

Evaluation of chronological change of body and oral function after dental implant treatment

(歯科インプラント治療に伴う身体および口腔機能の経時的変化に関する研究)

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Abstract

To clarify the effects of dental implant treatment on oral and physical function, chronological change between before and after treatment for six years was investigated in this study. In particular, the relationship between age at first visit and changes after treatment was focused.

Eighty-two subjects who had four occlusal support areas restored by dental implant treatment. Four examinations were performed at baseline and during the follow-up periods. The test items were gum masticatory performance assessment, hand grip strength, and body component. To evaluate the effect of intervention with dental implant treatment, Friedman's and post-hoc tests were used.

Hand grip strength and mastication performance were significantly maintained during follow-up period in under and over 65 years. In over 65 years, a few items were significantly lower than at baseline. No significant difference was observed about skeletal muscle mass (%), fat mass (%), fat-free mas (%), and leg (%) in under and over 65 years. These results indicated that hand grip strength and mastication performance were improved over a long period after dental implant treatment. It was speculated that the improvement in hand grip strength was associated with the recovery of systemic functions, especially in under 65 years old group.

Introduction

Oral frailty has been defined as a decrease in oral function possibly associated with a decline in cognitive and physical functions (1) and is a high risk of physical frailty, sarcopenia, severe conditions requiring nursing care (2). The relationship among occlusal condition, masticatory function, and systemic conditions has been reported widely (2-7). Hand grip strength should be evaluated as an indirect evaluation method of masticatory function (8). Tooth loss is a risk factor for postural instability, but the effects of restoration on masticatory function by dental treatment on systemic conditions have not been clarified (9). To assess dynamic physical function, walking speed is commonly used as an indicator of frailty, and the relationship between masticatory function and walking speed has been investigated (10).

On the other hand, as a method of evaluating the static physical function of the older adults, the interpretation of body composition by skeletal muscle mass and fat-free mass index (FFMI) is effective, and it is used as an indicator that reflect frailty (11, 12). It has also been reported that FFMI changes little with age (13), there are various interpretations of these factors (12, 14). In any case, body composition is widely used as an index for evaluating health and nutritional status (15-17). Besides, it is also recommended that "body composition analyzer" that can easily measure body composition will lead to effective health management (15-17). In the field of dentistry, previous studies reported the direct association between oral and physical frailty in the older adults (17-19). Furthermore, Techapiroontong S et al. (20) reported on the relationship between the intervention of wearing dentures and body composition and masticatory efficiency. However, there are very few reports to analyze changes about them by dental implant treatment, and the number of subjects is very small (21).

Though dental implant treatment has a high application because its purpose is clear and effective, there are very few studies on changes in long-term masticatory and physical function that accompany the intervention (21). Maekawa et al. reported that fewer functional teeth are more strongly associated with mortality in the older adults than fewer present teeth (22). However, whether this applies to the number of functional teeth after dental implant treatment has not been revealed fully.

To clarify the effects of dental implant treatment on oral and physical function, chronological change between before and after treatment for six years was investigated in this study. In particular, the relationship between age at first visit and changes after treatment was focused.

Materials and Methods

1. Study design and participants

Participants in the present study were retrospectively selected from among patients who visited Nakamura Dental Clinic (Koto Ward, Tokyo) with the chief complaint of occlusal function recovery with the following criteria: above 40 years of age, were able to communicate, dental implant treatment at this clinic, 6 years after treatment in 2021, all oral examination, oral and physical function evaluations are performed, restored to group A in Eichner's classification (23, 24) after implant, received nutrition and exercise guidance from qualified persons, and consented to informed consent. Concerning about exercise for participants, two types of exercise guidance, towel gathering (25) and standing on one leg with eyes open (26) were conducted. Nutrition and exercise guidance was continuously provided to the subjects who gave their informed consent at the time of their visit. Exclusion criteria were patients whose Eichner classification changed due to additional treatment or changes in the oral cavity during follow-up period and part of the examination was inadequate due to physical condition on the day of examination. Data from 82 participants (34 males, 48 females; mean age of 67.6 years) were extracted from the clinic database according to the above criteria and subjected to statistical analysis.

The study was conducted in accordance with the Declaration of Helsinki, and consent was obtained from the subjects after fully explaining the contents of the study. This study was approved by the Ethics Committee of Nihon University Matsudo School of Dentistry (approval number: EC21-020).

2. Evaluation items and outcome

1) Oral function evaluation

Masticatory performance evaluation

The test was conducted using gum for the assessment of masticatory performance (XYLITOL® masticatory performance evaluating gum, Lotte, Japan). The subjects avoided measurements for 30 minutes after eating and brushing of teeth and drank a mouthful of water before chewing for more than 5 seconds. Gum was chewed 60 times at a rate of one per second to ensure that the upper and lower teeth were properly engaged. The change in gum color after chewing was evaluated on a dedicated color scale of 1 to 5 (27).

2) Physical function evaluation

(1) Hand grip strength (left and right)

Hand grip strength was measured using an M-type hand dynamometer (model number 121100, Matsumiya Medical Seiki Seisakusho, Japan). For the measurement position, the left and right upper limbs were hung at the side of the body, and the maximum hand grip strength was measured twice on both sides, and the average value of each was taken as the representative value.

(2) Body composition

Measurements were performed using a high-precision body composition analyzer (InBody370: InBody Japan Inc., Japan) using simultaneous multi-frequency impedance measurement (SMFIM method). Details of the measurement items are shown in Table 1. With InBody370, skeletal muscle mass, body fat mass, and lean mass are shown as test values with different standard ranges for each individual (height). Therefore, the intermediate value between the maximum value and the minimum value in the standard range was used as the standard value, and the ratio value (%) was calculated by dividing

the actual value (amount) by the standard value. Solids were standardized from the calculated percentage values and used for analysis. Muscle balance by region was defined as the development rate (%) against body weight.

Outcome data was collected four times: at baseline (as a control), at the end of treatment, and the follow-up period (two and six years after the treatment). "End of treatment" defined as when the implant abutment is fixed, and four occlusal support areas were restored. (Table2).

Table 1. Diagram of the method.

	1	2	3	4
Number of collection	Baseline (control, first visit)	After end of treatment	Follow-up period	
Outcome data			at 2 years after	at 6 years after
Number of patients		82 (34 males and 48 females)		
Intraoral examination items	Basic data collection ¹	Basic data collection ¹	Basic data collection ¹	Basic data collection ¹
Eichner's classification	Groups B and C		Group A	Group A
Oral functional recovery treatment		Dental implant treatment	(Additional treatment ²)	
Evaluation items	Oral function evaluation ³ Physical function evaluation ⁴	Final superstructures fitting Oral function evaluation ³ Physical function evaluation ⁴	Oral function evaluation ³ Physical function evaluation ⁴	Oral function evaluation ³ Physical function evaluation ⁴

- 1: Basic data collection contains intra oral photographs, panoramic X-rays and CT X-rays.
- 2: Treatment given only if necessary to maintain Group A of Eichner's classification.
- 3: Oral function evaluation contains masticatory performance assessment.
- 4: Physical function evaluation contains hand grip strength and body composition analysis.
- 5: Exercise guidance contains towel gathering and standing on one leg with eyes open.

Table 2. Impedance measurement items

- Physical constitution
Skeletal muscle mass (%), Fat mass (%), Fat-free mass (%)
 - Muscle mass of each limb and trunk
Arm (Right · Left) (kg · %), Trunk (kg · %), Leg (Right · Left) (kg · %)
 - Body composition
Body water (kg), Protein content (kg), Mineral content (kg)
 - Obesity level
Body Mass Index (kg/m^2), Body fat percentage (%),
Internal fat level, Waist circumference (cm)
-

3. Statistical analysis

All statistical analyses were performed using SPSS Statistics ver 27.0J for windows (IBM, Tokyo). All participants were divided into two groups: < 65 years and ≥ 65 years. Furthermore, these two groups were classified into < 20 functional teeth and ≥ 20 functional teeth (28). In this study, the effects on oral and physical function after dental implant treatment were compared between patients with < 20 functional teeth and those with ≥ 20 functional teeth in both under and over 65 years groups.

Each baseline measurement item was compared using chi-square and the Mann-Whitney U test. To evaluate the effect of intervention with dental implant treatment, comparisons between the baseline and follow-up periods were performed using the Friedman test and respectively performed post-hoc test. $p < 0.05$ was considered significant.

Results

1. Participants' attributes at baseline (Table 3,4)

Attributes and all measurements of patients at baseline under 65 and over 65 years old showed in table 3 and 4, respectively. Participants consisted 10 people under 65 years had < 20 functional teeth, 20 people under 65 years had ≥ 20 functional teeth, 22 people over 65 years had < 20 functional teeth, and 30 people over 65 years had ≥ 20 functional teeth. Concerning about the sex and ages, no significant difference observed between under 65 years and over 65 years. In the Eichner classification, showing a significant difference between under and over 20 functional teeth groups between under 65 years and over 65 years ($p < 0.01$).

In those under 65 years, the body fat (%) was significantly higher in the group with many functional teeth, and the trunk skeletal muscle (%) was significantly lower. A significant difference was observed in the left and right gum mastication performance in subjects over 65 years, and the force was higher in the group with many functional teeth.

Table 3. All measurements of under 65 years group at baseline.

Variables		Under 65 years		<i>p</i> -value
		<20 ^a (n=10)	≥ 20 ^b (n=20)	
Sex	Male	7 (70.0%)	9 (45.0%)	0.260 ^d
	Female	3 (30.0%)	11 (55.0%)	
Age	Median (IQR) ^c	61.0 (56.8-62.0)	60.0 (56.0-62.0)	0.746 ^e
Eichner's classification	Group A	0	5	< 0.01 ^d
	Group B	5	14	
	Group C	5	1	
Variables		< 20 ^a (n=10)	≥ 20 ^b (n=20)	<i>p</i> -value ^e
		Median (IQR) ^c	Median (IQR) ^c	
A. Masticatory performance assessment				
Functional teeth ^f		17.5 (6.8-19.0)	22.5 (21.0-24.0)	< 0.001
Gum mastication performance (Right)		1.5 (1.0-2.0)	2.0 (1.3-3.0)	0.131
Gum mastication performance (Left)		2.0 (1.0-2.3)	2.5 (2.0-3.0)	0.091
B. Physical constitution				
Right hand grip strength (kg)		27.5 (23.5-38.8)	25.0 (21.3-34.8)	0.448
Left hand grip strength (kg)		27.0 (23.0-37.5)	26.0 (21.0-34.8)	0.475
Skeletal muscle mass (%)		92.9 (83.7-100.8)	92.4 (83.7-103.8)	0.812
Fat mass (%)		136.9 (110.0-194.3)	183.6 (130.7-223.5)	0.131
Fat-free mass (%)		49.3 (38.4-54.7)	38.8 (33.5-50.2)	0.231
C. Muscle mass of each limb and trunk				
Right arm (kg)		2.8 (1.7-3.2)	1.9 (1.4-2.8)	0.155
Left arm (kg)		2.8 (1.7-3.1)	1.9 (1.4-2.8)	0.248
Right arm (%)		94.1 (89.0-100.9)	87.4 (81.2-97.2)	0.082
Left arm (%)		91.7 (86.9-96.1)	86.0 (81.3-95.5)	0.350
Trunk (kg)		22.6 (16.4-24.9)	17.2 (14.2-23.2)	0.248
Trunk (%)		96.9 (92.9-99.0)	92.5 (89.3-97.0)	0.049
Right leg (kg)		7.5 (5.6-8.4)	5.9 (4.6-8.0)	0.307
Left leg (kg)		7.6 (5.5-8.4)	5.8 (4.7-7.9)	0.307
Right leg (%)		93.6 (85.1-97.8)	88.6 (84.1-92.8)	0.286
Left leg (%)		93.5 (87.1-97.0)	90.6 (84.7-92.8)	0.214
D. Body composition				
Body water (kg)		36.3 (28.3-40.3)	28.6 (24.7-37.0)	0.231
Protein content (kg)		9.9 (7.5-10.8)	7.6 (6.5-10.0)	0.198
Mineral content (kg)		3.2 (2.5-3.6)	2.8 (2.4-3.4)	0.373
E. Obesity level				
Body Mass Index (kg/m ²)		22.9 (19.9-26.2)	24.8 (20.5-27.6)	0.350
Body fat percentage (%)		25.6 (22.1-30.1)	33.7 (26.8-39.1)	0.006
Internal fat level		8.5 (6.8-13.0)	10.5 (7.0-13.8)	0.619
Waist circumference (cm)		77.5 (71.0-90.3)	84.5 (71.0-93.0)	0.373

a:Young Few Functional Teeth Group, b:Young Many Functional Teeth Group, c:Interquartile range (IQR), d:Comparisons between the <20 and ≥20 groups by χ^2 test, e:Comparisons between the <20 and ≥20 groups by Mann-Whitney U test, f:The number of functional teeth.

Table 4. All measurements of over 65 years group at baseline.

Variables		Over 65 years		<i>p</i> -value
		< 20 ^a (n=22)	≥ 20 ^b (n=30)	
Sex	Male	6 (27.3%)	12 (40.0%)	0.390 ^d
	Female	16 (72.7%)	18 (60.0%)	
Age	Median (IQR) ^c	71.0 (68.8-72.0)	72.0 (69.8-74.0)	0.241 ^e
Eichner's classification	Group A	1	7	<0.01 ^d
	Group B	9	22	
	Group C	12	1	
Variables		< 20 ^a (n=22)	≥ 20 ^b (n=30)	<i>p</i> -value ^e
		Median (IQR) ^c	Median (IQR) ^c	
A. Masticatory performance assessment				
	Functional teeth ^f	15.5 (12.0-18.0)	23.0 (21.8-24.0)	< 0.001
	Gum mastication performance (Right)	1.0 (1.0-1.0)	2.0 (1.0-3.0)	< 0.001
	Gum mastication performance (Left)	1.0 (1.0-2.0)	2.0 (1.0-3.0)	0.001
B. Physical constitution				
	Right hand grip strength (kg)	21.0 (17.8-27.3)	24.0 (19.8-28.5)	0.166
	Left hand grip strength (kg)	22.0 (19.5-25.0)	22.0 (18.8-29.0)	0.522
	Skeletal muscle mass (%)	90.6 (83.6-94.2)	88.8 (86.2-92.1)	0.591
	Fat mass (%)	150.9 (121.8-178.5)	138.2 (116.4-165.2)	0.684
	Fat-free mass (%)	36.8 (35.2-42.0)	37.4 (32.9-42.7)	0.839
C. Muscle mass of each limb and trunk				
	Right arm (kg)	1.7 (1.6-2.1)	1.7 (1.4-2.1)	0.985
	Left arm (kg)	1.7 (1.6-2.1)	1.7 (1.4-2.1)	0.970
	Right arm (%)	87.2 (79.5-91.3)	84.5 (79.8-89.3)	0.274
	Left arm (%)	85.5 (79.3-90.0)	84.3 (78.5-87.4)	0.448
	Trunk (kg)	16.0 (15.2-18.6)	16.0 (14.1-18.8)	0.846
	Trunk (%)	92.2 (88.5-96.8)	90.3 (86.3-92.9)	0.182
	Right leg (kg)	5.5 (5.0-6.0)	5.2 (4.6-6.4)	0.470
	Left leg (kg)	5.5 (5.0-6.2)	5.2 (4.6-6.4)	0.442
	Right leg (%)	86.7 (82.1-90.3)	83.7 (81.8-87.9)	0.179
	Left leg (%)	87.0 (83.4-92.0)	83.6 (80.0-87.2)	0.061
D. Body composition				
	Body water (kg)	27.1 (26.0-30.8)	27.5 (24.5-31.5)	0.993
	Protein content (kg)	7.2 (6.9-8.2)	7.3 (6.5-8.4)	0.985
	Mineral content (kg)	2.6 (2.5-2.9)	2.7 (2.4-2.9)	0.941
E. Obesity level				
	Body Mass Index (kg/m ²)	22.4 (21.3-25.4)	22.7 (21.0-23.5)	0.781
	Body fat percentage (%)	31.7 (28.2-37.6)	31.1 (26.5-35.7)	0.517
	Internal fat level	9.0 (7.8-11.0)	8.0 (6.0-10.5)	0.538
	Waist circumference (cm)	78.0 (75.0-85.0)	77.0 (72.8-81.0)	0.468

a:Senior Few Functional Teeth Group, b:Senior Many Functional Teeth Group, c:Interquartile range (IQR),

d:Comparisons between the <20 and ≥ 20 groups by χ^2 test, e:Comparisons between the <20 and ≥ 20 groups by

Mann-Whitney U test, f:The number of functional teeth.

2. Comparison between the baseline and follow-up period (Fig.1-A, B, C)

1) Oral function evaluation (Fig.1A)

As for mastication performance (right and left), it was significantly maintained during follow-up period in under and over 65 years groups ($p < 0.01$).

2) Physical function evaluation (Fig.1B)

(1) Physical constitution

Hand grip strength (right and left) was significantly maintained during follow-up period in under and over 65 years groups ($p < 0.05$). No significant difference was observed about skeletal muscle mass (%), fat mass (%) and fat-free mas (%) in under and over 65 years groups.

(2) Muscle mass of each limb and trunk (Fig.1C)

The right arm (%) showed a significant decrease at six years after treatment ($p = 0.021$) in under 20 functional teeth of over 65 years. No significant difference was observed in under 65 years. The left arm (%) showed no significant difference in under and over 65 years. In the trunk (%), it decreased significantly at six years after treatment in over 65 years groups of under ($p = 0.010$) and over ($p = 0.008$) 20 functional teeth groups. In addition, no significant difference was observed in the right and left leg (%) in under and over 65 years.

(3) Body composition and obesity level

There were no significant differences in under and over 65 years groups at any time point (data not shown).

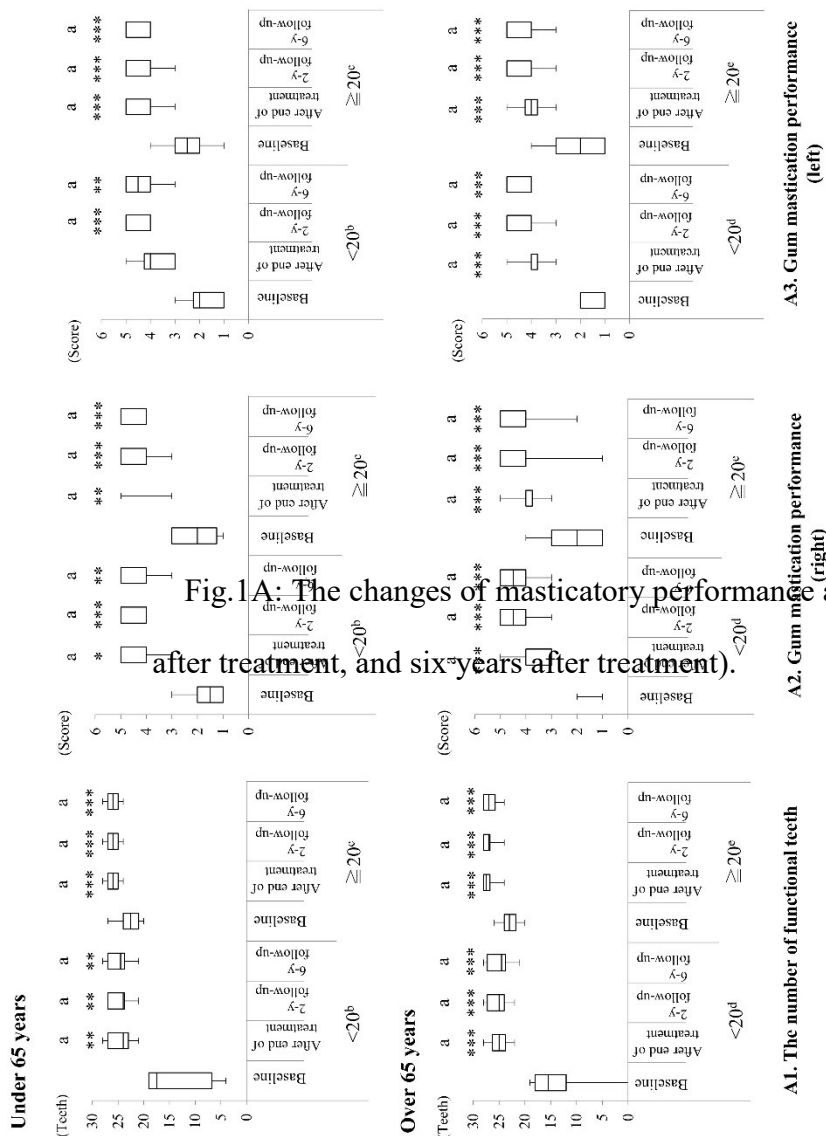


Fig. 1A: The changes of masticatory performance assessment between baseline and the follow-up periods (2 years after treatment, and six years after treatment).

a : Comparisons between the baseline and other follow-up periods, b : Young Few Functional Teeth Group, c : Young Many Functional Teeth Group, d : Senior Few Functional Teeth Group, e : Senior Many Functional Teeth Group, p<0.05, ** p<0.01, ***p < 0.001

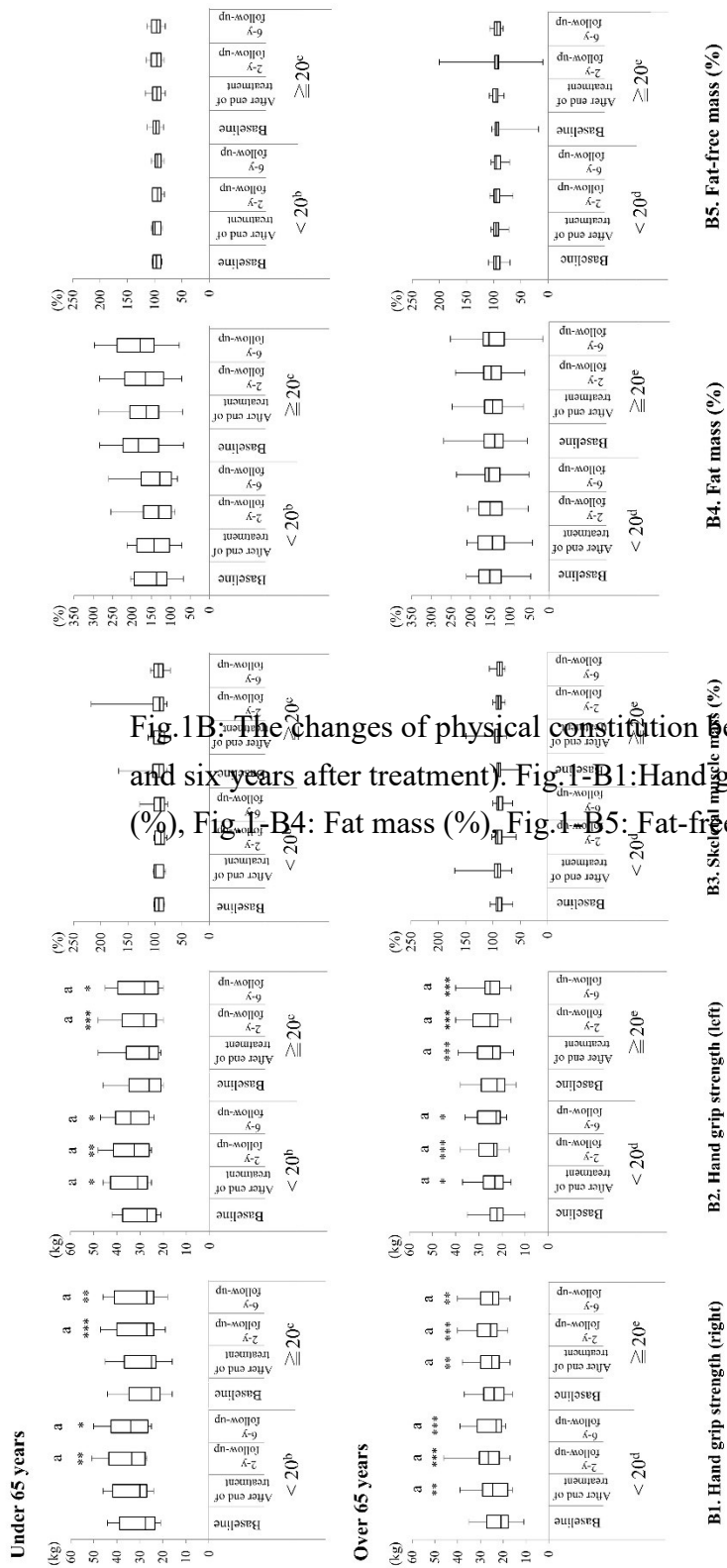


Fig.1B: The changes of physical constitution between baseline and the follow-up period (after 2 and six years after treatment). Fig.1-B1: Hand grip strength (right), Fig.1-B2: Hand grip strength (left), Fig.1-B3: Skeletal muscle mass (%), Fig.1-B4: Fat mass (%), Fig.1-B5: Fat-free mass (%).

a : Comparisons between the baseline and other follow-up periods, b : Young Many Functional Teeth Group, c : Young Many Functional Teeth Group, d : Senior Few Functional Teeth Group, e : Senior Many Functional Teeth Group. p<0.05, ** p<0.01, ***p<0.001

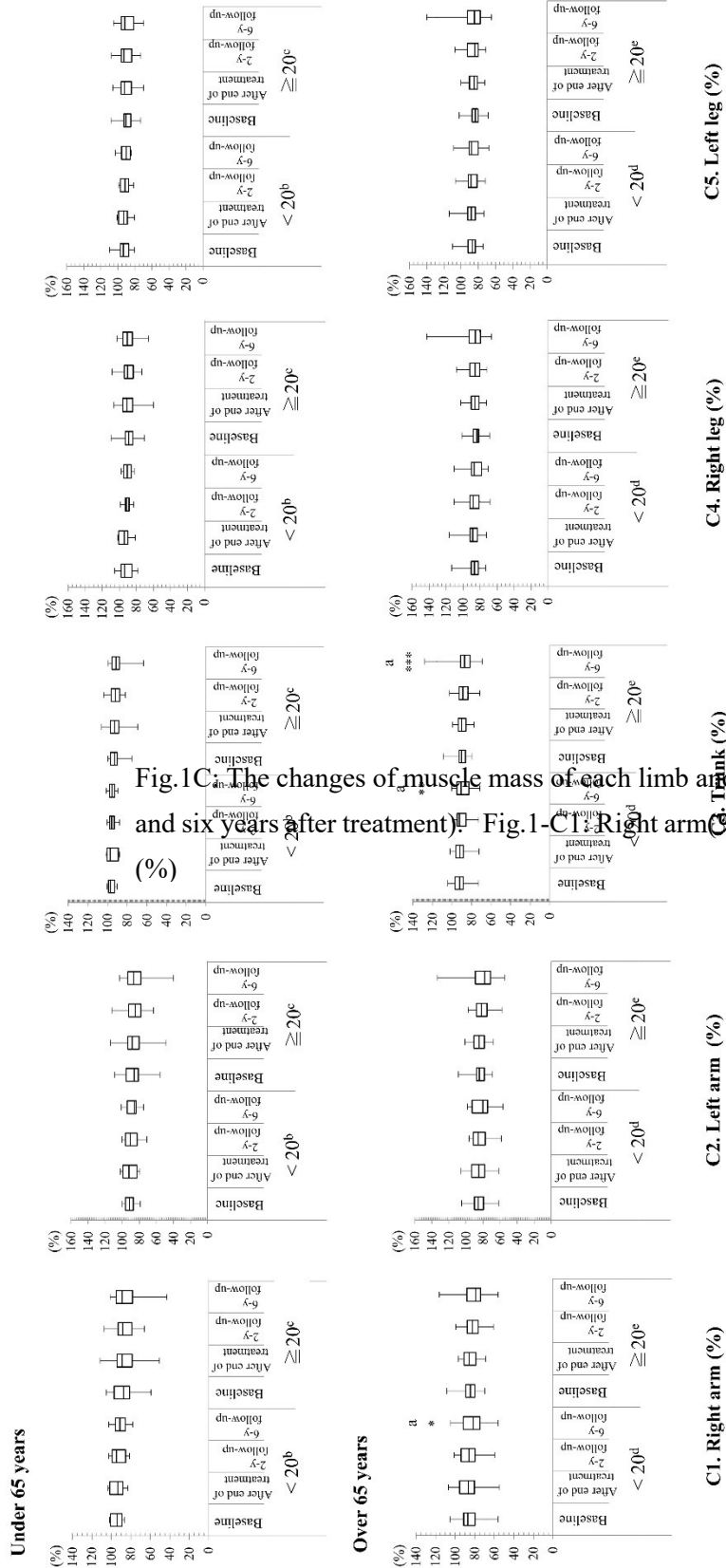


Fig.1C: The changes of muscle mass of each limb and trunk (between baseline and the follow-up period and six years after treatment) Fig.1-C1: Right arm (%), Fig.1-C2: Left arm (%), Fig.1-C3: Trunk(%)

a : Comparisons between the baseline and other follow-up periods, b : Young Few Functional Teeth Group, c : Young Many Functional Teeth Group, d : Senior Few Functional Teeth Group, e : Senior Many Functional Teeth Group, p<0.05, ** p<0.01, ***p < 0.001

Discussion

The purpose of this study was to clarify the effects of dental implant treatment on oral and physical function, chronological change for six years was investigated. Mastication performance and hand grip strength were significantly maintained during follow-up period, but almost no significant difference was observed about body composition in this study.

Regarding masticatory force, it should be evaluated by hand grip strength, which has a significant correlation (8), and gum test is a simple masticatory performance assessment in the older adults (29). Patients wearing dentures are described to have a 1.64 times higher risk of decreased hand grip strength than patients without dentures (30). On the other hand, there is scarce knowledge about the effect of implant treatment on hand grip strength. In the present study, it was inferred that hand grip strength and masticatory performance improved with an increase in the number of functional teeth by dental implant treatment. In the previous studies on the improvement of masticatory performance by gum test after wearing a total denture (31) or an overdenture (30, 32), but the evaluation was very short, within half a year after wearing. few reports after dental implant (30). The long-term retrospective follow-up analysis of this study is clinically significant because reports on mastication performance after dental implant treatment are very scarce (33). The results in this study indicate that hand grip strength and masticatory performance are effective in the long term after dental implant treatment, regardless of the size of the occlusal support area at baseline. Hand grip strength can be used as an indicator of skeletal muscle mass, especially in Japanese (34). It was speculated that the improving hand grip strength after dental implant treatment indirectly suggests an increase in skeletal muscle mass and associated with the recovery of systemic functions.

On the other hand, it was described that skeletal muscle mass cannot be used as an indicator because there is no relationship with masticatory force (8). In addition, the amount of pure muscle tissue is reduced in older adults, so comparisons of relative strength to other populations can be misleading without considering appropriate measurements of muscle size (35). Therefore, for the purpose of static measurement of body composition, including skeletal muscle mass, body composition analyzer was used in this study. InBody, which is a multi-frequency impedance measurement method, has been widely applied in clinical research because it shortens the time required while measuring a large amount of information by simultaneous direct multi-frequency measurement of body area (17,36,37), and it has been reported to be highly accurate (38,39). Although body fat mass increases with age (11), it has been reported that the percentage of it and lean body mass decrease in the older adults (35). Regarding oral function, relationship between few remaining teeth or ill-fitting removable dentures and inappropriate fat mass (20, 40) have been reported. And masticatory function recovery leads to appropriate amount of fat (40). Concerning about occlusal support area recovery and InBody, Takeuchi H et al. was reported that masticatory force, BMI, body fat percentage, and intake of specific nutrients improved after dental implant treatment, but only two cases were included in study (21). In this study, the restoration of the occlusal support area after dental implant treatment did not improve body composition in this study.

There was no gender difference between the participants regardless of the number of functional teeth and insufficient participants to separate by sex, gender was not considered in this study. Whereas the ratio of female participants was 1.4 times higher than that of male in this study, and this proportion was consistent with previous reports that high prevalence of dental implants in females (39). Among older adults Japanese, Fat mass

(%) and FFMI was described higher in females and then intentionally decrease with age (41). In addition, diabetes mellitus significantly affects body composition (42). Therefore, the results of this study are limited due to the presence of the effect of gender differences.

These results indicated that hand grip strength and mastication performance were improved over a long period after dental implant treatment. It was speculated that the improvement in hand grip strength was associated with the recovery of systemic functions, especially in under 65 years old group. In addition, body composition did not improve after dental implant treatment, it was mostly maintained until 6 years later.

Conclusion

- In under 65 years of age, both under and over 20 functional teeth groups had improved masticatory function and hand grip strength that were maintained for 6 years after dental implant treatment. Muscle mass of each limb and trunk, body composition and obesity level were not improved but was maintained for 6 years after dental implant treatment.

- In over 65 years of age, both under and over 20 functional teeth groups had improved masticatory function and hand grip strength that were maintained for 6 years after dental implant treatment. Right arm (%) and trunk (%) with under 20 functional teeth group, and trunk (%) with over 20 functional teeth group decreased significantly after 6 years of treatment. Body composition and obesity level was not improved but was maintained for 6 years after dental implant treatment.

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