contrast, the sample selected for the current study included subjects with varying degrees of mandibular ridge resorption, and most were satisfied with existing dentures. Kapur and colleagues<sup>19</sup> indicated that patients dissatisfied with conventional dentures may report greater improvement after treatment with implant therapy compared to a broader sample of denture wearers. If implant overdenture treatment is proposed for the general edentulous population, evaluation of outcomes in a greater range of patient groups is necessary prior to establishing the general treatment benefits of IOD compared to CD therapy.<sup>1,23</sup>

Based on the previous results of objective capacity to chew,<sup>5,6</sup> it was initially thought that edentulous patients with extremely resorbed mandibular ridges would have greater perceived improvement in satisfaction with the IOD compared to the CD. Although there was a significant interaction of ridge height and denture type for eating enjoyment with the retrospective questions (questionnaire 2), in general,

the perceptions of dentures following treatment with either the mandibular CD or IOD were similar for the 2 denture groups and were not dependent on the bone height of the mandibular ridge. This may be the result, in part, of the relatively small sample size and also of the differences between objective and subjective methods of assessment. Clearly, the relatively small number of subjects in each denture group, which was then split further into 3 additional groups according to the degree of mandibular ridge height, and the high variability associated with patient satisfaction scores between individuals present a problem with statistical power.<sup>6</sup> For example, simulated power estimates (Simpower procedure with 3000 repetitions, STATA Release 8.0, STATA, College Station, TX) were developed for key items related to chewing, security, and satisfaction for both questionnaires, based on the observed data. Power for rejecting the hypothesis of equal cell means with the ANOVA tests ranged from 15% to 66% for questionnaire 1 and from 55% to 75% for questionnaire 2. Even if mean differences between groups are simulated to be 1 point (likely to be a clinically meaningful difference), the large SDs lead to little change in power. In addition, multiple tests were performed on questionnaire items that are likely to be related, and there is an increased chance that spurious significant differences may be found. While the small sample size, limited statistical power, and use of multiple statistical tests on related data in the current study may limit generalization of the results, they provide an initial indication that differences in perceived satisfaction with conventional and overdenture therapy may not be great in a population of "average" denture



wearers. In addition, the results will be helpful for guiding future studies directed at a more definitive evaluation of these subgroups.

Generally, functional outcomes of denture treatment have been evaluated by assessing the subject's subjective perceptions and using objective tests of masticatory capability. However, these 2 methods of assessment frequently do not agree.<sup>7,8</sup> Interestingly, subjective assessments by patients are more frequently used, partly because of their simplicity, low cost, and lack of need for special equipment, and because of the desire to evaluate psychosocial factors.<sup>24</sup> These subjective evaluations often utilize 2 different types of questionnaires, similar to the 2 employed in this study. Questionnaire 1 provided longitudinal data to measure change in perceptions by asking patients to assess function and satisfaction at single points in time, separately before and after treatment. In contrast, questionnaire 2 was a comparative questionnaire that required subjects to recall their experience with original dentures and rate the change that occurred with the study denture.

In this study, comparisons failed to show significant differences between the 2 denture groups in regard to their scores with original and study dentures, and in regard to the change in scores (treatment effect) across ridge height groups for most of the 13 variables in questionnaire 1. In contrast, when subjects were asked to retrospectively compare their study denture with the original denture in questionnaire II, those with the IOD perceived greater improvement with study dentures for 4 questions (chewing comfort, ability to eat hard foods, eating enjoyment, and security with dentures) compared to those with the CD. This may indicate problems with questionnaires that are dependent on significant recall for comparative evaluations, as subjects' recall for the previous conditions may be unreliable<sup>18</sup> and the effects of significant "cost" to the subject in terms of surgery and time may produce a differential expectation for outcome between CD and IOD groups. The results of questionnaire 2 should be interpreted with caution because of this limitation.

## CONCLUSION

It was previously reported that treatment with a mandibular IOD improves masticatory performance only in persons with less than adequate mandibular ridge. The current study suggested that mandibular IODs and CDs offer similar advantages in terms of improvement in patient perceptions, irrespective of mandibular ridge height. Taken together, the results of these 2 studies indicate that patients with

adequate mandibular ridge height are likely to experience similar improvement whether they are treated with mandibular IODs or CDs, in both objective function and subjective perceptions of function and satisfaction. Thus, an IOD with 2 anterior implants may not provide significant benefit compared to a new CD in terms of satisfaction and chewing function in edentulous patients having adequate ridge height in mandible. Within the limitations of this study, subjects reported similar improvements in perceptions of dentures following treatment with either a mandibular CD or IOD, and these perceptions were not dependent on the bone height of the mandibular ridge.

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## REFERENCES

1. Brånemark P-I, Svensson B, van Steenberghe D. Ten-year survival rates of fixed prostheses on four or six implants ad modum Brånemark in full edentulism. *Clin Oral Implants Res* 1995;6:227-231.
2. Mericske-Stern R. Treatment outcomes with implant-supported overdentures: Clinical considerations. *J Prosthet Dent* 1998;79:66-73.
3. Balshi TJ, Wolfinger GJ, Bashi SF II. Analysis of 356 pterygomaxillary implants in edentulous arches for fixed prosthesis anchorage. *Int J Oral Maxillofac Implants* 1999;14:398-406.
4. Fontijn-Tekamp FA, Slagter AP, Van Der Bilt A, et al. Biting and chewing in overdentures, full dentures, and natural dentition. *J Dent Res* 2000;79:1519-1524.
5. Geertman ME, Slagter AP, van Waas MAJ, Kalk W. Comminution of food with mandibular implant-retained overdentures. *J Dent Res* 1994;73:1858-1864.
6. Kimoto K, Garrett NR. Effect of mandibular ridge height on masticatory performance with mandibular conventional and implant-assisted overdentures. *Int J Oral Maxillofac Implants* 2003;18:523-530.
7. Gunne HSJ, Bergman B, Enbom L, Hogstrom J. Masticatory efficiency of complete-denture patients—A clinical examination of potential changes at the transition from old to new dentures. *Acta Odontol Scand* 1981;40:289-297.
8. Slagter AP, Olthoff LW, Steen WH, Bosman F. Comminution of food by complete-denture wearers. *J Dent Res* 1992;71:380-386.
9. Helkimo E, Carlsson GE, Helkimo M. Chewing efficiency and state of dentition. A methodologic study. *Acta Odontol Scand* 1978;36:33-41.
10. Slagter AP, Olthoff LW, Bosman F, Steen WHA. Masticatory ability, denture quality, and oral conditions in edentulous subjects. *J Prosthet Dent* 1992;68:299-307.

11. Boerrigter EM, Geertman ME, Van Oort RP, et al. Patient satisfaction with implant-retained mandibular overdentures. A comparison with new complete dentures not retained by implants—A multicentre randomized clinical trial. *Br J Oral Maxillofac Surg* 1995;33:282–288.
12. Geertman ME, van Wassen MAJ, van't Hof MA, Kalk W. Denture satisfaction in a comparative study of implant-retained mandibular overdentures: A randomized clinical trial. *Int J Oral Maxillofac Implants* 1996;11:194–200.
13. Bouma J, Boerrigter LM, van Oort RP, van Sonderen E, Boering G. Psychosocial effects of implants-retained overdentures. *Int J Oral Maxillofac Implants* 1997;12:515–522.
14. Geertman ME, Slagter AP, van Waas MAJ, Kalk W. Masticatory performance and chewing experience with implant-retained mandibular overdentures. *J Oral Rehabil* 1999;26:7–13.
15. Meijer HJA, Raghoebar GM, van't Hof MA, Geertman ME, Van Oort RP. Implant-retained mandibular overdentures compared with complete dentures; A 5-years' follow-up study of clinical aspects and patient satisfaction. *Clin Oral Implants Res* 1999;10:238–244.
16. Raghoebar GM, Meijer HJA, Stegenga B, van't Hof MA, van Oort RP, Vissink A. Effectiveness of three treatment modalities for the edentulous mandible. A five-year randomized clinical trial. *Clin Oral Implants Res* 2000;11:195–201.
17. Awad MA, Locker D, Korner-Bitensky N, Feine JS. Measuring the effect of intra-oral implant rehabilitation on health-related quality of life in a randomized controlled clinical trial. *J Dent Res* 2000;79:1659–1663.
18. Allen PF, McMillan AS, Walshaw D. A patient-based assessment of implant-stabilized and conventional complete dentures. *J Prosthet Dent* 2001;85:141–147.
19. Kapur KK, Garrett NR, Hamada MO, et al. A randomized clinical trial comparing the efficacy of mandibular implant-supported overdentures and conventional dentures in diabetic patients. Part III: Comparisons of patient satisfaction. *J Prosthet Dent* 1999;82:416–427.
20. Garrett NR, Kapur KK, Hamada MO, et al. A randomized clinical trial comparing the efficacy of mandibular implant-supported overdentures and conventional dentures in diabetic patients. Part II. Comparisons of masticatory performance. *J Prosthet Dent* 1998;79:632–640.
21. Kapur KK. Veterans administration cooperative dental implant study comparisons between fixed partial dentures supported by blade-vent implants and removable partial dentures. Part IV: Comparisons of patient satisfaction between two treatment modalities. *J Prosthet Dent* 1991;66:517–529.
22. Garrett NR, Kapur KK, Perez P. Effects of improvements of poorly fitting dentures and new dentures on patient satisfaction. *J Prosthet Dent* 1996;76:403–413.
23. Locker D. Patient-based assessment of the outcome of implant therapy: A review of the literature. *Int J Prosthodont* 1998;11:453–461.
24. Boretti G, Bickel M, Geering AH. A review of masticatory ability and efficiency. *J Prosthet Dent* 1995;74:400–403.