Comparison masticatory function between two different types of implant supported prostheses and complete denture for fully edentulous patient

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Comparison masticatory function between two different types of implant supported prostheses and complete denture for fully edentulous patient

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오늘날 하나의 인격체가 되기까지 헌신과 사랑으로 키워 주신 부모님 지치고 힘든 모든 순간에 격려 하여준 아내 혜승 그리고 형 태훈에게 감사를 드리며 나의 삶의 모든 길을 예비하시고 이룰 수 있도록 힘주시며 결국에는 그 뜻대로 모든 것을 이루어가시는 하나님께 감사와 찬송을 올려 드립니다.

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저 자 씀

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Abstract

A Comparison Study of Masticatory Function between Two Different Types of Implant Supported Prostheses and Complete Denture for the Fully Edentulous Patient

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For over three decades and since the preliminary studies on osseointegration, dental implants have been used extensively for the rehabilitation of completely and partially edentulous patients. Dental implant treatment provides many benefits including oral function improvement and greater patient satisfaction. The improvement arising from the dental implant's objective function appears to depend on the particular type of implant support used with the denture. The early form of implant prosthesis for the complete edentulous patient was a fixed-detachable hybrid prostheses developed by Zarb. It consisted of attaching the denture teeth with a heat-polymerized acrylic resin to a cast metal substructure. More recently, a metal ceramic fixed partial denture type of implant prosthesis is frequently used. It is reported that 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 type of implant prosthesis used with different materials.

The objective of this study is to assess the masticatory performance, bite 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 measures, the sieving method, and the Prescale Dental System.

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 I was restored with fixed-detachable hybrid prostheses with resin teeth. Group II had fixed dentures with porcelain teeth while Group III had a complete denture. The results show 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 (S50) and maximum bite force compared with conventional dentures ($p < 0.05$). The numbers of implant and material of implant prostheses does not appear to impact patient satisfaction, masticatory performance or bite force.

Key words: Completely edentulous patient, Masticatory performance, Maximum bite force, Dental implant, GOHAI

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I. Introduction

For over three 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 providing a significant oral function improvement and increased patient satisfaction.[1] Fewer complaints, increased satisfaction, and higher ratings with regard to chewing comfort and ability compared to conventional denture wearer are all reported.[1] Improvement attributed to the dental implant in 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-detachable hybrid prostheses developed by Zarb[2]. It 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 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 envisaged that the use of acrylic resin teeth would be useful for shock protection on implants[7] and recommended the use of acrylic resin as the material of choice for the occlusal surfaces of implant prostheses[8]. The resiliency of this material 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[10]. Conversely, gold and porcelain surfaces are not considered to provide adequate force absorption but they are much stronger and 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 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, bite 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 measures, the sieving method, and the Prescale Dental System.

We hypothesized that (a) the implant number and material impact patient satisfaction, masticatory performance and bite force; and (b) edentulous patients who have implant supported prosthesis would demonstrate comparable improvement in their oral health-related quality of life.

II. Materials 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 from 42 to 75 years, 18 were male and 12 were female. Patients were selected for the study and divided into 3 groups of 10 each. Group I was restored with fixed-detachable hybrid prostheses with resin teeth. Group II had fixed dentures with porcelain teeth while Group III 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 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.

1. 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 use of medication to relieve mouth pain or discomfort. The qualified questions were evaluated using a five 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 item 5 and 7. This allows 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 the 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, USA).

Table I. Summary of patient data.

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

2. Masticatory performance

In this study, masticatory performance is defined as the particle size reduction and distribution of food particles after a given number of chewing 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, five cubes of Impregum with edge sizes of 5.0 mm were offered (Fig.1).

Each patient from all three groups was asked to chew the prepared artificial food on both sides and to stop chewing after 15 closing strokes. The contents in the mouth were 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 eight size categories 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,

$Yv_X = \sum 4/3\pi\ (A^{-2}/2)^3$

The value Yv was used in all further calculations as though it represented the total volume of particles retained by each sieve size. The following steps in calculating the median

particle size were followed according to Partridge[16]. For each size category the percent of the total, Yv %, which was contributed by Yv, was calculated using the formula,

$Yv\%x = Yv/\sum Yv*100$

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

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

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 by Allen[17] 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. 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 year of prosthesis, which might have significant effect on patients' masticatory performance. Data from three groups were analyzed using SAS version 9.1 (SAS Inc., Cary, NC USA).

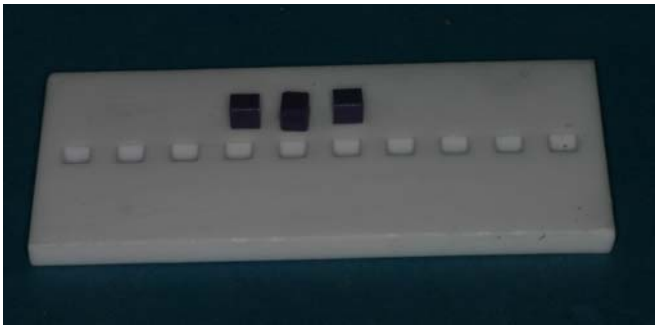

Fig. 1. Test food made with impregum F (3M ESPE, Seefeld, Germany).

Table II. The treatment of data from one 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	-0.10	-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
0.4	-0.91	3.65	0.98	0	100	0	0

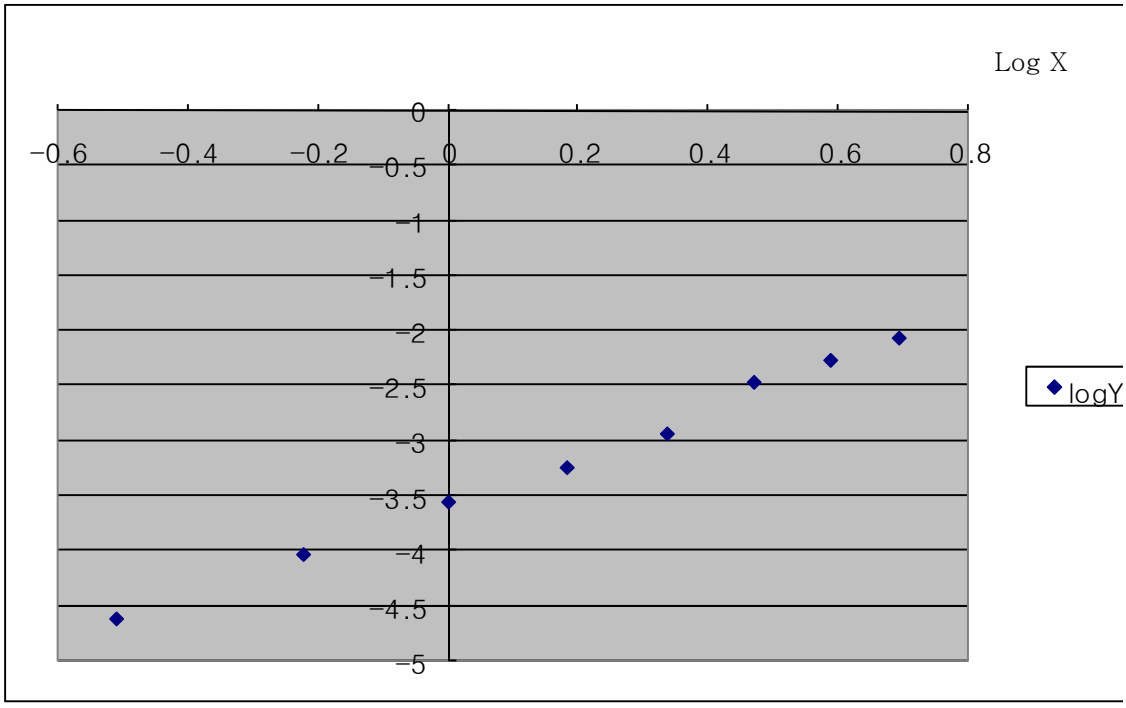

Fig. 2. A plot of log X against log Y of the data given in Table II.

3. Maximum bite force

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., Tokyo, Japan) to read and calculate the maximum biting force therein (Fig. 3).

Each patient in the three groups was seated in an upright position in a dental chair and instructed how to bite the recording bite film for the actual test. The bite force was measured 3 times, with 1 minute of rest between the measurements. The highest recorded value represented the maximum bite 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., Cary, NC, USA).

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

III. Results

1. Patient satisfaction

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 Group I, II and III respectively. GOHAI items and the mean frequency score for Group I, II and III are demonstrated in Table III. The most commonly reported problem was question 1 and 2 from Group III, followed by the psychosocial problem; question 6, 7, 9, and 10 from Group III (Table III). The mean GOHAI score from Groups I and II showed only minor differences. The patients from Group III limited the kinds and amounts 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 III patients worried about their oral health and were nervous or self-conscious because of problems with their denture (Fig. 4).

There are significant statistical differences between Groups (ANOVA, $p<0.05$). Multiple comparisons by LSD method revealed statistical differences in physical and psychosocial function between Group I and III, and Group II and III (Table IV and V).

The result demonstrated acceptable reliability and validity of the instrument, with an 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.

Table III. Comparison of frequency score of individual GOHAI Items.

Question items	Group		
	I	II	III
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	4.0
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	3.0
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	3.0
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)	3.60 (1.398)

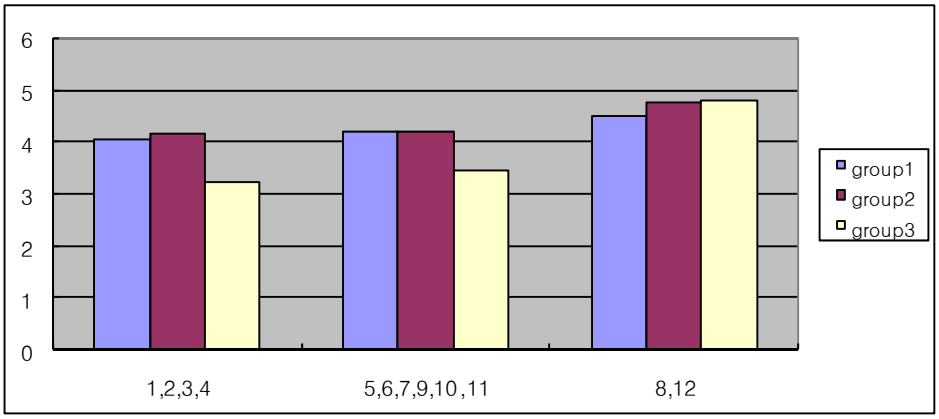

Fig. 4 Comparison between groups with GOHAI questions in three dimensions

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
I to II	0.1000	(-0.6613, 0.4613)
II to III	0.7250	(0.3637, 1.4863)***
I to III	0.6250	(-0.2637, 1.3863)***

Comparison significant at the 0.05 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
I to II	0.0000	(-0.4682, 0.4682)
II to III	0.7267	(0.2486, 1.1849)***
I to III	0.7267	(0.2486, 1.1849)***

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

2. Masticatory performance

The mean value for the S_{50} after 15 chewing strokes was 3.23 mm (SD0.40), 3.18 mm (SD0.52) and 3.49mm (SD0.43) for Group I, II and III respectively (Table VI). Group II showed the most efficient reduction rate of sample, with Groups I and III in following order. Statistical differences in mean value of S_{50} between three groups were significant upon Kruskal-Wallis test with Wilcoxon score ($p<0.05$). Bonfferoni multiple comparisons revealed statistical differences in masticatory performance between Groups I and II, and Group II and III ($P<0.05$). 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 more accurate measure.

Table VI. Summary statistics of particle size of each subject on Group I, II, III

Group	Subject	Particle size				
		a	b	S_{50} (㎜)	Mean of S_{50} (㎜)	SD
I	1	-3.71	3.35	2.71	3.23	0.40
	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	3.00	3.32		
	7	-5.00	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		
II	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	3.70	2.72		
	5	-4.60	3.90	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		
III	1	-4.90	4.10	3.01	3.49	0.43
	2	-4.25	3.50	3.03		
	3	-4.30	2.73	4.24		
	4	-4.22	3.36	3.14		
	5	-4.20	2.99	3.59		
	6	-4.08	3.19	3.20		
	7	-4.10	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 *

3. Maximum bite force

Bite force measurements ranged 79.1 to 1143.5N. The median values of Group I, II and III were 370.4N, 431.4N and 122.2N respectively (Table VII). Two implant supported prostheses groups showed more than two times the high value compared to conventional dentures. Upon comparison between Group I and III, which used the same resin teeth but differences in fixed or removable type, maximum bite force in Group I was 2.23 times greater than Group III. 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 ($p<0.05$). Bonfferoni multiple comparisons revealed statistical differences in bite force between Group I and II, and Group II and III ($p<0.05$). The results showed no associations with sex, age, and age of prosthesis upon correlation analysis and two sample t-tests.

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

Group	Subject	Occlusal force		
		Value (N)	Median value (N)	Range
Group I	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 II	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 III	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

IV. Discussion

The implant supported prosthesis showed similar GOHAI mean value with patients who had healthy natural dentition in another study[14]. Most frequent problems on denture patients were limitation of food type and chewing difficulty. This has been directly attributed to the poor result of this study on masticatory performance and biting force.
We can assume that implant supported prosthesis can recover the functional problems with denture.

Excellent aesthetics in porcelain teeth was expected to have better satisfaction compared to other groups which have resin teeth. However, the GOHAI result showed the same degree of aesthetic satisfaction in two different types of teeth. Resin teeth on Group I and III, which are less durable than porcelain, were expected to have a more frequent teeth fracture 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 unfavorable distribution of occlusal forces due to a short arch length span and can create problems such as possible bone resorption or periodontal disease. The GOHAI score did not indicate any problems of pain due to cantilever type of support or difficulty from short span of arch length.

Implant supported fixed dentures could not meet the requirements in the case of severe crestal bone loss and soft tissue needs to be restored. Hybrid prosthesis attached to a bar can be designed to satisfy such needs and to meet these requirements.
Compared with these advantages, the fixed-detachable hybrid prosthesis has the following shortcomings[1]. First, passive fit of the metal substructure may frequently require sectioning and soldering after initial fabrication[18]. 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[19]. However, it is adventurous to be utilized where anatomic limitation requires inevitable cantilever distal extension prosthesis.

A successful rehabilitation of the 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 U.S.A. in 1990 and was later renamed as the General Oral Health Assessment Index. It has been validated in an elderly Caucasian sample primarily 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 [20, 21, 22, 23].

The GOHAI had been translated into Korean for the studies for Korean population in Los Angeles, U.S.A.[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 valuable information about the effectiveness of implant therapy on functional capacity and well-being. These are the areas that patients are most interested and familiar with. The attribute

of comfort, a factor difficult for the clinician to measure irrespective of the excellence of the prosthesis, 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 chewing 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 the large number of very small particles dominates the data, obscuring the relatively few middle 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[24]. This difficulty was solved by Lucas, who determined the theoretical median sieve size (S_{50}) that would retain 50% by volume of the particles[25]. Olthoff used a particle-size distribution function for calculating the value of S_{50}[26]. The median size is, of course, reduced as more chewing 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 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 using pellets made from a silicon impression material, and this material was successfully used in several subsequent studies by others[24].

Originally more than 100 patients were selected for the study but those who had partial or complete denture for opposing arch were excluded to standardize the patient pool to the group with natural dentition. Those patients with denture who were not able to create the particle after 15 cycle of chewing were excluded to fit in the masticatory performance test.

Sufficient bite force is essential in order to maintain a healthy food intake. It is reported that the maximum bite force is significantly related to the mastication score determined by a food intake questionnaire. However, few referential data on bite force has been reported because the previous method for measuring bite force involved a relatively complex field survey. Recently, however, the Dental Prescale has been developed and has advantages over the field survey in that operation is simple. In the similar study, the median of maximum bite force in healthy elderly subjects was found to be 408 N for male and 243.5 N for female and individual variation were from 171N to 1,219.3N[27].

The median value of maximum occlusal force for Groups I, II (370N and 431.4N respectively) was very similar to that of a healthy elderly group with natural dentition. However the maximum occlusal force for Group III showed lower than the average of an elderly patient. It was 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 questionnaires in more detail will need to be administered during the further evaluation periods to provide longitudinal measures of patient responses to dental implant therapy and prosthodontic rehabilitation.

V. Conclusion

Masticatory performance and impact on patient's satisfaction of two different types of implant prostheses compared to conventional complete denture by using GOHAI, the sieving method and Prescale Dental System were compared.

Within the parameters of this study the results demonstrated:

1. The comparison of GOHAI mean value showed significant improvement in oral health-related quality of life with dental implant compared to conventional denture ($p<0.05$).
2. Implant supported prostheses showed higher masticatory performance and maximum bite force than conventional denture ($p< 0.05$).

   However there were no statistical differences in between Group I and II ($p> 0.05$).
3. Age, sex, and year after prosthesis did not influence masticatory performance in all groups upon correlation analysis and two sample t-test.
4. Numbers of implant and material of implant prosthesis did not impact patient satisfaction, masticatory performance and bite force.

This study can be a future reference for different number of implant prosthesis in patient satisfaction, masticatory efficiency and maximum bite force of future study

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국문요약

완전 무치악 환자에서 서로 다른 임플란트 보철물과 총의치간에 저작 기능 비교

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이 재 훈

치과영역에서 임플란트는 초기 연구 이후 삼십 년 이상 계속해서 부분 및 전체 무치악 환자의 치료에 사용되어 왔다. 치과용 임플란트는 구강 기능 및 환자의 만족도에 있어서 많은 장점을 제공 하고 있다. 연구에 의하면 기존의 의치보다 적은 불만, 보다 높은 만족도, 구강 기능 시 편안함을 가져다 주었다. 이러한 장점은 보철물의 종류에 의해 그 정도가 나누어 질 수 있다. 임플란트를 이용한 보철물은 고정성과 가철성 그리고 사용된 치아의 종류가 레진인가 도재인가에 따라 나누어 질 수 있겠다. 무치악 환자에 사용한 임플란트 보철물의 초기 형태는 hybrid 형태의 보철물이고 최근에는 전악 보철물이 분리된 단위로 수복됨에 따라서 도재 금관 계속 가공의치가 새로운 선택적 치료 방법으로 상용되고 있다. 후자의 경우는 대개 분리된 구조를 갖고 있으므로 8개의 임플란트가 요구되며 전자의 경우는 6개의 임플란트가 하나의 구조물에 연결되는 형태를 가지고 있다. 임프란트의 수와 위치가 교합압의 분산에 영향을

미치고 있음이 보고 되었다. 이러한 임플란트 수와 재료등의 차이에서 오는 보철물간의 정량적인 비교는 거의 이루어져 있지 않다. 본 연구의 목적은 전악 무치악을 두 개의 다른 형태의 임플란트 보철물로 수복한 환자를 선택하여 객관적으로 검증된 GOHAI로 만족감을, 각각의 조각들의 총 부피의 50%를 거를 수 있는 체의 크기를(S_{50}) 계산하여 저작 효율을 그리고 Prescale 2(Fuji Film Co. Tokyo, Japan)를 이용하여 최대 교합력을 각각 분석하여 각 보철물간에 저작 효율을 기존 총의치와 함께 비교하여 보았다. 연세대학교 치과병원의 보철과 및 임플란트 클리닉을 내원한 환자 중 총 30명의 무치악 환자를 연구를 위해 선정하였다. 각 집단 I, II, III에 10명씩의 환자들은 1999년에서 2006년까지 골 유착성 임플란트로 지지된 레진 치아를 갖는 hybrid 형태의 보철물과 도재 치아로 수복된 고정성 가공의치 그리고 총의치로 수복된 환자들을 선정 하였다. 모든 보철물은 연구의 형평성을 위하여 자연치와 대합되고 있었다. 세 그룹에서 측정된 모든 데이터는 통계프로그램을 사용하여 분석 하였다. 결론적으로 실험에서 사용한 서로 다른 임플란트 보철물에서 각각 기존 총의치보다 만족도, 저작효율과 최대 교합력에서 통계적학적으로 유의차 있는 증가를 나타내었다. 그러나 임플란트의 수와 재료가 다른 종류의 두 임플란트 보철물 간에는 통계적 유의 차를 나타내지 않았다.

핵심어: 완전 무치악 환자, 저작 효율, 최대 교합력, 치과용 임플란트, GOHAI