 DOI:10.4047/jkap.2008.46.6.591

A COMPARISON OF THE MASTICATORY FUNCTION BETWEEN TWO DIFFERENT TYPES OF IMPLANT SUPPORTED PROSTHESES AND COMPLETE DENTURE FOR FULLY EDENTULOUS PATIENTS

Jae-Hoon Lee[1], DDS, MS, PhD, **Woo Hyun Kim**[2], DDS, **Rie-Hye Shin**[3], DDS, MS, PhD, **Keun Woo Lee**[4]*, DDS, MS, PhD
[1]*Assistant professor, Department of Prosthodontics, College of Dentistry at Yonsei University, Korea*
[2]*Graduate student, Department of dental biomaterials and bioengineering, College of Dentistry at Yonsei University, Korea*
[3]*Private practice, 8-7 Hibarigaoka Kashiwa, Chiba 277-0088, Japan*
[4]*Professor, Department of Prosthodontics, College of Dentistry at Yonsei University, Korea*

INTRODUCTION

For over 3 decades and since the preliminary studies on osseointegration, dental implants have been used extensively for the rehabilitation of completely and partially edentulous patients. Dental treatment with implants appears to provide many benefits for the edentulous patient as well as a significant oral function improvement and increased patient satisfaction.[1] Fewer complaints, increased satisfaction, and higher ratings with regard to masticatory comfort and ability compared to conventional denture wearer have been all reported.[1] Improvement attributed to the dental implant in an objective function appears to depend on the type of implant support for the denture.[1] The implant supported denture can be divided by type of prosthesis (fixed or removable) or material for the teeth (porcelain or resin). The early form of implant prosthesis for edentulous patients was fixed dental prostheses referred by Zarb[2], which consisted of attached denture teeth with heat-polymerized acrylic resin to a cast metal substructure. More recently, metal ceramic fixed partial dentures are more frequently used. The latter type of prosthesis needs 8 implants because it is restored as a separated unit compared to the former splinted type with 5 to 6 implants.

It is reported that the number and positioning of implants have an influence on force transfer and subsequent stress distribution around implants.[3] The increase in number improves the biomechanical implants behavior, especially when subjected to bending forces.[3,4] Distribution and magnitude of occlusal forces on implants carrying fixed prostheses was investigated while supported by 5 - 6 and 3 - 4 implants.[5] Higher forces were observed with a decreasing number of implants.

It is also reported that the type of prosthesis can affect implant loading mode. Loading of the extension parts of the prostheses, commonly used in the former type of prosthesis, caused a hinging effect. This in turn, induced considerable compressive forces on the implants closest to the location of load application and lower compressive or tensile forces on other implants.[6]

Regardless of its design, an implant-prosthesis complex transmits occlusal forces to the peri-implant bone.[5] Therefore, the force absorption quotient of the prosthesis material has been a topic of research interest. Skalak[7] envisaged that the use of acrylic resin teeth would be useful for shock protection on implants and recommended the use of acrylic resin as the material of choice for the occlusal surfaces of implant prostheses.[8] The resiliency of resin was suggested as a safeguard against the negative effects of impact forces of the bone-implant interface. The literature, however, is inconclusive on its effect on shock absorption.[9] In fact acrylic resins are burdened with technical and subjective disadvantages. For example, due to their low wear resistances, premature contacts often occur after several months of prosthesis delivery. Conversely, gold and porcelain surfaces are not considered to provide adequate

Corresponding Author: ***Keun Woo Lee***
Department of Prosthodontics, College of Dentistry at Yonsei University
134 Shinchondong, Seodaemoongu, Seoul, 120-752, Korea: e-mail, jaehoon115@yuhs.ac
Received October 22, 2008 Last Revison November 26, 2008 Accepted November 28, 2008.

force absorption but they are much stronger and more durable.

Although the choice of prosthesis material still remains controversial, it is agreed that it does not have any significant influence on implant survival.[11] However, there are few studies comparing bite force and masticatory performance of implant prostheses with a supporting number of implants and prosthesis material. Moreover, implant therapy outcomes have been reported largely in terms of implant survival rates and on the durability of prosthesis components.[11,12] Scant attention has been given to patient-based assessments of the outcome of implant therapy. Presently, there is a growing interest in the assessment of health-related quality of life and the impact of clinical procedures on the health status of patients.

The objective of this study is to assess the masticatory performance, occlusal force and impact of two different type of implant-stabilized prostheses on oral health-related quality of life compared to conventional methods such as a GOHAI complete denture, validated oral-specific health status[14], the sieving method[24], and the Prescale Dental System[25]. It is hypothesized that: (1) the implant number and material impact patient satisfaction, masticatory performance and occlusal force, and (2) edentulous patients who have an implant supported prosthesis would demonstrate comparable improvement in their oral health-related quality of life.

MATERIAL AND METHODS

From the years 1999 to 2006, a total of 30 completely edentulous patients in a single arch were selected retrospectively from the Department of Prosthodontics and Implant Clinic at Yonsei University Dental Hospital, in Seoul, S. Korea. Of the 30 patients ranging in age 42 to 75, 18 were male and 12 were female. Patients were selected for the study and divided into 3 groups of 10 each. Group HR was restored with implant supported fixed dental prostheses with resin teeth. Group FP had fixed dentures with porcelain teeth while Group CD had a complete denture (Table I). The residual ridge shape, tissue resiliency, and location of the border tissue attachment of the denture supporting tissue and prosthesis were assessed by intra-oral examination and from diagnostic cast. One experienced and study- blinded prosthodontist scored the tissues under complete denture according to the Kapur scoring method.[13] The scores ranged from 3 to 10; dentures with a score above 7 were accepted for the study. Three different types of prostheses were then compared statistically. Originally more than 100 patients were selected for the study but those who had partial or complete dentures on an opposing arch were excluded to standardize the patient pool to the subjects with natural dentition. Those patients with dentures who were not able to create the particle after 15 chewing cycle of mastication were excluded from the masticatory performance test.

Patient satisfaction

Patients in all groups were asked to give their perception on prostheses and allude to aspects of satisfaction regarding oral function using the GOHAI (General Oral Health Assessment Index). The GOHAI is designed to estimate the degree of satisfaction and effectiveness of the prosthesis[14]. The 12 items of GOHAI reflect the problems affecting patients in three dimensions: (1) physical function, including eating, speech and swallowing, (2) psychosocial function, including worry or concern about oral health, dissatisfaction with appearance, self-consciousness about oral health, and avoidance of social contact, and (3) pain or discomfort, including the use of medication to relieve mouth pain or discomfort. The qualified questions were evaluated using a 5 grade categorizing scale: always (5), often (4), sometimes (3), seldom (2), never (1). Before calculating the GOHAI score the responses to all items have been reversed except items 5 and 7. This allows the final high scores for the GOHAI to represent more positive oral health. The GOHAI score is determined by submitting the final score of each of the 12 items, which ranges from 0 to 60. Internal consistency, as measured by Cronbach' s alpha, measures the extent to which items in the same scale are interrelated and represents a measure of reliability. Data were analyzed using SAS version 9.1 (SAS Inc, Cary, NC).

Masticatory performance

In this study, masticatory performance is defined as the particle size reduction and distribution of food particles after

Table I. Summary of patient data

Group	Patient number	Sex	Age	Number of implant	Prosthesis location	Years after treatment
HR	1	M	68	6	Mandible	2 yr 5 mo
	2	M	52	6	Mandible	1 yr 6 mo
	3	F	72	6	Mandible	2 yr 4 mo
	4	F	53	6	Mandible	2 yr 1 mo
	5	M	54	6	Mandible	2 yr 9 mo
	6	F	62	6	Mandible	3 yr 3 mo
	7	M	55	6	Maxillae	4 yr 3 mo
	8	M	69	6	Mandible	3 yr 6 mo
	9	F	43	6	Mandible	2 yr 2 mo
	10	M	66	6	Maxillae	3 yr 1 mo
FP	1	M	70	8	Mandible	1 yr 1 mo
	2	F	55	8	Mandible	3 yr 4 mo
	3	M	68	8	Mandible	3 yr 3 mo
	4	M	51	8	Maxillae	3 yr 11 mo
	5	F	57	8	Maxillae	3 yr 3 mo
	6	M	46	10	Maxillae	1 yr 10 mo
	7	M	68	8	Mandible	3 yr 6 mo
	8	M	57	8	Mandible	2 yr 2 mo
	9	F	42	8	Mandible	2 yr 8 mo
	10	F	63	9	Maxillae	3 yr 2 mo
CD	1	M	73	N/A	Maxillae	5 yr 3 mo
	2	F	63	N/A	Maxillae	3 yr 2 mo
	3	F	72	N/A	Maxillae	1 yr 2 mo
	4	M	50	N/A	Maxillae	2 yr 5 mo
	5	F	75	N/A	Maxillae	2 yr 6 mo
	6	M	61	N/A	Maxillae	4 yr 3 mo
	7	M	54	N/A	Maxillae	3 yr 2 mo
	8	M	71	N/A	Maxillae	3 yr 5 mo
	9	M	59	N/A	Maxillae	2 yr 6 mo
	10	F	73	N/A	Maxillae	1 yr 2 mo

a given number of masticatory strokes. Masticatory performance tests were performed utilizing a dental impression material polyether Impregum F (3M ESPE, Seefeld, Germany) as a standardized artificial test food. In order to determine masticatory performance, 5 cubes of Impregum with edge sizes of 5.0 mm were offered (Fig. 1).

Each patient from all 3 groups was asked to masticate the prepared artificial food on both sides and to stop mastication after 15 closing strokes. The contents in the mouth were then rinsed into a beaker with filtering paper. The particles from each container were transferred onto a Petri dish and placed on a black background. A digital image of the particles was obtained using an image analysis system (Kontron Elektronik, Munich, Germany). Median particle sizes (S_{50}) were determined from the particle images.[15] The median particle size is the aperture of a theoretical sieve through which 50% of the particles can pass by gravity. The image was segmented and the minimum dimension D and area A of each particle was measured. Data for the particles were stored in a separate computer file for each subject. A program was written to read each subject's file and to sort the data by minimum dimension, D, into 8 size categories

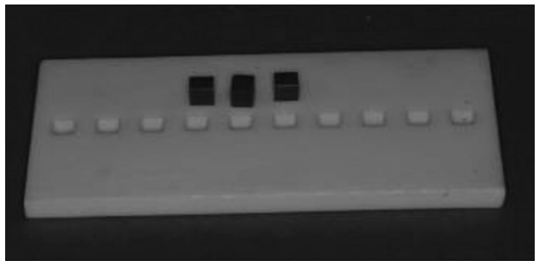

Fig. 1. Test food made with impregum F (3M ESPE, Seefeld, Germany).

between 0.4 and 2.0 mm. (Table II). The approximate volume for each particle was calculated, assuming a spherical shape. For each size category X, the sum of the particle volumes Yv, was calculated using the formula,

$$Yvx = \Sigma 4/3\pi (A^{-2}/2)^3$$

The value Yv was used in all further calculations as though it represented the total volume of particles retained by each sieve size. For each size category the percent of the total, Yv %, which was contributed by Yv, was calculated using the formula,

$$Yv\%x = Yv/\Sigma\ Yv^*100$$

The cumulative percentage Yc%, of the volume 'passing through' each size category was calculated using the formula,

$$Yc\%x = 100-\Sigma\ Yv\%.$$

The cumulative percent of the volume 'retained' by each size category was calculated using the formula,

$$Yr\%x = 100 - Yc_x\ \%.$$

The Rosin-Rammler function, expressed in the form,

$$\log X = a + b \log [\log(100 / Yr\ \%)]$$

was used to express the relation between size category and cumulative percentage of the volume retained.[15] The method of least squares was used to determine the characteristics of the best-fit straight line that could be drawn through the log X and log Y data points (Fig. 2). By this method the intercept a on the y axis and slope b of the function were determined.

The size category S_{50}, which would theoretically retain 50% of the total volume of particles, was calculated by substituting in Allen's equation for a and b, and 50% for Yv. Linear regression analysis was used to analyze any factors like age, sex, and age of prosthesis, which might have significant effect on patients' masticatory performance. Data from three groups were analyzed using SAS version 9.1 (SAS Inc).

Dental Prescale 2, 50 H, R-type (Fuji Film Co., Tokyo, Japan), which is a pressure sensitive film, was used to measure the maximum bite force of prosthesis during maximal biting in maximal occlusion. Prescale consists of a 98㎛ scanning film which can record a patient's bite along with an analyzer (Occluzer; Fuji Film Co.) to read and calculate the maximum biting force therein (Fig. 3).

Each patient in the 3 groups was seated in an upright position in a dental chair and instructed how to bite the

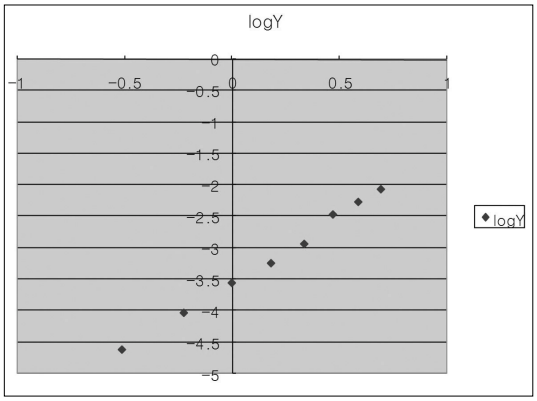

Fig. 2. A plot of log X against log Y of the data given in Table II.

Fig. 3. Dental Prescale recording bite film (Fuji film Co., Tokyo, Japan).

Table II. The treatment of data from 1 food sample

x	Log x	Yv	Yv%	Yc%	Yr	Y	Log Y
2	0.69	328.78	88.06	11.93	88.06	-0.13	-2.06
1.8	0.59	7.75	2.08	9.85	90.14	-0.1	-2.27
1.6	0.47	6.4	1.71	8.14	91.85	-0.08	-2.46
1.4	0.34	11.1	2.97	5.17	94.83	-0.05	-2.94
1.2	0.18	5.02	1.34	3.83	96.17	-0.04	-3.24
1	0	3.8	1.02	2.81	97.19	-0.03	-3.56
0.8	-0.22	3.95	1.06	1.75	98.25	-0.02	-4.04
0.6	-0.51	2.89	0.77	0.98	99.02	-0.01	-4.62

recording bite film for the actual test. The occlusal force was measured 3 times, with 1 minute of rest between the measurements. The highest recorded value represented the maximum occlusal force for each patient. Correlation analysis and two sample t-tests was used to find any association with sex, age, and age of prosthesis. The measured data were then statistically analyzed by using SAS version 9.1 (SAS Inc).

RESULTS

The overall GOHAI score ranged from 28 to 58 from the three groups. Mean scores for the GOHAI were 50.3 (SD 1.304), 51.2 (SD 0.993), and 43.3 (SD 1.398) for Groups respectively. GOHAI items and the mean frequency score for Groups are demonstrated in Table III. The most commonly reported problem was question 1 and 2 from Group CD, followed by the psychosocial problem; question 6, 7, 9, and 10 from Group CD (Table III). The mean GOHAI score from Groups HR and FP showed only minor differences. The patients from Group CD limited the kind and amount of food eaten more frequently and had problems chewing foods such as firm meat or apples. Functional problems with speech or swallowing follow similar trends and more often time Group CD patients worried about their oral health and were nervous or self-conscious because of problems with their dentures (Fig. 4). There are significant statistical differences between the groups (ANOVA) ($P < .05$). Multiple comparisons by LSD method revealed statistical differences in physical and psychosocial function between Group HR and CD, and Group FP and CD (Tables IV and V). The results demonstrated acceptable reliability and validity of the instrument, with inter-item and item-scale correlations for the GOHAI. The Cronbach's alpha of 0.87 showed a high degree of internal consistency and homogeneity between items.

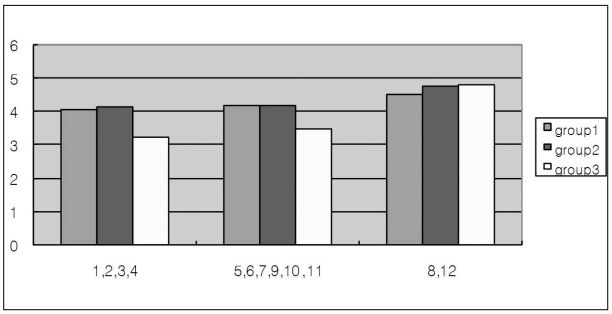

Fig. 4. Comparison between groups with GOHAI questions in 3 dimensions.

The mean value for the S_{50} after 15 chewing strokes was 3.23 mm (SD 0.40), 3.18 mm (SD 0.52) and 3.49 mm (SD 0.43) for Groups respectively (Table VI). Group FP showed the most efficient reduction rate of sample, with Groups HR and CD in following order. Statistical differences in mean value of S_{50} between three groups were significant upon Kruskal-Wallis test with Wilcoxon score ($P < .05$). Bonferroni multiple comparisons revealed statistical differences in masticatory performance between Groups HR and CD, and Group FP and CD ($P < .05$). In a linear regression analysis no factors were found to have a significant effect on patients' masticatory performance. Two standards deviation outlier was excluded from the statistical analysis for a more accurate measure.

Occlusal force measurements ranged from 79.1 to 1143.5 N. The median values of Groups were 370.4 N, 431.4 N and 122.2 N respectively (Table VII). Two implant supported prostheses groups showed more than two times the high value compared to conventional dentures. Upon comparison between Group HR and CD, which used the same resin teeth but differed in fixed or removable type, maximum occlusal force in Group HR was 2.23 times greater than Group CD. Statistical analysis was performed using a Kruskal-Wallis test with Wilcoxon score to compare differences between Groups (Table VII). Significant associations were shown between bite force and group classification ($P < .05$). Bonfferoni multiple comparisons revealed statistical differences in bite force between Group HR and CD, and Group FP and CD ($P < .05$). The results showed no association with sex, age, or age of prosthesis upon correlation analysis and two sample t-tests.

DISCUSSION

The implant supported prosthesis showed similar GOHAI mean value with patients who had healthy natural dentition in another study.[14] The most frequent problems for denture patients were limitation of food type and chewing difficulty. This has been directly attributed to the poor results in this study on masticatory performance and biting force. It can be assumed therefore that implant supported prosthesis can

Table III. Comparison of frequency score of individual GOHAI Items

Question items	Group HR	Group FP	Group CD
1. How often did you limit the kinds or amounts of food you eat because of problems with your teeth or dentures?	3.9	4.2	2.5
2. How often did you have trouble biting or chewing different kinds of food, such as firm meat or apples?	3.8	3.9	2.5
3. How often were you able to swallow comfortably?	4.3	4.4	4
4. How often have your teeth or dentures prevented you from speaking the way you wanted?	4.2	4.1	3.9
5. How often were you able to eat anything without feeling discomfort?	4.6	4.7	4.4
6. How often did you limit contacts with people because of the condition of your teeth or dentures?	4.5	4.1	3
7. How often were you pleased or happy with the looks or your teeth and gums, or dentures?	4.1	4.2	3.2
8. How often did you use medication to relieve pain or discomfort from around your mouth?	4.6	4.9	4.7
9. How often were you worried or concerned about the problems with your teeth, gums or dentures?	3.8	3.6	3.1
10. How often did you feel nervous or self-conscious because of problems with your teeth, gums or dentures?	3.6	4.1	3
11. How often did you feel uncomfortable eating in front of people because of problems with you teeth or dentures?	4.5	4.4	4.2
12. How often were your teeth or gums sensitive to hot, cold or sweets?	4.4	4.6	4.9
GOHAI mean score (SD)	4.19 (1.304)	4.26 (0.993)	3.6 (1.398)

Table IV. Multiple comparison by LSD method in physical function items (1, 2, 3 and 4)

Two group comparison	Difference	between means 95% confidence limits
HR to FP	0.1000	(-0.6613, 0.4613)
FP to CD	0.7250	(0.3637, 1.4863)***
HR to CD	0.6250	(-0.2637, 1.3863)***

Comparison significant at .05 level are indicated by ***

Table V. Multiple comparison by LSD method in psychosocial items (5, 6, 7, 9, 10 and 11)

Two group comparison	Difference between means	95% confidence limits
HR to FP	0.0000	(-0.4682, 0.4682)
FP to CD	0.7267	(0.2486, 1.1849)***
HR to CD	0.7267	(0.2486, 1.1849)***

Comparison significant at the 0.05 level are indicated by ***

recover the functional problems with denture.

Excellent aesthetics in porcelain teeth was expected to have better satisfaction compared to other groups which had resin teeth. However, the GOHAI result showed the same degree of aesthetic satisfaction for these two different types of teeth. Resin teeth on Group HR and CD, which are less durable than porcelain, were expected to have a more frequent teeth fracture rate which might cause pain or discomfort and eventually require more dental visits. However, the GOHAI result did not show these problems from resin teeth. The cantilever type of prosthesis was assumed to have an unfavorable distribution of occlusal forces due to a short arch length span which can create possible bone resorption or periodontal disease. The GOHAI score did not indicate any pain problems due to cantilever type of support or difficulty from short span of arch length.

Implant supported fixed dentures cannot meet the

Table VI. Summary statistics of particle size of each subject on s Groups

Group	Subject	Particle size				
		a	b	S_{50} (㎜)	Mean of S_{50} (㎜)	SD
HR	1	-3.71	3.35	2.71	3.23	0.4
	2	-3.33	2.67	3.03		
	3	-4.73	3.34	3.69		
	4*	-3.65	2.31	4.15		
	5	-4.02	3.29	3.03		
	6	-3.96	3	3.32		
	7	-5	4.18	3.03		
	8	-4.03	3.18	3.16		
	9	-3.74	3.05	3.02		
	10	-4.01	3.11	3.22		
FP	1	-4.19	3.59	2.89	3.18	0.52
	2	-4.12	3.48	2.93		
	3	-3.92	3.56	2.71		
	4	-4.08	3.7	2.72		
	5	-4.6	3.9	2.96		
	6*	-3.56	2.15	4.42		
	7	-3.18	2.43	3.17		
	8	-3.68	2.56	3.65		
	9	-3.66	2.68	3.41		
	10	-4.27	3.59	2.97		
CD	1	-4.9	4.1	3.01	3.49	0.43
	2	-4.25	3.5	3.03		
	3	-4.3	2.73	4.24		
	4	-4.22	3.36	3.14		
	5	-4.2	2.99	3.59		
	6	-4.08	3.19	3.2		
	7	-4.1	2.67	4.05		
	8	-3.76	2.85	3.29		
	9	-4.46	3.06	3.81		
	10	-4.77	3.46	3.57		

Two standards deviation outlier is indicated by *

requirements in the case of severe crestal bone loss where soft tissue needed to be restored. The prosthesis, used in group HR, can be designed to satisfy such needs and to meet these requirements.

Compared with these advantages, the fixed dental prosthesis in Group HR has the following shortcomings.[1] First, passive fit of the metal substructure may frequently require sectioning and soldering after initial fabrication.[16] Second, access holes must be present to allow for screw tightening or retrieval of the prosthesis. The access holes may compromise esthetics and occlusion, especially when implants are angled or placed labially to the planned tooth position as a result of severe bone resorption.[3] Third, the clinical and laboratory techniques are complex and generally require an experienced clinician and technician[17]. However, it is adventurous to be utilized where anatomic limitation requires inevitable cantilever distal extension prosthesis.

A successful rehabilitation of an edentulous condition requires functional and psychosocial adaptation by the patient. Quality of life is markedly affected by the amount of satisfaction or dissatisfaction with their dental therapy. Patient concerns are primarily related to comfort, function, and aesthetics. When these do not meet the patient's expectations, anxiety, insecurity, diminished self-esteem, and introversion are typical psychosocial responses.

The 12-item Geriatric Oral Health Assessment Index (GOHAI) was developed in the USA in 1990 and was later renamed as the General Oral Health Assessment Index. It has been validated in an elderly Caucasian sample primarily

Table VII. Summary statistics of maximum bite force of each subject

Group	Subject	Occlusal force		
		Value (N)	Median value (N)	Range
Group HR	1	212.4	370.4	526.1
	2	702.5		
	3	176.4		
	4	454.4		
	5	350.7		
	6	339.6		
	7	542.4		
	8	348.2		
	9	390.2		
	10	694.4		
Group FP	1	306.4	431.4	837.1
	2	339.6		
	3	390.2		
	4	454.4		
	5	350.7		
	6	1126.9		
	7	408.5		
	8	461.5		
	9	1143.5		
	10	684.5		
Group CD	1	94.9	122.2	382.4
	2	90.2		
	3	101.3		
	4	347.1		
	5	79.1		
	6	143.2		
	7	461.5		
	8	232.8		
	9	101.3		
	10	208.2		

N: Newton

in the United-States and later in a mixed-age adult sample of Hispanics and African-Americans.[14] Chinese, French, Japanese and Swedish versions have been published and recently confirmed.[18-21] The GOHAI had been translated into Korean for the studies in the Korean population in Los Angeles, Calif.[14] The validity of the distribution and reliability were acceptable with all three choices of response categories.

The patient responses to the questionnaire provide clinicians and researchers with valuable information about the effectiveness of implant therapy on functional capacity and well-being. These are the areas with which patients are most interested and familiar. The attribute of comfort, a factor difficult for the clinician to measure irrespective of the excellence of the prosthesis which, may be predictive of successful prosthetic management, as defined by patient responses, produced a single quality of life measure.

Efficient masticatory performance may be defined as the breakdown of food with the minimum effort, and maximum rate of particle-size reduction. A direct method of measuring masticatory efficiency is to collect the chewed food particles and pass them through sieves of various mesh sizes. The distribution of particle sizes after breaking is not linear, as a large number of very small particles dominate the data, obscuring the relatively few medium and larger sized particles. Edlund and Lamm used the proportion by weight of food trapped by coarse, medium and fine meshes, to derive an index of chewing efficiency for individuals, but were not able to derive a data value relating weight to size.[22] This difficulty was solved by Lucas, who determined the

theoretical median sieve size (S_{50}) that would retain 50% by volume of the particles.[23] Olthoff used a particle-size distribution function for calculating the value of S_{50}.[24] The median size is, of course, reduced as more masticatory strokes are used, but this is a power function rather than a linear relation.

The assumption made in the calculation of the particle volume-that particles were all spherical-is clearly unfounded but for practical purposes it appeared to satisfy the basic premise of the Rosin-Rammler function. The plot (Fig. 2) showing the relation between 'sieve' size and particle 'volume' is a straight line with a good fit. Therefore it seems that it may not be necessary to weigh food particles in the determination of particle size, if two-dimensional measurements can be made using image analysis. A recent study has established the reliability of the imaging technique in comparison to sieving methods.[15]

Artificial test foods may be preferred to natural foods for measuring masticatory performance and efficiency because of a better reproducibility of their physical properties. The texture of natural foods such as carrots, peanuts and almonds cannot be standardized. It is proposed that using pellets made from a silicon impression material would give a more standard masticatory performance, and this material was successfully used in several subsequent studies by others.[22]

Sufficient occlusal force is essential in order to maintain a healthy food intake. It is reported that the maximum occlusal force is significantly related to the mastication score determined by a food intake questionnaire. However, little referential data on occlusal force has been reported because the previous method for measuring occlusal force involved a relatively complex field survey. Recently, however, the Dental Prescale has been developed and has advantages over the field survey in that application is simple. In a similar study, the median of maximum occlusal force in healthy elderly subjects was found to be 408 N for male and 243.5 N for female, while individual variations ranged from 171 N to 1,219.3 N[25].

The median value of maximum occlusal force for Groups HR and FP (370 N and 431.4 N respectively) was very similar to that of a healthy elderly group with natural dentition. However the maximum occlusal force for Group CD measured lower than the average of elderly patients on the past study.[25] It was therefore thought that the prostheses supported by implants in this study sufficiently satisfied masticatory performance regardless of groups.

The clinical significance of the findings in this study would support the use of dental implants to manage the conventional dissatisfied complete denture patient. However, additional more detailed questionnaires will need to be administered during further evaluation periods in order to ascertain appropriate longitudinal corrective measures for patient responses to dental implant therapy and prosthodontic rehabilitation.

CONCLUSIONS

Masticatory performance and impact on patient satisfaction of 2 different types of implant prostheses compared to conventional complete dentures by using GOHAI, the sieving method and Prescale Dental System were compared. Within the limitations of this study, the following conclusions were drawn:

1. The comparison of GOHAI mean value showed a significant improvement in oral health-related quality of life with dental implants compared to conventional denture ($P < .05$).
2. Implant supported prostheses showed higher masticatory performance and maximum occlusal force than conventional dentures ($P < .05$). However there were no statistical differences between Group HR and FP ($P > .05$).
3. Patient age, sex, and age of prosthesis did not influence masticatory performance in all groups upon correlation analysis and a two- sample t-test.
4. The number of implants and the material of implant prostheses did not impact patient satisfaction, masticatory performance or occlusal force.

This study can be a future reference for a different number of implant prosthesis research article related to patient satisfaction, masticatory efficiency and maximum occlusal force.

REFERENCES

1. Lundqvist S, Carlsson GE. Maxillary fixed prostheses on osseointegrated dental implants. J Prosthet Dent 1983;50:262-70.
2. Zarb GA, Symington JM. Osseointegrated dental implants: preliminary report on a replication study. J Prosthet Dent 1983;50:271-6.
3. Hobkirk JA, Havthoulas TK. The influence of mandibular deformation, implant numbers, and loading position on detected forces in abutments supporting fixed implant superstructures. J Prosthet Dent 1998;80:169-74.
4. Korioth TW, Chew CB, Chung DH. Effect of implant number on transverse bending moments during simulated unilateral loading of mandibular fixed-detachable prostheses. J Oral Implantol 1998;24:93-6.
5. Duyck J, Van Oosterwyck H, Vander Sloten J, De Cooman M, Puers R, Naert I. Magnitude and distribution of occlusal forces on oral implants supporting fixed prostheses: an *in vivo* study. Clin Oral Implants Res 2000;11:465-75.
6. Osier JF. Biomechanical load analysis of cantilevered implant systems. J Oral Implantol 1991;17:40-7.
7. Skalak R. Biomechanical considerations in osseointegrated prostheses. J Prosthet Dent 1983;49:843-8.
8. Zarb GA, Zarb FL. Tissue-integrated prostheses: osseointegration in clinical dentistry. Chicago: Quintessence 1985:241-82.
9. Stegaroiu R, Kusakari H, Nishiyama S, Miyakawa O. Influence of prosthesis material on stress distribution in bone and implant: a 3-dimensional finite element analysis. Int J Oral Maxillofac Implants 1998;13:781-90.
10. Zarb GA, Schmitt A. The longitudinal clinical effectiveness of osseointegrated dental implants: the Toronto study. Part III: Problems and complications encountered. J Prosthet Dent 1990;64:185-94.
11. Walton JN, MacEntee MI. Problems with prostheses on implant; retrospective study. J Prosthet Dent 1994;71:283-8.
12. Brunski JB, Puleo DA, Nanci A. Biomaterials and biomechanics of oral and maxillofacial implants: current status and future developments. Int J Oral Maxillofac Implants 2000;15:15-46.
13. Kapur KK, Soman S. The effect of denture factors on masticatory performance. II. Influence of the polished surface contour of denture base. J Prosthet Dent 1965;15:231-40.
14. Atchison KA, Dolan TA. Development of the Geriatric Oral Health Assessment Index. J Dent Educ 1990;54:680-7.
15. van der Bilt A, van der Glas HW, Mowlana F, Heath MR. A comparison between sieving and optical scanning for the determination of particle size distributions obtained by mastication in man. Arch Oral Biol 1993;38:159-62.
16. Goll GE. Production of accurately fitting full-arch implant frameworks: Part I-Clinical procedures. J Prosthet Dent 1991;66:377-84.
17. Kan JY, Rungcharassaeng K, Bohsali K, Goodacre CJ, Lang BR. Clinical methods for evaluating implant framework fit. J Prosthet Dent 1999;81:7-13.
18. Wong MC, Liu JK, Lo EC. Translation and validation of the Chinese version of GOHAI. J Public Health Dent 2002;62:78-83.
19. Naito M, Suzukamo Y, Nakayama T, Hamajima N, Fukuhara S. Linguistic adaptation and validation of the General Oral Health Assessment Index (GOHAI) in an elderly Japanese population. J Public Health Dent 2006;66:273-5.
20. Tubert-Jeannin S, Riordan PJ, Morel-Papernot A, Porcheray S, Saby-Collet S. Validation of an oral health quality of life index (GOHAI) in France. Community Dent Oral Epidemiol 2003;31:275-84.
21. Hägglin C, Berggren U, Lundgren J. A Swedish version of the GOHAI index. Psychometric properties and validation. Swed Dent J 2005;29:113-24.
22. Edlund J, Lamm CJ. Masticatory efficiency. J Oral Rehabil 1980;7:123-30.
23. Lucas PW, Luke DA. Methods for analysing the breakdown of food in human mastication. Arch Oral Biol 1983;28:813-9.
24. Olthoff LW, van der Bilt A, Bosman F, Kleizen HH. Distribution of particle sizes in food comminuted by human mastication. Arch Oral Biol 1984;29:899-903.
25. Miura H, Watanabe S, Isogai E, Miura K. Comparison of maximum bite force and dentate status between healthy and frail elderly persons. J Oral Rehabil 2001;28:592-5.

A COMPARISON OF THE MASTICATORY FUNCTION BETWEEN TWO DIFFERENT TYPES OF IMPLANT SUPPORTED PROSTHESES AND COMPLETE DENTURE FOR FULLY EDENTULOUS PATIENTS

Jae-Hoon Lee[1], DDS, MS, PhD, **Woo Hyun Kim**[2], DDS, **Rie-Hye Shin**[3], DDS, MS, PhD, **Keun Woo Lee**[4*], DDS, MS, PhD

[1]*Assistant professor, Department of Prosthodontics, College of Dentistry at Yonsei University, Korea*

[2]*Graduate student, Department of Dental Biomaterials and Bioengineering, College of Dentistry at Yonsei University, Korea*

[3]*Private practice, 8-7 Hibarigaoka Kashiwa , Chiba 277-0088, Japan*

[4]*Professor, Department of Prosthodontics, College of Dentistry at Yonsei University, Korea*

STATEMENT OF PROBLEM: The improvement in oral function and comfort from the dental implant appears to depend on the particular type of implant support used with the denture. The number and positioning of implants have an influence on the force transfer and subsequent stress distribution around implants. Nevertheless, a quantitative comparison has not been made between the types of implant prosthesis used with different materials compared to conventional complete denture. **PURPOSE:** The objective of this study is to assess the masticatory performance, bite force and impact of two different type of implant supported prostheses on oral health-related quality of life compared to conventional complete denture with GOHAI, validated oral-specific health status measures, the sieving method, and the Prescale Dental System. **MATERIAL AND METHODS:** From the years 1999 to 2006, a total of 30 completely edentulous patients in a single arch were selected from the Yonsei University Dental Hospital, Department of Prosthodontics and Implant Clinic in Seoul, S. Korea. Patients were divided into 3 groups of 10 each. Group HR was restored with fixed-detachable hybrid prostheses with resin teeth. Group FP had fixed dentures with porcelain teeth while Group CD had a complete denture. The masticatory performance was compared between 3 groups. **RESULTS:** The results showed a significant improvement in oral health-related quality of life with dental implants compared to a conventional denture in GOHAI comparison. Overall, implant prostheses showed a higher masticatory performance (S_{50}) and maximum bite force compared with conventional dentures ($P < .05$) but no differences between different implant supported prostheses ($P > .05$). **CONCLUSION:** Within the limitation of this study, the numbers of implant and material of implant prostheses does not appear to impact patient satisfaction, masticatory performance or bite force.

KEY WORDS: Fully edentulous patient, Masticatory performance, Maximum bite force, Patient satisfaction

Corresponding Author: ***Keun Woo Lee***

Department of Prosthodontics, College of Dentistry at Yonsei University

134 Shinchondong, Seodaemoongu, Seoul, 120-752, Korea: e-mail, jaehoon115@yuhs.ac

Article history

Received October 22, 2008 Last Revison November 26, 2008 Accepted November 28, 2008.