Biting ability alteration accompanied by implant restoration in second molar

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This certifies that the Master′s Thesis
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감사합니다.

2011 년 6 월

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ABSTRACT

Biting ability alteration accompanied by extraction and implant restoration in second molar

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The aim of the present study was to analyze biting ability alteration associated with implant restoration of the second molar; the subjective impact of the implant treatment on the patient was also assessed.

Biting ability was recorded objectively before cementation of implant supported single crowns (ISSCs), immediately following cementation, and 1 month after cementation. Subjective evaluation of biting ability was conducted before treatment and 1 month after treatment through use of a questionnaire.

Load-bearing contact area, maximum bite force, and patient satisfaction were found to increase significantly 1 month after cementation of ISSCs. Restoration of the second molar with an implant increased both objective biting ability and subjective satisfaction

one month after cementation of the ISSC. Subjects presenting with a missing second molar may therefore benefit from this type of treatment. Longer study periods and larger sample populations are needed to obtain more definitive results.

Key words: second molar, biting ability, subjective satisfaction

Biting ability alteration accompanied by implant restoration in second molar

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I. INTRODUCTION

Many studies have demonstrated that the prevalence of tooth loss increases with age (Battistuzzi et al., 1987a, 1987b; Salonen et al., 1990; Nitschke and Hopfenmüller, 1996; Walter et al., 2001), and that molars are lost more frequently than other teeth. In particular, the second molar is one of the most frequently lost teeth (Micheelis and Reich, 1999; Kerschbaum, 2006). A fixed partial denture is not the ideal treatment for missing second molars, as cantilevered reconstructions have been shown to produce unfavorable biomechanics (Himmel et al, 1992); additionally, a removable partial denture may prove uncomfortable to the patient in terms of both function and wear (Budtz-Jörgensen, 1996).

Consequently, the use of implant-supported single crowns (ISSCs) for second molar reconstructions appears to be a preferable treatment.

ISSCs have become a frequently used therapy for replacing missing single teeth. The procedure of replacing individual missing teeth with dental implants has high success rates and does not compromise the adjacent natural dentition (Pjetursson and Lang 2008). However, most studies of ISSCs have focused on implant survival rates and biological and technical complications (Jung et al. 2008), and information about the effects of treatment using ISSCs on oral function and daily life is limited. The few studies that focus on oral function have only discussed either bite force or masticatory performance (Matsui et al. 1995; Shiota et al. 1998), but they do indicate that better masticatory function might be expected on a subjective level.

Based upon implant survival rate, the placement of single-tooth implants in the second molar region was found to be an effective and reliable treatment modality (Koo, 2010). However, controversy exists as to whether missing second molars should be replaced. Patients with missing second molars are sometimes not treated with implants due to anatomic positional limits, such as maxillary sinus (Bahat O, 1993) and inferior alveolar nerve (Kilic, 2010). Financial issues and questionable masticatory function (Teofilo, 2007) may also restrict treatment using ISSCs.

The concept of ‘shortened dental arches’ (SDA) was therefore introduced as a reflection of the tendency to limit the use of ISSCs. The SDA concept, allows for sufficient adaptive capacity in subjects in whom at least four occlusal units (OUs) are left: a pair of occluding premolars corresponds to one unit; a pair of occluding molars corresponds to two units (Käyser, 1981). The SDA model has gradually gained

acceptance and has a role in contemporary clinical practice (Witter, 1997; Allen, 1998; Rich and Goldstein, 2002; Korduner, 2006). However, it has been criticized because loss of molars is associated with reduced masticatory performance and insufficient chewing ability (al-Ali, 1998; Applegate, 1954; Fontijin-Tekamp, 2000).

Edentulous patients treated using prostheses supported by dental implants were found to have better masticatory function, higher satisfaction, and improved quality of life in comparison to patients treated with conventional complete mandibular dentures (Bakke et al., 2002; Feine and Lund, 2006; Strassburger et al., 2006). Self-reported masticatory ability depended upon the number of teeth present (Agerberg and Carlsson, 1981; Gotfredsen and Walls, 2007). In addition, the masticatory performance and efficiency, maximum molar bite force, the maximum activity in jaw elevator muscles are correlated positively with the occlusal contacts, the occlusal area of natural teeth, and the number of posterior teeth (Bakke et al., 1990; Wilding, 1993; Bakke, 2006; Buschang, 2006). A previous study showed a significant linear relationship between the number of missing OUs and adverse effects on Oral Health-Related Quality of Life (OHRQoL; Steele et al., 2004).

Evidence from the literature suggests that occlusal unit change imparted by implant restoration of second molars may cause changes in biting ability; however, to date, no investigations of such effects have been published.

The aim of this study was to analyze the effects of second molar implant restoration on biting ability. In addition, the study investigated the subjective effects of the implant treatment.

II. MATERIALS AND METHODS

1. Patient selection

All procedures were performed after obtaining written consent from patient. The study protocol was approved by the Institutional Review Board (IRB) at Gangnam Severance Hospital (Seoul, South Korea). Patients who required implant therapy for missing second molars were recruited at the Department of Periodontology, Gangnam Severance Hospital between March 2010 and October 2010 and were selected as subjects for this study. All patients were in good general health; none had cardiovascular disease or diabetes. Patients were excluded from the study if they lacked opposing teeth, had treatment plans for numerous implant restorations, or presented with temporomandibular disorder, bruxism, or clenching habit, as any of these conditions precluded independent evaluation of the biting ability of the second molar. The surgical and prosthetic procedures were thoroughly explained to each patient.

A total of 21 patients (13 males and 8 females) participated, with a mean age of 51 years and an age range of 36 years to 74 years (Table 1). Four right maxillary second molar implants (#17, according to Two-Digit World Dental Federation Notation), 4 left maxillary second molar implants (#27), 8 left mandibular second molar implants (#37), and 5 right mandibular second molar implants (#47) were performed (Table 2).

Table 1. Age and gender distribution of patients

Gender	Age (years)					Total
	30 to 39	40 to 49	50 to 59	60 to 69	70 to 79	
Male	1	6	5	0	1	13
Female	0	2	2	1	3	8
Total	1	8	7	1	4	21

Table 2. Distribution of implant site

Implant site†	17	27	47	37	**Total**
Patient	4	4	5	8	21

†Two-Digit World Dental Federation Notation

2. Treatment protocol and study design

Biting ability was recorded prior to ISSC cementation, immediately after cementation and 1 month after cementation to allow for adaptation (the specific protocol is described below). A subjective evaluation of biting ability was performed before cementation and 1 month after cementation using the questionnaire (Table 3). All implant surgeries were performed using a two-stage method after permittinging sufficient healing time. The second surgery was performed six and three months later for maxillary and mandibular implants, respectively. Prostheses were delivered three weeks after the second surgery. All prostheses were made and delivered with consideration of criteria such as light infraocclusion, narrow occlusal table, axial loading and minimal contact. The same investigator performed the entire examination and all procedures in the patients.

3. Measurement of maximum occlusal force and occlusal contact area

Occlusal load was measured using a pressure sensitive foil (Dental Prescale Film 50H, type R, GC, Fuji Film, Tokyo, Japan, Figure 1) mounted in a holder during maximum clenching in the intercuspal position for 2 seconds. Tests were performed three times using a new foil each time and with an interval of at least 30 seconds. The patient was asked to close the jaw slowly to ensure correct position and to prevent sliding of the foil while the head was positioned with the Frankfurt plane parallel to the floor. The horseshoe-shaped foil has a thickness of 0.097 mm and contains a layer of microcapsules of various sizes containing a colorless dye and a developer layer. When force is applied,

the foil undergoes a graded color producing chemical reaction as the capsules break, and the involved area turns red. The thinnest capsules with the largest diameters break with a pressure above 5 MPa, and with increasing pressure also the thicker with smaller diameter (Shinogaya et al., 2000). After recording the foils that were digitized (Occluzer FPD-707, Fuji Film, Figure 2) and the occlusal load (Pa), the load-bearing contact area (mm2), and the maximum bite force (N) on the maxillary dental arch for each patient were calculated.

Figure 1. Pressure sensitive foil

(Dental Prescale Film 50H, type R, GC, Fuji Film, Tokyo, Japan)

Figure 2**.** Occluzer FPD-707, Fuji Film

4. Questionnaires

The possible impact of the oral health situation on the daily life in the last month before and the month after cementation of the ISSCs was rated as the total sum of the scores of the three Oral Health Impact Profile (OHIP; Slade and Spencer, 1994) questions concerning biting ability. These three items (Questions 1, 28, and 32) evaluate chewing difficulties in general, chewing of different types of food and difficulties in finishing meals due to dental problems. To further evaluate biting ability, a mastication index with regard to the patient's diet was used; this was modified after Yoshida et al. (2002). Finally, the patients evaluated global satisfaction of treatment with scores from 0 (very satisfied) to 5 (very dissatisfied). The specific questions are presented in Table 3.

Table 3. Questionnaires on daily life

1. Have you had chewing difficulties in general foods because of problems with your teeth? never been experienced (0) hardly ever (1) occasionally (2) fairly often (3) very often (4)
2. Have you had chewing difficulties in different type of foods (hard, tough) because of problems with your teeth? never been experienced (0) hardly ever (1) occasionally (2) fairly often (3) very often (4)
3. Have you had difficulties in finishing meals due to dental problems? never been experienced (0) hardly ever (1) occasionally (2) fairly often (3) very often (4)
4. Chose one of four possibilities for your masticatory function. normal (0) able to eat anything but it takes long (1) able to eat a soft diet only (2) difficult to eat even a soft diet and it takes long (3) only liquid diet (4)
5. Evaluate global satisfaction of treatment with scores from 0 (very satisfied) to 5 (very dissatisfied).

5. Statistical analysis

The D'Agostino–Pearson test was used to test the normality of the distribution. The Friedman test was used to analyze the difference in occlusal load (Pa), load-bearing contact area (mm2), and maximum bite force (N) among the three tests administered before ISSC cementation, just after ISSC cementation and 1 month after ISSC cementation. Post hoc analysis of results was performed using the paired Wilcoxon test with correction for multiplicity.

Wilcoxon's signed rank test was used to analyze the difference in scores between the surveys conducted before ISSC cementation and 1 month after ISSC cementation. Statistical software (MedCalc for Windows, version 11.2.1.0, MedCalc Software, Mariakerke, Belgium.) was used to process the data, and values were deemed statistically significant if $p \leq 0.05$.

III. RESULTS

The outcome variables exhibited non-normal distribution except occlusal load and questionnaire score (Table 4).

Occlusal load was 30.1 ± 4.7 Pa before cementation. It increased to 33.0 ± 6.4 Pa just after cementation and decreased to 31.5 ± 6.3 Pa at 1 month after cementation (p = 0.005; Table 5, Figure 3). The difference between occlusal load before and just after cementation was statistically significant (p = 0.0019). The final value for occlusal load was statistically similar to the initial value.

Prior to cementation, load-bearing contact area was 13.3 ± 8.3 mm^2. The value declined to 11.0 ± 8.5 mm^2 just after cementation and increased to 15.5 ± 6.8mm^2 at 1 month after cementation (p = 0.002; Table 6, Figure 4). The difference between load-bearing contact area immediately after cementation and 1month after cementation was statistically significant (p = 0.0023). The final value measured for this parameter was higher than the first value measured.

Maximum bite force was found to be 405.0 ± 259.6 N before cementation. This value decreased to 361.0 ± 284.2 N just after cementation and increased to 411.8 ± 200.3 N at 1 month after cementation (p = 0.005; Table 7, Figure 5). The difference between maximum bite force immediately after cementation and 1month after cementation was found to be statistically significant (p = 0.0037).

The mean questionnaire score decreased from 5.8 ± 2.8 (prior to cementation) to 2.9 ± 2.5 at 1 month after cementation (p = 0.002; Table 8, Figure 6). Detailed analysis

indicated that the number of negative answers decreased and positive answers increased after final placement of the ISSC (Table 9).

Table 4. Normality test (D'Agostino–Pearson test)

	Before cementation	**Just after cementation**	**1 month after cementation**
Occlusal load (Pa)	0.6825	0.6212	0.1136
Load-bearing contact area (mm^2)	0.0790	0.0001	0.0252
Maximum bite force (N)	0.0103	0.0001	0.1624
Questionnaire score	0.4037	N/A	0.2943

Table 5. Occlusal load alteration [M ± SD(median(95% CI for the median))]

	Occlusal load (Pa)	p-value	Post hoc analysis	
Before cementation	30.1±4.7 30.2(27.0-32.4)	0.005*	0.0019*	0.3927
Just after cementation	33.0±6.4 33.0(29.6-35.0)		0.4445	
1 month after cementation	31.5±6.3 30.2(27.6-33.3)			

* satatistical significance

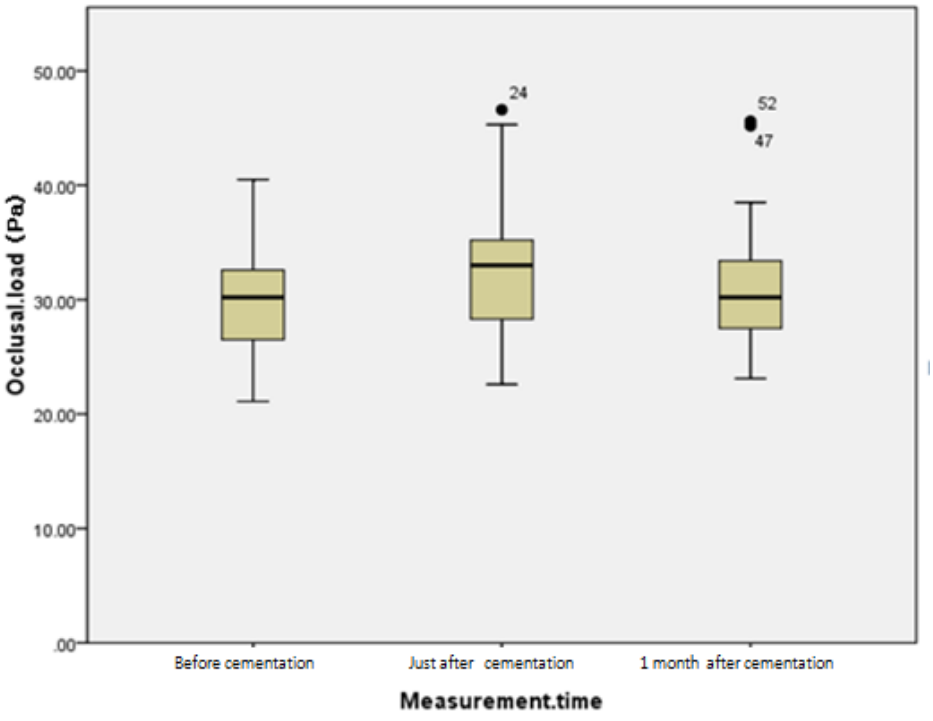

Figure 3. Occlusal load alteration

Table 6. Load-bearing contact area alteration [M ± SD(median(95% CI for the median))]

	Load-bearing contact area (mm^2)	p-value	Post hoc analysis	
Before cementation	13.3±8.3 12.1(8.8-17.3)		0.1327	
Just after cementation	11.0±8.5 9.9(5.3-14.9)	0.002*		0.1054
1 month after cementation	15.5±6.8 14.5(12.2-17.6)		0.0023*	

* satatistical significance

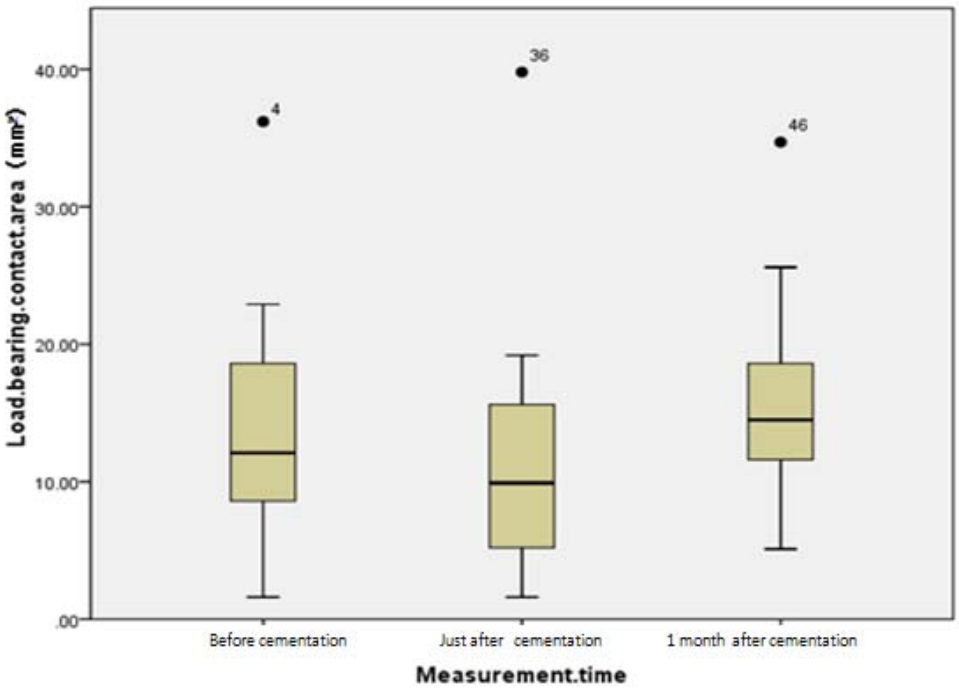

Figure 4. Load-bearing contact area alteration

Table 7. Maximum bite force alteration [M ± SD(median(95% CI for the median))]

	Maximum bite force (N)	p-value	Post hoc analysis	
Before cementation	405.0±259.6 367.0(301.2-467.0)	0.005*	0.2443	0.1536
Just after cementation	361.0±284.2 351.8(171.5-398.8)		0.0037*	
1 month after cementation	411.8±200.3 425.0(333.1-540.9)			

* satatistical significance

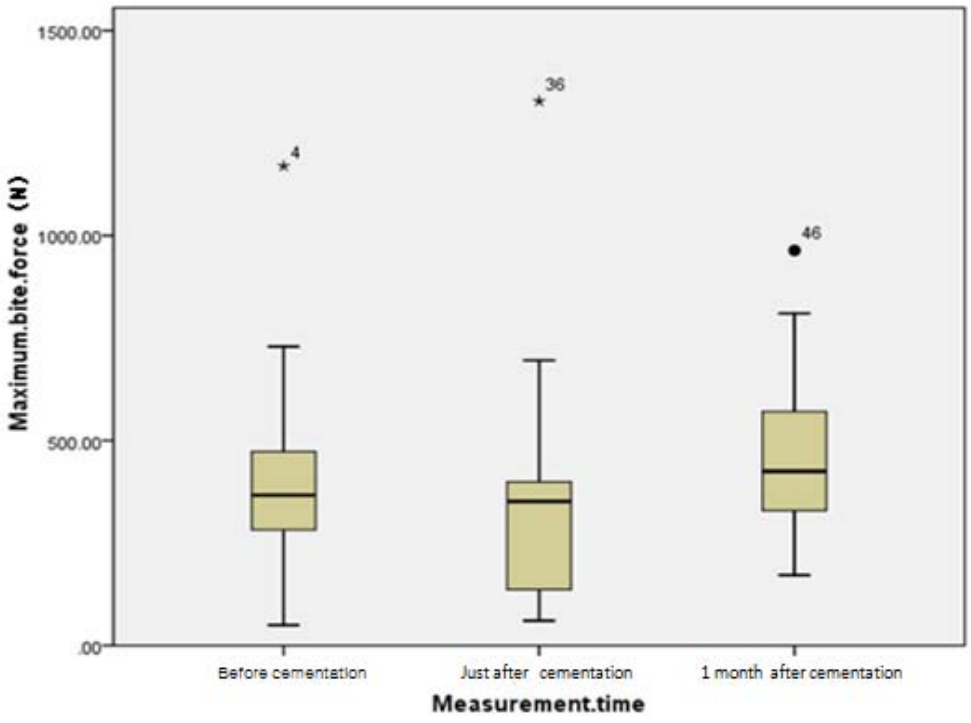

Figure 5. Maximum bite force alteration

Table 8. Questionnaire score alteration [M ± SD(median(95% CI for the median))]

	Before cementation	1 month after cementation	p-value
Questionnaire score	5.8±2.8 6.0(3.3-8.0)	2.9±2.5 2.0(1.0-5.0)	0.002*

* satatistical significance

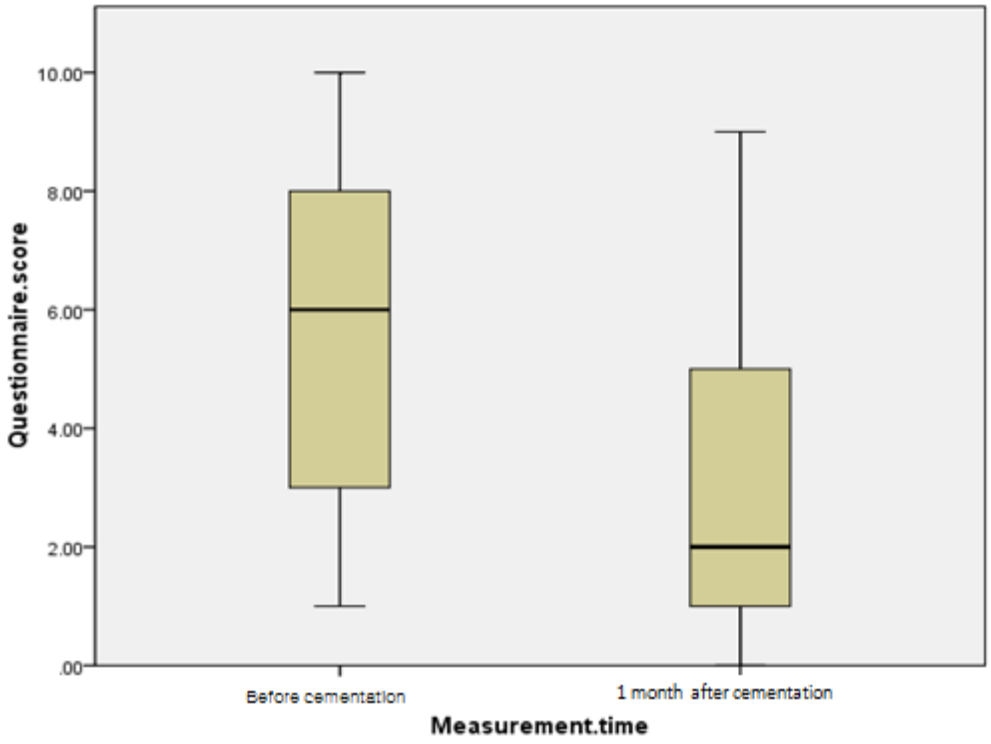

Figure 6. Questionnaire score alteration

Table 9. Questionnaire alteration

1. Have you had chewing difficulties in general foods because of problems with your teeth?		
	Before cementation	1 month after cementation
never been experienced (0)	4	12
hardly ever (1)	8	7
occasionally (2)	5	2
fairly often (3)	3	0
very often (4)	0	0
2. Have you had chewing difficulties in different type of foods (hard, tough) because of problems with your teeth?		
	Before cementation	1 month after cementation
never been experienced (0)	2	7
hardly ever (1)	6	7
occasionally (2)	8	6
fairly often (3)	5	1
very often (4)	0	0
3. Have you had difficulties in finishing meals due to dental problems?		
	Before cementation	1 month after cementation
never been experienced (0)	13	18
hardly ever (1)	8	3
occasionally (2)	0	0
fairly often (3)	0	0
very often (4)	0	0
4. Chose one of four possibilities for your masticatory function.		
	Before cementation	1 month after cementation
normal (0)	10	15
able to eat anything but it takes long (1)	9	6
able to eat a soft diet only (2)	2	0
difficult to eat even a soft diet and it takes long (3)	0	0
only liquid diet (4)	0	0

5. Evaluate global satisfaction of treatment with scores from 0 (very satisfied) to 5 (very dissatisfied)

	Before cementation	1 month after cementation
0 ~ 1	7	15
~2	8	4
~3	1	1
~4	5	1
~5	0	0

IV. DISCUSSION

As occlusal units increase in number, load bearing area and biting force also increase. The association between maximum bite force and the amount of occlusal contact is closet in the posterior region; as a consequence, loss of molar support results in reduction of force (Bakke, 2006). In our study, the number of occlusal units increased with the placement and cementation of ISSCs. One month after cementation, load-bearing contact area and maximum bite force increased to a level greater than before the procedure. This result agreed with previous studies that found that the maximum molar bite force is positively correlated with the occlusal contacts, the occlusal area of natural teeth, and the number of posterior teeth (Bakke et al., 1990; Wilding, 1993; Bakke, 2006; Buschang, 2006).

Changes in occlusion due to ISSC placement could present at first as occlusal interference. It has been shown experimentally that artificial obstacles added to the crown of a molar tooth alter masticatory muscle activity and jaw movements (Bakke, 1980; Hannam, 1981; Magnusson, 1984; Belser, 1985; Karlsson 1992). Malocclusion can cause impairment of masticatory performance and efficiency (English, 2002; Owens, 2002). Significant recoveries were found to occur during the course of repetitive chewing cycles performed under the altered occlusal condition (Yoshiro, 2010). Similarly, patients in our study did not adapt immediately to occlusal variation, as the cementation of the ISSCs caused a decline in biting ability immediately after placement. At this point in treatment, load-bearing contact area and maximum bite force decreased. Occlusal load as a function

of a bite force per unit area increased because there was a greater decrease of load-bearing contact area as compared to the decrease in maximum bite force. After 1 month of adaptation, load-bearing contact area and maximum bite force increased to a level greater than that prior to ISSC cementation, while occlusal load decreased to a similar level to that measured before the procedure.

The replacement of missing teeth with ISSCs was associated with an improved OHRQoL score 1 month after crown cementation (Goshima, 2010). The questionnaire score decrease was statistically significant in a manner similar to that of previous study. For all questions posed, the proportion of negative answers decreased, while positive answers increased. This indicates that the patient's subjective level of satisfaction was improved by the amelioration of biting ability. Tooth loss can be a disabling condition (Fiske, 1998), and has a profound impact on such aspects of patients' well-being as lowered self-confidence and feelings of repugnance towards one's appearance, and can alter behaviors such as socializing and forming close relationships. Our results indicated that psychological satisfaction related to complete dentition was reflected in the questionnaire score.

Occlusal load, load-bearing contact area, and maximum bite force are important in evaluating biting ability, but biting efficiency must also be considered. However, an exact method for evaluating biting efficiency has not been established, and so various methods are used together to determine biting efficiency. It is known that biting efficiency and maximum activity in jaw elevator muscles are correlated positively with occlusal area and the number of posterior teeth (Wilding, 1993; Buschang, 2006). Given this information, we can extrapolate that biting efficiency is improved with increased load-

bearing contact area and maximum bite force. In our study, all prostheses were made and delivered based upon such criteria as light infraocclusion, narrow occlusal tables and minimal contact. These properties were desirable as osseointegrated implants do not permit the same mobility during chewing and loading as do natural teeth with periodontal ligaments (Lundgren and Laurell, 1994). Such properties might affect biting efficiency negatively; however, effects due to prosthetic limitations were expected to be negligible. Further studies are necessary to determine the biting efficiency of second molar implants.

The inspiration for this research was an inquiry by a patient with regard to rehabilitation of a missing second molar. Our results indicate that treatment of a missing second molar using an implant improves both biting ability and patient quality of life.

V. CONCLUSION

Restoration of a missing second molar was associated with an objective increase in biting ability. The subjective measure of patient satisfaction also improved 1 month after placement and cementation of ISSCs. Therefore, subjects lacking second molars may benefit from this treatment. Follow-up over longer periods and larger sample populations are needed to determine more conclusively the effects of this treatment.

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국문요약

제 2 대구치에서 임플란트 수복에 따른 교합능력 변화

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본 연구의 목적은 상실 제 2 대구치에서 임플란트 수복에 따른 교합 능력의 변화를 분석하고 또한 제 2 대구치에서 임플란트 치료의 주관적 영향을 평가하는데 있다.

임플란트 보철물 접착전, 접착 직후, 접착 1 달 후에 교합 능력을 객관적으로 측정하였다. 모든 환자에서 치료 전과 1 달 후에 설문을 통하여 교합능력에 대한 주관적 만족도를 조사하였다.

임플란트 환자에서 보철물 접착 1 달 후에 교합면적, 최대 교합력, 환자의 만족도가 접착전과 비교하였을 때 통계학적 유의성 있게 증가하였다. 임플란트를 이용한 상실 제 2 대구치의 수복 1 달 후 객관적인 교합 능력과 주관적인

만족도 모두 증가하였다. 그러므로 제 2 대구치를 상실한 환자에서 임플란트를 이용한 수복은 유용한 치료 방법이 될 수 있다. 더욱 명확한 결과를 위해서는 장기적 관찰과 환자수가 많은 연구가 필요할 것이다.

핵심 단어: 제 2 대구치, 교합 능력, 주관적 만족도