Multicenter Experience with Maxillary Prostheses Supported by Brånemark Implants: A Clinical Report

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This retrospective study involved Japanese patients with prostheses supported by Brånemark implants following maxillectomy. Questionnaires were sent to 75 institutions, and data on 19 patients were collected from 8 institutions. The mean age of patients at the time of implant placement was 64.2 years (range 22 to 82 years). The mean follow-up time was 27.6 months. Of the 81 implants placed, 16 were lost for an implant survival rate of 80.2%. The effects on implant survival rate of radiotherapy, chemotherapy, hyperbaric oxygen therapy, and the support system of the prosthesis were analyzed, but no significant differences were observed.
(INT J ORAL MAXILLOFAC IMPLANTS 1998;13:531–538)

Key words: Brånemark implants, chemotherapy, maxillary prostheses, maxillary tumor, multicenter study, radiotherapy, survival rate

The proven effectiveness of prosthetic treatment using osseointegrated implants has been widely recognized in Japan, where this approach is considered to be one of the most useful.[1,2]

Maxillary defects are mainly the result of tumors, congenital malformations, trauma, inflammation, cysts, and the like. In particular, defects following resection of malignant maxillary tumors are frequently associated not only with maxillary bone defects, but also with a wide range of dental problems. Such defects interfere with major oral functions such as mastication, deglutition, and speech, and lead to facial deformities that can hinder the patient's return to normal social life. In addition, it is difficult to maintain jaw prostheses in satisfactory condition over the long term because of a variety of factors, including recurrence or metastasis of the primary tumor, ulceration or myelitis caused by radiotherapy, and postsurgical disturbances in mouth opening.[3,4] Conventionally, clasps or attachments have been used to secure jaw prostheses. Prostheses have also been supported by engaging undercuts in the surrounding tissues of the edentulous jaw. However, specialized skills are required to use implants to support prostheses in such jaws since many problems involving stability, closure of the maxillary defect, and occlusal condition have been reported for such prostheses.[3] It is particularly difficult to achieve a satisfactory result in the edentulous jaw.

Recently, with the use of questionnaires, a retrospective study of patients with maxillary prostheses supported by Brånemark implants following maxillary tumor resection was conducted. This report describes the treatment results and current clinical condition of these patients.

Materials and Methods

In March 1995, questionnaires (Appendix 1) were sent to 75 institutions in Japan. Subjects were limited to those in whom Brånemark implants (Nobel Biocare, Goteborg, Sweden) were used to retain maxillary prostheses following maxillectomy. Patients with congenital malformations such as cleft palate and those with maxillary defects resulting from inflammation, trauma, cysts, and so forth, were excluded.

The questionnaire was used to gather the following information: *(1)* general information such as the

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Table 1 Names of Institutions and Number of Patients

Institution	No. of patients
Nagoya University	5
Hamamatsu Medical School	2
Tokyo Medical and Dental School	1
Tokyo Dental School	1
Nippon Dental School	1
Kyoto University	1
Fujita Health University	1
Saga Medical School	7
Total	19

Table 2 Characteristics of Postoperative Tumor Patients

					Implants	
Patient	Age (y)	Sex	Primary disease*	Size**	Placed	Lost
1	81	F	SCC	T2	5	0
2	43	F	Ameloblastoma	Unidentified	5	0
3	82	M	SCC	T1	4	0
4	71	M	SCC	T3	5	2
5	63	F	SCC	T4	5	1
6	22	M	Mucoepithelial carcinoma	T4	3	0
7	45	F	Mucoepithelial carcinoma	Unidentified	5	2
8	67	M	SCC	T3	3	0
9	55	F	SCC	T3	5	2
10	57	M	SCC	T4	7	1
11	82	F	SCC	T3	2	0
12	65	M	Adenocystic carcinoma	Unidentified	5	4
13	60	F	Adenocystic carcinoma	T4	4	0
14	67	M	SCC	T1	5	3
15	65	F	SCC	T2	3	1
16	74	M	SCC	T1	5	0
17	77	F	Pleomorphic adenoma	15mm	2	0
18	78	M	SCC	T1	5	0
19	66	M	SCC	T2	3	0

*SCC = squamous cell carcinoma.
**The size of benign tumors was not determined; the T class of the TNM classification system (UICC, 1987) was used to index the size of malignant tumors.

patient's age, gender, primary disease, site, and treatment (surgery, chemotherapy, radiotherapy, hyperbaric oxygen therapy, reconstructive surgery by bone grafting, and so forth); *(2)* information related to the implants, such as the time required for connection of abutments after implant placement, the type of prosthesis, and time since prosthesis placement; and *(3)* information regarding the implants used, the implantation site, bone quality at the implantation site (based on the classification system of Lekholm and Zarb[5]), condition of the implants (lost or survived, functional or nonfunctional) (Appendix 1). The criteria for survival of implants were that they were not clinically abnormal and that no radiolucency around the implants was recognized on radiographs.

The effects of chemotherapy, radiotherapy, hyperbaric oxygen therapy, and the method of prosthesis support on implant survival were evaluated using the χ^2 test.

Results

Responses were received from 35 (46.6%) of the 75 institutions contacted. Nineteen patients restored with maxillary prostheses anchored by Brånemark implants after maxillary tumor resection were reported by 8 institutions (10.6%) (Table 1). No such cases were reported by the other 27 institutions who responded. Patient age ranged from 22 to 82 years, with a mean of 64.2 years. The study group comprised 10 males and 9 females (Table 2). Implant survival rates were 77.8% in males and 83.3% in females, or approximately 5.5% higher in females (Table 3). The primary disease most frequently involved the maxillary gingiva (12 patients), followed by the hard palate (3 patients), and then the soft palate, maxillary sinus, and pharynx (1 patient each) (Table 4). The primary disease was malignant in 17 patients and benign in 2 patients. The size of the tumor and the number

Table 3 Implant Survival Rates for Female and Male Patients

Gender	Mean age (y)	No. of patients	Implants		Survival rate (%)
			Placed	Surviving	
Female	63.4	9	36	30	83.3
Male	64.9	10	45	35	77.8
Total	64.2	19	81	65	80.2

Table 4 Sites of Primary Disease

Site	Maxillary gingiva	Hard palate	Soft palate	Sinus	Pharynx	Total
Left	8	3	1	1	0	13
Right	4	0	0	0	1	5
Total	12	3	1	1	1	18*

*One patient unknown.

Table 5 Implant Survival Rates for Bar and Magnetic Attachments

Type of attachment	No. of patients	Implants		Survival rate (%)
		Placed	Surviving	
Bar	12	53	41	77.4
Magnetic	4	17	13	76.5
Total	16	70	54	77.1

of implants placed and lost for each patient are shown in Table 2. Tumor size was not determined for benign tumors, and the T class of the TNM classification system (UICC, 1987) was used to index the size of malignant tumors (Table 2).

In 16 of 19 patients, maxillary prostheses had been fabricated before the questionnaires were completed. The mean time between implant placement and abutment connection was 9.1 months. Removable prostheses were used for all patients and were supported by a bar attachment in 12 (75%) and by a magnetic attachment in 4 (25%). Survival rates for implants in these groups were 77.4% and 76.5%, respectively. The mean time from prosthesis placement was 20.5 months (Table 5). A total of 81 implants were placed and 16 were lost, for an implant survival rate of 80.2%. The mean follow-up period was 27.6 months. Differences in implant survival rates among four groups (radiotherapy only, chemotherapy only, combined radiotherapy and chemotherapy, and nonradiotherapy and nonchemotherapy) were investigated. One patient was excluded because it was not known whether chemotherapy and radiotherapy were provided. The 7 patients in the nonradiotherapy and nonchemotherapy group had 21 of 30 implants surviving, for a rate of 70%. The 3 patients in the radiotherapy only group had 10 of 12 implants surviving, for a rate of 83.3%. The 1 patient in the chemotherapy only group had all 5 implants survive, for a rate of 100%. The 7 patients in the combined radiotherapy and chemotherapy group, in which 23 of 27 implants survived, had a rate of 85.2% (Table 6).

In the radiotherapy group, survival rates, mean irradiation dose, and time between radiotherapy and initial surgery were investigated in 7 patients in whom radiotherapy was administered prior to implant placement, in 1 patient in whom radiotherapy was performed after implant placement, and in 2 patients in whom radiotherapy was performed both before and after implant placement. The mean irradiation dose in the group that received radiotherapy before implant placement was 62.3 Gy. The mean period before implant placement was 77.3 months, and the implant survival rate was 82.8%. Radiotherapy was performed after implant placement in only 1 patient at a dose of 60.8 Gy. The period between placement and radiotherapy was 1 month, and the implant survival rate was 100%. The mean irradiation dose in the group that received radiotherapy both before and

Table 6 Implant Survival Rates for Radiotherapy and Chemotherapy Patients

	No. of patients	Implants		Survival rate (%)
		Placed	Surviving	
R(–) + C(–)	7	30	21	70
R(+) only	3	12	10	83.3
C(+) only	1	5	5	100
R(+) + C(+)	7	27	23	85.2

R(+): radiotherapy performed.
C(+): chemotherapy performed.
R(–): radiotherapy not performed.
C(–): chemotherapy not performed.

Table 7 Implant Survival Rates for Patients Receiving Radiation Before, After, and Before and After Implantation

Time of radiation	No. of patients	Implants		Survival rate (%)	Irradiation	
		Placed	Surviving		Dose (Gy)	Interval (mo)
Before implantation	7	29	24	82.8	62.3	77.3
After implantation	1	4	4	100	60.8	1
Before and after implantation	2	6	5	83.3	39.2 (Before) 40.6 (After)	6.5 13

Table 8 Implant Survival Rates for Patients Treated with Irradiation and HBO and with Irradiation Only

Treatment	No. of patients	Implants		Survival rate (%)
		Placed	Surviving	
Irradiation with HBO	4	19	16	82.4
Irradiation only	6	20	17	85.0

HBO = hyperbaric oxygen.

Table 9 Correlation Between Site of Implants and Survival Rate

Site	Implant length (mm)						Total	Implants lost	Survival rate (%)
	6	7	10	13	15	18			
Incisor	0	3	5	5	0	0	13	3	76.9
Canine	0	2	3	5	9	3	22	1	95.5
Premolar-molar	1	2	5	7	0	0	15	6	60.0
Maxillary process	0	0	5	2	2	2	11	3	72.2
Zygomatic process	0	2	1	1	2	0	6	1	83.3
Hard palate	0	1	0	0	0	0	1	1	0
Grafted bone	0	4	3	1	3	2	13	1	84.6
Total	1	14	22	21	16	7	81	16	80.2

after implant placement was 79.8 Gy, and the mean period between radiotherapy and placement was 6.5 months before and 13 months after placement. The implant survival rate was 83.3% (Table 7). The differences in survival rates between the two groups that received radiotherapy either before or after implant placement were not statistically significant.

In 4 patients in the radiotherapy group that received hyperbaric oxygen therapy, 3 of 19 implants were lost for a survival rate of 84.2%. In 6 patients who did not receive hyperbaric oxygen therapy, 3 of 20 implants were lost for a survival rate of 85% (Table 8). The difference between these two groups was not statistically significant.

The placed implants included 45 standard-type (55.6%), 26 self-tapping (32.1%), and 10 MK-II (12.3%). Lengths of the implants used were 10 mm (27.2%), 13 mm (25.9%), 15 mm (19.8%), 7 mm (16%), 18 mm (8.6%), and 6 mm (1.2%) (Table 9). The implant diameter was generally 3.75 mm, with the exception of two 4-mm- and two 5-mm-diameter implants.

The most common implant sites were the canine tooth (22), followed by the premolar and molar (15), anterior tooth (13), maxillary process (11), and zygomatic process (6). Survival rates according to the implantation site were 95.5% for the canine followed by 83.3% for the zygomatic process, 76.9% for the anterior tooth, 72.2% for the maxillary process, and 60% for the posterior tooth (Table 9). However, actual function rates were 69.2% for the anterior tooth, 63.6% for the canine, 45.5% for the maxillary process, 33.3% for the zygomatic process, and 6.6% for the posterior tooth. For sites other than the anterior tooth and canine, function rates were 50% or less. Bone quality at the implantation site was most frequently observed to be Lekholm and Zarb[5] class 3 (54%), followed by class 4 (26.8%).

Implants were placed in grafted bone in 3 patients: 1 in whom the alveolar ridge was reconstructed using a block of autologous iliac bone; 1 in whom iliac cancellous bone was grafted in the maxillary sinus base on the opposite side; and 1 in whom iliac bone was grafted in the inferior nasal concha. Thirteen implants were placed following graft healing and 2 were lost, for a survival rate of 84.6%.

Discussion

In accordance with recent improvements in treatment results for malignant tumors of the oral and maxillofacial region, it is important to enhance the patient's postsurgical quality of life. In particular, patients who have undergone maxillectomy resection not only require restoration of masticatory function, but also deglutition, speech, nasopharyngeal closure function, and facial morphology.

In this investigation, neither the number of remaining teeth nor the occlusal condition after surgery was evaluated, since the objective was to assess the implant survival rate in patients with maxillary defects. However, these factors should be considered when evaluating masticatory function in patients with maxillary defects.

Although questionnaires were sent to 75 institutions, only 19 patients from 8 institutions met the inclusion criteria for this investigation. In the study of Ohyama et al,[4] implants were used for maxillofacial prosthetic treatment at 68 of 540 institutions, and Brånemark implants were used at a majority (35) of those institutions. In their investigation, details were not provided regarding the number of patients in whom Brånemark implants were used for treatment of maxillary defects after tumor resection.

Granström et al[6] reported approximately 35% loss of implants based on 11 years of clinical observation of 125 implants in 32 patients who had undergone radiotherapy to the craniofacial bones. The failure rate was found to be significantly higher than the 14% failure rate reported by Jacobsson et al,[7] the 9% failure rate reported by Lundgren et al,[8] or the 5% failure rate reported by Wolfaardt et al.[9] However, based on long-term observation, Granström et al[6] concluded that radiotherapy is a risk factor for reduced survival of implants, and that the survival rate of implants differed depending on the implantation site. In addition, they reported a 14% failure rate for implants in the maxillary bone, which is in agreement with the failure rate observed in the present investigation (Table 6).

The optimal time for placing implants in patients receiving radiotherapy has not yet been determined. In terms of quality of life, early placement of implants is desirable, but a period of several years may be required to evaluate the effectiveness of tumor treatment. Furthermore, a period of several months is required after radiotherapy for bone healing. Marx and Johnson[10] insisted that a period of 6 to 18 months is necessary after radiotherapy to minimize serious complications such as postradiation osteomyelitis following surgical invasion of irradiated tissues. According to Granström et al,[6,11] implants are generally lost within 6 years of initial surgery in patients who receive radiotherapy. They recommend that the patient's oral function be restored in the early stage using implants in combination with hyperbaric oxygen therapy. In this investigation, implants were placed 77.3 months after radiotherapy, suggesting that implants were placed after confirming that there was no recurrence of the tumor and the effects of radiation on the bones and soft tissues had completely subsided.

No statistically significant difference was observed in implant survival rate in patients receiving radiotherapy before and after implantation, because the sample size was too small in this patient population. However, Granström et al[12] stated that when radiotherapy is performed after implantation, not only should prostheses and abutments be removed, but implants should be re-covered by mucosa or skin during radiotherapy, since skin ulcers could develop around the implantation site as the result of backscatter. In this multicenter investigation, no complications resulting from radiation

exposure after implantation were reported. Nevertheless, special care should be taken when performing radiotherapy on patients after implants have been placed.

Hyperbaric oxygen therapy reverses tissue damage caused by radiotherapy and has been employed for the treatment of radiation-induced osteomyelitis and to enhance success rates in reconstruction surgery.[13,14] In the recent literature, it has been reported that the survival rate of implants can be improved by performing hyperbaric oxygen therapy before and after radiotherapy.[6] In the present investigation, hyperbaric oxygen therapy was administered both before and after radiotherapy in only four patients, who were treated at the Department of Maxillofacial Surgery of Nagoya University. Currently, it appears that hyperbaric oxygen therapy to enhance the survival rate of implants after radiotherapy is not widely used.

In this survey, survival rates of implants were compared among four groups that were classified according to whether radiotherapy and/or chemotherapy had been administered (Table 6). The sample size was small and included only 1 patient in the chemotherapy only group and 3 patients in the radiotherapy only group. It was therefore not possible to determine whether radiotherapy and/or chemotherapy affect the survival of implants. The survival rate in the nonradiotherapy and nonchemotherapy group was the lowest of the four groups. It is thought that factors other than radiotherapy and chemotherapy were involved in the loss of implants. The number of lost implants in the nonradiotherapy and nonchemotherapy group was nine. Most of those lost were 7 mm in length (5), followed by 10 mm (2), 13 mm (1), and 15 mm (1). Lengths of the lost implants in the other three groups were 7 mm and 10 mm. These findings suggest that shorter implants are lost more frequently than long implants.

In patients with associated maxillary defects, two types of prostheses supported by implants should be considered: fixed and removable. In the present investigation, all prostheses were removable because the major cause of the defect was tumor resection. Accordingly, dentures must be easily removable for postsurgical observation and must be easily cleaned by the patient. This probably was one reason that it was not possible to embed a satisfactory number of implants. Hutton et al[15] reported that, in the treatment of maxillary edentulous patients using implants, those with removable prostheses generally tended to show higher failure rates than did those with fixed restorations during a 5-year observation period. Moreover, in the study of Jemt and Lekholm,[16] the implant failure rate was higher for removable (16% within 1 year of placement) than for fixed prostheses. Based on the findings of these reports, it may be preferable to perform bone grafting and ensure that a sufficient number of implants are embedded to permit the placement of a fixed prosthesis in patients in poor condition after maxillary tumor resection. However, the procedure should be performed only after the clinical course of the tumor has been adequately observed, taking into consideration the serious consequences of tumor recurrence. In addition, for the placement of removable prostheses, it is important to carefully analyze the implant support and occlusal characteristics so as to minimize lateral stresses on the implants.

The results of the present investigation do not permit the comparative determination of whether bar or magnetic attachments are more effective for supporting implants, since no significant differences were observed in implant survival rates. However, implant survival rates in these patients were high despite the fact that most had malignant maxillary tumors and belonged to high-risk groups that underwent radiotherapy, chemotherapy, and surgical resection. This was presumably because each implant was connected using a bar.

In general, it is more difficult to place implants in the maxilla than in the mandible, since the maxilla is more anatomically complicated and the bone quality and quantity are different from those of the mandible. In addition, the implantation site is restricted when there are associated maxillary defects. In the present study, the largest number of implants had been placed in the canine region, and there was loss of only a single implant. Based on these results, the canine is considered to be the most suitable site for placing implants. In contrast, 6 of 15 implants were lost in the maxillary premolar and molar regions, presumably not ideal sites for implants. The reason for this may be that bone mass is inadequate because of the adjacent maxillary sinus, that the bone is more porous than in the anterior area, or that the bone is damaged by radiotherapy or chemotherapy. Furthermore, in most patients, the implants at these sites that were lost were short (7 or 10 mm). However, relatively long implants can be embedded in the maxillary process and the zygomatic process, suggesting that these are suitable sites for implant placement. Implants were actually functional in one half or less of the patients when located in the molar, maxillary process, and zygomatic process. The function rate was lowest in the molar region, possibly because secondary surgery was delayed as a result of disease recurrence or reconstruction by bone grafting, or because of the inclusion of patients who died from

the recurrence of disease or metastasis. Based on the current findings, it should be useful to determine whether implants were actually functional in addition to evaluating their survival and failure rates.

Three patients who received bone grafts were included in this study. Among them, resorption of grafted bone and loss of implants were recognized, and prostheses were removed from one patient in whom bone was grafted in the maxillary sinus. Currently, a variety of bone grafts may be employed to address bone resorption in the maxilla. These include performing the aforementioned surgery for elevation of the maxilla, grafting of iliac cancellous bone or an iliac bone block, interpositional bone grafting in conjunction with Le Fort I osteotomy, and placement of a horseshoe-shaped onlay graft in the remaining maxilla. With any of these methods, implants can be placed simultaneously with bone grafting or after bone viability has been confirmed. No evaluation based on long-term observation has been reported regarding these two methods. Over a 2-year observation period, the mean survival rate reported by Nyström et al[17] was 77.4% (54.4% in the development group and 88.3% in the routine group), while the survival rate reported by Adell et al[18] was 75.3%. Although the observation period was only 2 years, the results of Nyström et al were as would be expected when compared with an implant survival rate of 78% to 92%[18–21] for conventional treatment of the edentulous maxilla. The question of whether bone should be grafted in a maxillary defect remains controversial; however, bone grafting in the remaining maxilla is usually required to improve the chances of recovery of masticatory function and to enhance the survival rate of implants.

The choice of a self-tapping or standard implant largely depends on the surgeon's preference and experience as well as the condition of the bone. In addition, the preferred implant placement method (ie, the choice between use of a drill or a tap) has not yet been determined. In the literature, the majority of implants used in the maxilla were of the standard type. This is probably the result of the developmental process of implants. Currently, there are no reports of cases in which a prosthesis was placed on MK-II implants. Survival rates of implants according to the type used have almost been the same as in past reports on general tooth defects, with no significant differences observed.[22] Nevertheless, studies have shown loss rates of 28.9% and 15.3%, respectively, for standard-type and old-type self-tapping implants. In patients with poor bone quality, a self-tapping implant is considered preferable, and it has been suggested that the choice of implant and the placement method have a significant effect on implant survival.

Conclusion

A questionnaire survey involving Japanese institutions was conducted to investigate closure of maxillary defects and recovery of masticatory function following tumor resection. Of the 75 institutions that cooperated in the survey, patients meeting inclusion criteria were obtained from 8. The mean age of the patients was 64.2 years, and the mean observation period was 27.6 months.

The total number of placed implants for all patients was 81, of which 16 were lost, for a survival rate of 80.2%. Radiotherapy, chemotherapy, hyperbaric oxygen therapy, and methods used to support the prostheses were statistically evaluated to determine whether these factors had a significant effect on implant survival rates. The results seen in this relatively small patient population showed no significant differences in survival rates. The patients included in the survey were considered the most difficult type to treat, so no judgment of treatment method could be established.

Acknowledgments

We would like to thank our colleagues at the 75 medical institutions who kindly cooperated with the questionnaire and especially those at the 8 institutions that provided clinical cases (in no particular order): Dr Minoru Ueda and Dr Atsushi Niimi, Department of Oral Surgery, Nagoya University School of Medicine; Dr Michio Shikimori, Department of Oral and Maxillofacial Surgery, Hamamatsu University School of Medicine; Dr Takashi Ohyama and Dr Haruyuki Yanagisawa, Department for Stomatognathic Dysfunction, Tokyo Medical and Dental University School of Dentistry; Dr Shoji Enomoto, The Second Department of Oral Surgery, Tokyo Medical and Dental University School of Dentistry; Dr Hitoshi Takamori and Dr Atsushi Nomura, Department of Oral Implantology, The Nippon Dental University School of Dentistry; Dr Tomohiro Shigematsu and Dr Chikara Saito, The Second Department of Oral and Maxillofacial Surgery, Tokyo Dental College School of Dentistry; Dr Yoichi Tsuboi, Department of Oral and Maxillofacial Surgery, Kyoto University Faculty of Medicine; Dr Takaaki Tujikawa, Department of Oral and Maxillofacial Surgery, Fujita Health University School of Medicine.

Appendix 1: Survey Questionnaire

I. General examination
   1. Age
   2. Sex
   3. Primary disease and location
   4. Treatment for primary disease
      Surgery
      Chemotherapy
      Radiotherapy
      Preoperative radiotherapy (Gy)
      Radiotherapy before implant placement (Gy)

Term from radiotherapy to implant placement (months)
Postoperative radiotherapy (Gy)
Radiotherapy after implant placement (Gy)
Term from radiotherapy to implant placement (months)

5. Jaw reconstruction (Yes/No)
   Method and term of reconstruction
6. Bone grafting: (Yes/No)
   Method and term of bone grafting
7. Hyperbaric oxygen therapy (Yes/No)
   Before implant placement (ATM/times/days)
   After implant placement (ATM/times/days)

II. Prosthodontic treatment
1. Term from implant placement to abutment connection (months)
2. Type of prosthesis
3. Follow-up term after placement of prosthesis (months)
4. Region of missing teeth, implant placement, and prosthesis

III. Implant
1. Type
2. Length (mm)
3. Diameter (mm)
4. Region
5. Bone quality (classification of Lekholm and Zarb[5])
6. Bone quality of grafted bone (hard/medium/soft)
7. Present status (functional/nonfunctional/lost)
8. Term from implant placement to implant loss (months)
9. Term from loading to implant loss (months)
10. Term from implant placement to abutment connection (months)

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