Effect of Mandibular Ridge Height on Masticatory Performance with Mandibular Conventional and Implant-assisted Overdentures

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Purpose: *This study assessed the impact of mandibular bone height on masticatory performance following treatment with a mandibular conventional denture (CD) or implant-retained overdenture (IOD).* ***Materials and Methods:*** *Evaluation of masticatory performance in 63 participants was made with original CDs and 6 months after treatment completion with new dentures; 25 patients received a mandibular CD and 38 received a mandibular IOD. Anterior ridge height at the mandibular symphysis was determined on lateral cephalograms to provide subgroups of low (≤ 21 mm), moderate (> 21 mm, < 28 mm), and high (≥ 28 mm) ridge height for both CDs and IODs. Masticatory performance tests on the preferred chewing side (PS) and swallowing threshold tests were made with peanuts and carrots.* ***Results:*** *Analysis of variance was used for comparisons of mean change in performance after treatment with study dentures for the 3 bone height groups; this indicated significant differences between the CD and IOD for PS masticatory performance with peanuts (P = .05) and carrots (P = .03). Post hoc tests found significant mean differences between the CDs and IODs with peanuts (P = .008) and carrots (P = .01) only in the low bone height group. Although no significant differences were found in swallowing threshold performance, the mean change scores for subjects with low bone height were greater with the IODs than those with CD for swallowing threshold performance, strokes, and time.* ***Discussion:*** *It is suggested that only in patients with advanced ridge resorption is the mandibular IOD more likely than a CD to result in improvements in masticatory performance.* ***Conclusion:*** *The study indicated that treatment with a mandibular IOD may improve masticatory performance only in persons with a less than adequate mandibular ridge.* (INT J ORAL MAXILLOFAC IMPLANTS 2003;18:523–530)

Key words: *complete denture, dental implants, mandibular symphysis, mastication, masticatory force, overdenture*

Edentulous patients with a severely resorbed mandibular ridge often experience difficulty with denture adaptation and chewing and frequently report dissatisfaction with conventional dentures (CDs).[1,2] While it has been reported that these problems may be successfully managed using fixed prostheses supported by implants,[3,4] it is more common for an implant-assisted mandibular overdenture (IOD) to be recommended for patients who were dissatisfied with or had difficulty adapting to CDs.[5,6] Among the stated advantages of IODs are the ability to provide facial support in the presence of advanced alveolar ridge resorption, the use of relatively few implants for support, reasonable treatment cost, and easy removal by the patient for abutment and prosthesis hygiene.[7,8]

Generally, one of the most frequent reasons that patients request a change from a CD to an IOD is to improve chewing ability.[6,9–12] While denture wearers report perceptions of increased chewing ability after restoration with an IOD,[5,6,9,10,13] it has been shown that similar perceptions of increased chewing ability may be seen for subjects receiving a new CD.[13] However, these patient perceptions of function with CDs and IODs do not generally agree

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with their actual ability to masticate food.[13] Objective tests of masticatory function are utilized to verify whether a denture treatment is actually changing patient function. However, it is not clear from the results of studies of chewing function what conditions are required for improved mastication to be achieved with IOD therapy.[11,12,14]

In a randomized controlled clinical trial (RCT) of CD wearers before and after receiving a new maxillary CD with either a mandibular CD or IOD in patients who expressed satisfaction with their original CD and/or had an adequate mandibular ridge, no significant improvement in masticatory performance was seen 6 months after treatment with either a CD or an IOD.[14] However, a similar RCT comparing CD and IOD treatment in patients who expressed strong dissatisfaction with their original CD and/or had a severely resorbed mandibular ridge found significant improvement in masticatory performance with the mandibular IOD compared to the CD.[11]

Recently, it was found in a cross-sectional study[12] that persons with adequate mandibular ridge height who received a new CD performed better than those with low ridge height who received an IOD. Additionally, subjects with low ridge height and a CD performed more poorly than similar patients with an IOD. These reports suggest that the height of the mandibular ridge may influence the relative effectiveness of treatment with a mandibular CD and an IOD to improve masticatory function.

The aim of this study was to evaluate the effect of mandibular bone height on masticatory performance (MP) following treatment with a mandibular CD or IOD. Specifically, it is hypothesized that denture wearers with low mandibular bone height will have greater improvement in masticatory function following treatment with a mandibular IOD compared to a CD. Additionally, it is hypothesized that subjects with adequate to good mandibular bone height will have no change in performance with either denture treatment. These results may provide guidance in the identification of patients most likely to have a significant improvement in chewing function with IOD therapy.

MATERIALS AND METHODS

An extensive RCT was undertaken to compare treatment success rates, functional and perceptual outcomes, and cost of care with mandibular CDs (CD group) and IODs (IOD group) in denture wearers with diabetes treated with insulin (IT) or without insulin (NIT). The detailed study design, methodology, and number of outcomes have been reported previously.[13–16] Briefly, all subjects were evaluated at entry with their original dentures and were then randomly assigned to receive new CDs with either a CD or IOD in the mandible. The IOD had plastic clip retainers for a Hader bar that connected 2 IMZ implants (Interpore International, Irvine, CA) placed in the right and left canine areas. Nonanatomic 0-degree acrylic resin teeth were used to establish a monoplane occlusal plane without any incisal guidance and ramps for eccentric balance. Of the 89 patients who received study dentures, 63 with CDs at entry into the study completed testing at baseline with their original dentures and 6 months after treatment completion with study dentures. Each received a standardized cephalometric radiograph. The 25 participants in the CD group and the 38 in the IOD group were classified using the cephalogram into 3 levels of mandibular symphyseal bone height according to the following criteria:

1. Low ridge height of ≤ 21 mm (CD, n = 6; IOD, n = 11)
2. Moderate ridge height of > 21 mm but < 28 mm (CD, n = 8; IOD, n = 14)
3. High ridge height of ≥ 28 mm (CD, n = 11; IOD, n = 13)

According to Cawood and Howell's classification,[17] low ridge height is equivalent to Class V and VI, moderate ridge height is Class III and IV, and high ridge height is Class I and II (Figs 1a to 1c).

Measures of age, general health characteristics, and clinical quality of the denture and denture-bearing tissues were made at baseline with the original dentures, prior to new denture fabrication. A general rating of the denture-supporting tissue was made from the combination of ratings of the maxillary and mandibular ridge shape on a 4-point scale and tissue resiliency and tissue attachment on 3-point scales. A total score of 13 or less indicated that the tissue support was poor, 14 to 17 fair, and 18 to 20 good. Denture quality was established from a combined rating of stability and retention on 4-point scales and vertical and horizontal interocclusal relationships on 3-point scales for both the maxilla and mandible. Dentures with a total score of 14 or less were judged as poor, between 15 and 18 were fair, and 19 and 22 were good.[16,18]

Standardized MP tests on the preferred side (PS) and swallowing threshold (SWT) tests with peanuts and carrots were made at entry with the original dentures and 6 months after treatment with the study dentures. The reliability and validity of these tests have been established in previous studies.[19–21] Patients were asked at entry to identify their

Figs 1a to 1c *Cephalometric radiographs with examples of the Cawood and Howell classification of mandibular symphyseal bone height.* [17]

Fig 1a Patient with low ridge height (ie, ≤ 21 mm, Class V and VI) (CD, n = 6; IOD, n = 11 in this study population).

Fig 1b Example of moderate ridge height (> 21 mm and < 28 mm, Class III and IV) (CD, n = 8; IOD, n = 14 in this study population).

Fig 1c High ridge height (≥ 28 mm, Class I and II) (CD, n = 11; IOD, n = 13 in this study population).

preferred chewing side for all PS tests. Three portions of 3 g of peanuts or carrots were used for each test. For PS tests, each portion of peanuts was chewed for 20 strokes and carrots for 40 strokes on the subject's preferred chewing side. For SWT tests, participants were instructed to chew normally until ready to swallow, without regard to side or number of chewing strokes. For both PS and SWT tests, the retrieved chewed food was combined for all 3 portions of a test, and then a gravimetric sieving method was used to determine the volumes of particles finer and coarser than a US standard #12 mesh screen (1.7 mm opening) for peanuts and US standard #5 mesh screen (4.0 mm opening) for carrots. The ratio of the fine particles to total volume recovered, expressed as a percentage, provided the MP score.

In addition to the performance scores of the PS and SWT tests, the number of chewing strokes and chewing time in seconds were recorded for all SWT tests. Change scores (6-month score minus entry score) were calculated for all PS and SWT measures to evaluate the effect of treatment. Thus, the change scores represent the difference in performance following treatment with the new CD or IOD compared to the original denture.

Statistical Analysis

Comparisons of selected characteristics at entry between the CD and IOD groups and denture quality at baseline and 6 months after treatment completion were evaluated with Mann-Whitney *U* tests. Comparisons of the mean change scores for PS and SWT performances and SWT time and strokes were evaluated separately with 2×3 analyses of variance (ANOVAs) (denture group [CD/IOD] × bone height [low/moderate/high]). When an ANOVA F

Table 1 Comparison of Patient Characteristics with Low, Moderate, and High Mandibular Symphyseal Bone Height at Entry (Mean and SD) with Original CD

	CD	IOD	*P* value*
Low bone height (CD, n = 6; IOD, n = 11)			
Age (y)	65.8 (5.8)	69.2 (4.1)	.18
Height (inches)	65.5 (3.7)	66.5 (2.9)	.51
Weight (lb)	172.6 (21.5)	180.1 (36.9)	.63
Max dent exp (y)	28.8 (12.0)	23.6 (10.4)	.36
Mand dent exp (y)	18.2 (9.3)	26.3 (16.6)	.28
Tissue support†	13.0 (3.2)	12.7 (2.0)	.16
Denture quality‡	10.7 (2.4)	13.3 (2.8)	.85
Anterior mand bone height (mm)	16.3 (4.2)	19.1 (1.8)	.08
Posterior mand bone height (mm)	15.9 (4.1)	17.9 (2.2)	.21
Moderate bone height (CD, n = 8; IOD, n = 14)			
Age (y)	64.3 (5.5)	69.3 (4.1)	.69
Height (inches)	67.9 (4.3)	66.5(2.9)	.46
Weight (lb)	182.5 (39.4)	180.8 (36.9)	.92
Max dent exp (y)	23.2 (12.3)	23.6 (10.4)	.49
Mand dent exp (y)	21.4 (10.1)	26.4 (16.6)	.23
Tissue support†	13.9 (2.6)	12.2 (2.0)	.07
Denture quality‡	15.4 (2.6)	13.3 (2.8)	.13
Anterior mand bone height (mm)	24.4 (2.0)	24.1 (1.8)	.72
Posterior mand bone height (mm)	23.0 (2.3)	17.9 (2.2)	.89
High bone height (CD, n = 11; IOD, n = 13)			
Age (y)	62.0 (8.4)	66.0 (4.6)	.15
Height (inches)	68.0 (3.9)	68.3 (3.5)	.87
Weight (lb)	187.6 (31.1)	188.6 (41.6)	.95
Max dent exp (y)	16.2 (14.6)	13.2 (11.8)	.57
Mand dent exp (y)	12.7 (15.6)	6.8 (3.5)	.24
Tissue support†	17.4 (2.1)	16.5 (2.6)	.36
Denture quality‡	16.6 (4.1)	14.4 (2.8)	.12
Anterior mand bone height (mm)	31.2 (2.7)	32.9 (3.3)	.19
Posterior mand bone height (mm)	29.9 (3.2)	31.6 (3.5)	.22

*Mann-Whitney test.
†Tissue support: combined rating of ridge shape (4-point scale), tissue resiliency (3-point scale), and tissue attachment (3-point scale) of maxillary and mandibular jaws, range 6 to 20.
‡Denture quality: combined rating of stability (4-point scale), retention (4-point scale), and vertical and horizontal interocclusal relationships (3-point scale) of maxillary and mandibular dentures, range 6 to 22.

ratio was statistically significant, post hoc comparisons of specific bone height groups were made with Scheffe's test. A *P* value of less than .05 was considered significant. Statistical tests were completed using StatView software (version 4.58 for Windows; SAS Institute, Cary, NC).

RESULTS

Comparison of Patient Characteristics at Entry

Comparisons of selected variables for general and orofacial health characteristics at entry were made for participants with low bone height, moderate bone height, and high bone height (Table 1). The sample population ranged in age from 48 to 77 years (mean 65.5 ± 6.4 years), in maxillary denture experience from 0.3 to 43.5 years (mean 19.7 ± 12.9 years), and in mandibular denture experience from 0.3 to 43.5 years (mean 15.6 ± 12.2 years). Tissue support for dentures was rated poor in 49.2% of the 63 patients, fair in 33.3% of the patients, and good in 17.5% of the patients. The quality of the original denture was rated as poor in 54.0% of patients, fair in 34.9% of patients, and good in 11.1% of the 63 patients.

Masticatory Performance at Entry

Mean MP at entry with original dentures was similar for the subjects in the CD and IOD groups, as shown in Fig 2a for PS performance, Fig 2b for SWT performance, Fig 2c for SWT strokes, and Fig 2d for SWT time. Mean PS performance for the total sample was 38.2 ± 14.4% for peanuts; ANOVA showed no significant difference between the denture groups

Figs 2a to 2d *Comparisons of CD and IOD group mean scores (at entry with original dentures) for denture wearers with low, moderate, and high mandibular symphyseal bone height.*

Fig 2a Preferred-side masticatory performance (ANOVA comparison of peanuts PS performance: F = 1.77, *P* = .18; ANOVA comparison of carrots PS performance: F = 1.53, *P* = .21).

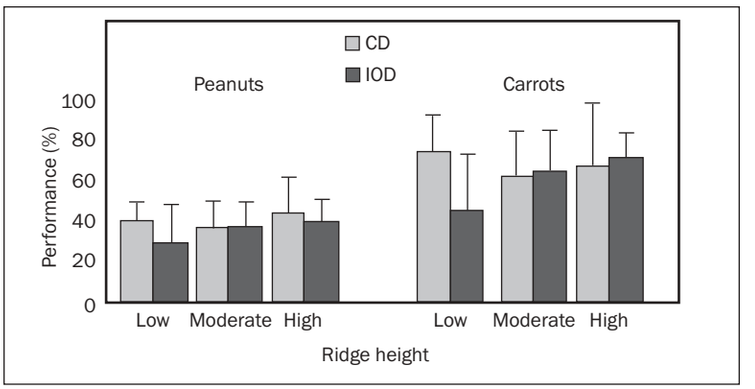

Fig 2b Swallowing threshold performance (ANOVA comparison of peanuts SWT performance: F = 0.54, *P* = .46; ANOVA comparison of carrots SWT performance: F = 0.15, *P* = .69).

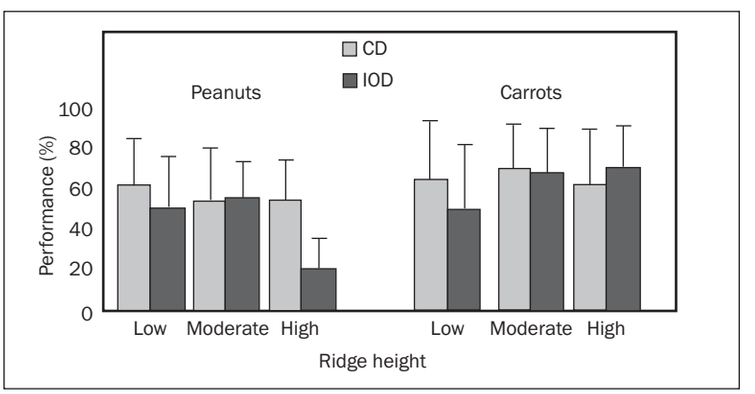

Fig 2c Chewing strokes for swallowing threshold performance (ANOVA comparison of peanuts SWT strokes: F = 0.003, *P* = .95; ANOVA comparison of carrots SWT strokes: F = 2.31, *P* = .10).

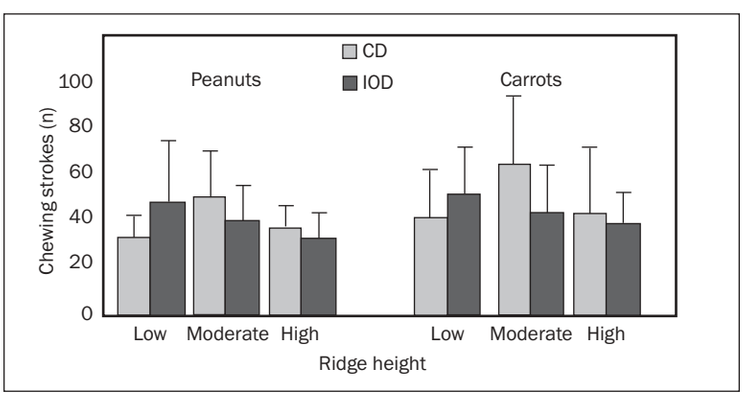

Fig 2d Chewing time for swallowing threshold performance (ANOVA comparison of peanuts SWT time: F = 1.80, *P* = .17; ANOVA comparison of carrots SWT time: F = 0.25, *P* = .77).

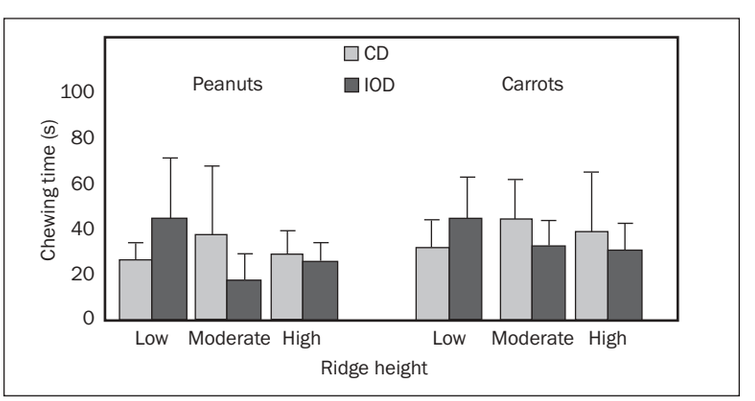

Table 2 Comparisons Between CD and IOD Groups of Clinical Quality of Study Dentures

	CD	IOD	*P* value*
Low bone height			
Maxillary stability	3.3	3.7	.36
Maxillary retention	3.8	4.0	.58
Mandibular stability	3.5	3.8	.29
Mandibular retention	1.7	4.0	.009
Centric occlusion	2.3	2.5	.51
Vertical dimension	2.2	2.5	.22
Moderate bone height			
Maxillary stability	4.0	3.8	.65
Maxillary retention	3.8	3.8	.77
Mandibular stability	3.3	4.0	.08
Mandibular retention	2.2	4.0	.003
Centric occlusion	2.5	3.0	.23
Vertical dimension	2.5	3.0	.23
High bone height			
Maxillary stability	4.0	3.7	.79
Maxillary retention	4.0	3.8	.86
Mandibular stability	4.0	3.8	.75
Mandibular retention	3.0	4.0	.008
Centric occlusion	3.0	2.8	.75
Vertical dimension	3.0	2.8	.75

*Mann-Whitney test.

(F = 1.77; *P* = .18) or between bone height groups (F = 1.41; *P* = .25), or in the interaction between denture groups and bone height (F = 0.74; *P* = .47). ANOVAs for PS performance with carrots and SWT tests with both also found no significant difference between denture groups (F values from 0.03 to 1.54; *P* values from .21 to .95) or bone height groups (F values from 0.64 to 2.44; *P* values from .11 to .93), or in the interaction between groups (F values from 0.45 to 3.27; *P* values from .06 to .64).

Comparison of Quality of Study Dentures

The mean rating for quality of study dentures is shown in Table 2 for low, moderate, and high bone height. The CD and IOD study dentures at 6 months after treatment completion were comparable for most measures. Mann-Whitney *U* tests showed that significant mean differences between the 2 denture groups existed only for the retention score of mandibular dentures, in favor of IODs, in all 3 bone height groups (*P* = .009 for low, *P* = .003 for moderate, *P* = .008 for high). The mean differences for other denture measures were not statistically significant (*P* ≥ .08).

Posttreatment Changes in Masticatory Scores

The mean change scores and standard deviations (6 months minus entry) are presented in Table 3a for PS performances, Table 3b for SWT performances, Table 3c for SWT strokes, and Table 3d for SWT time. ANOVA for 3 different bone height groups indicated that the mean difference between the CD and IOD groups was significant for PS performances with peanuts (F = 3.77, *P* = .05) and carrots (F = 4.89, *P* = .03). Post hoc tests showed that significant mean differences between the 2 denture groups existed in subjects with low bone height with peanuts (*P* = .008) and carrots (*P* = .01). No significant differences were seen in post hoc comparisons of study dentures in subjects with moderate and high bone height with either test food (*P* values ranged from .38 to .76).

No significant differences were found for SWT performance, SWT times, and SWT strokes with peanuts or carrots for either type of denture (F values ranged from 0.99 to 1.53 and *P* values from .22 to .91), bone height (F values ranged from 0.01 to 1.22 and *P* values from .27 to .99), or interaction (F values ranged from 0.22 to 2.48 and *P* values from .09 to .74). However, the mean change scores in the low bone height group with IODs were greater than those with CD for all SWT measures.

DISCUSSION

Epidemiologic studies have indicated that the rate of edentulousness in various populations worldwide ranges from 14% to 48% in persons 65 years of age and older.[22] A high percentage (10% to 30%) of edentulous patients complain of difficulty with their CDs, including oral pain, instability, and the inability to chew.[2,23,24] When planning treatment for patients with problems adapting to CDs, 3 options are generally considered: *(1)* if the patient has mandibular bone height of at least 15 mm at the anterior symphysis, fabrication of a new CD; *(2)* if mandibular bone height is inadequate, fabrication of a new denture following preprosthetic surgery to enhance the denture-bearing tissues; and *(3)* fabrication of fixed prostheses or IODs supported by implants.[25]

The use of an IOD in the mandible has increased dramatically in recent years because of reduced clinical time and financial expense compared to fixed prostheses.[8,25,26] However, controlled clinical trials comparing CDs and IODs[11,12,14] have indicated that some functional benefits of the IOD may be specific only to select groups of denture patients. While previous studies indicated that only persons with relatively low mandibular ridge height will have greater MP when restored with an IOD compared to a CD, the study design did not permit the determination of initial equivalency in MP of the groups prior to treatment with the CD or IOD.

Table 3a Mean Changes (SDs) in PS Masticatory Performance (6 Months Minus Entry) by Denture Type and Bone Height

Bone height group	Mean change (%)		
	CD	IOD	*P* value*
Peanuts			
Low	–4.2 (8.4)	9.8 (9.4)	.008
Moderate	2.3 (9.7)	3.9 (13.5)	.76
High	–4.0 (19.6)	3.0 (19.5)	.38
Carrot			
Low	–15.0 (31.2)	24.1 (27.0)	.01
Moderate	16.5 (18.6)	13.5 (25.1)	.76
High	4.8 (26.8)	11.4 (18.6)	.49

*Scheffe's test.
ANOVA comparison for peanuts: F = 3.77, *P* = .05. ANOVA comparison for carrot: F = 4.89, *P* = .03.

Table 3b Mean Changes (SDs) in SWT Performance (6 Months Minus Entry) by Denture Type and Bone Height

Bone height group	Mean change (%)		
	CD	IOD	*P* value*
Peanuts			
Low	–7.3 (16.0)	6.3 (17.0)	.12
Moderate	12.4 (24.9)	5.7 (17.0)	.69
High	3.2 (15.7)	11.2 (13.0)	.19
Carrot			
Low	1.6 (25.5)	22.8 (25.7)	.12
Moderate	13.9 (16.2)	8.0 (17.9)	.43
High	16.8 (24.0)	10.7 (16.1)	.47

*Scheffe's test.
ANOVA comparison for peanuts: F = 1.22, *P* = .27. ANOVA comparison for carrot: F = 0.35, *P* = .57.

Table 3c Mean Changes (SDs) in Chewing Strokes for SWT Performance (6 Months Minus Entry) by Denture Type and Bone Height

Bone height group	Mean change (strokes)		
	CD	IOD	*P* value*
Peanuts			
Low	3.4 (4.8)	–13.6 (19.4)	.06
Moderate	0.7 (15.6)	4.0 (17.3)	.65
High	0.2 (22.6)	7.1 (13.2)	.36
Carrot			
Low	2.0 (15.1)	–13.6 (18.4)	.09
Moderate	1.3 (29.4)	–2.2 (11.2)	.67
High	–6.7 (36.9)	–0.5 (12.5)	.57

*Scheffe's test.
ANOVA comparison for peanuts: F = 0.078, *P* = .78. ANOVA comparison for carrot: F = 0.96, *P* = .38.

Table 3d Mean Changes (SDs) in Chewing Time for SWT Performance by Denture Type and Bone Height

Bone height group	Mean change (s)		
	CD	IOD	*P* value*
Peanuts			
Low	3.3 (4.9)	–13.0 (19.4)	.15
Moderate	0.6 (15.6)	3.9 (17.4)	.56
High	0.2 (22.7)	7.1 (13.2)	.45
Carrot			
Low	–2.7 (12.6)	–6.4 (26.7)	.75
Moderate	–8.7 (30.2)	–2.7 (17.3)	.55
High	4.6 (35.5)	2.5 (13.6)	.84

*Scheffe's test.
ANOVA comparison for peanuts: F = 0.21, *P* = .64. ANOVA comparison for carrot: F = 0.28, *P* = .75.

In this longitudinal study, participants in the CD and IOD groups were classified according to 3 levels of mandibular symphyseal bone height using a standardized lateral cephalogram taken at entry into the study. At entry with original dentures, the 2 denture groups were found to be comparable in terms of general characteristics, age, previous denture experience, quality of original dentures and denture-bearing tissues, and PS and SWT MP scores for each of the ridge height levels. After verification of equivalent performance of the denture groups at entry, changes (scores from 6 months posttreatment minus entry scores) were calculated to determine the treatment effect of CD and IOD on MP.

Change scores for PS performance showed a significant difference between CD and IOD groups, with post hoc comparisons indicating greater improvement with the IOD, compared to CD, only in the patients with low bone height. Swallowing threshold performance, chewing time, and chewing strokes with both foods showed a similar pattern, with the IOD showing greater improvement than the CD in the low bone height group and little difference between CD and IOD for patients with moderate and high ridges. However, the differences in SWT scores were not statistically significant, possibly the result of the relatively small number of subjects and the high variability associated with masticatory scores between individuals. For example, power analysis of the PS performance differences in the moderate and high bone height groups indicated that the differences in MP between CD and IOD in these groups would have to be between 12% and 20% to have statistical significance.

As would be expected, there were significant differences in mandibular retention between the CD and IOD groups with study dentures for all 3 bone height levels in this study. Generally, implant therapy is chosen to increase retention and stability of dentures compared to CDs because it is believed

that functional ability is related to denture base fit. However, in this study, no change in functional level was seen with CDs or IODs in patients with adequate bone height after treatment, in spite of the increased retention of IODs. Evaluation of improved denture fit on MP[27,28] showed that the influence of denture factors such as base retention and stability on the chewing ability of denture wearers was limited. While implant therapy provided an increase in denture retention for all levels of bone height, the advantage did not directly relate to increases in chewing ability.

CONCLUSION

Within the limits of this study, it is suggested that treatment with a mandibular IOD impacts MP only in persons with less than adequate mandibular ridge height. In patients with advanced ridge resorption, the mandibular IOD is more likely than a CD to result in improvements in performance. Clinicians should consider the degree of mandibular ridge resorption before recommending IOD therapy for edentulous patients expressing a desire to improve chewing function.

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