Original

Changes in oral health-related quality of life after oral rehabilitation with dental implants in patients following mandibular tumor resection

Naoko Sato¹⁾, Shigeto Koyama¹⁾, Takehiko Mito¹⁾, Kuniyuki Izumita¹⁾,
Risa Ishiko¹⁾, Kensuke Yamauchi²⁾, Hitoshi Miyashita²⁾, Takenori Ogawa³⁾,
Moe Kosaka¹⁾, Tetsu Takahashi²⁾, and Keiichi Sasaki⁴⁾

¹⁾Tohoku University Hospital, Maxillofacial Prosthetics Clinic, Sendai, Japan

²⁾Division of Oral and Maxillofacial Surgery, Tohoku University Graduate School of Dentistry, Sendai, Japan

³⁾Department of Otolaryngology-Head and Neck Surgery, Tohoku University Graduate School of Medicine, Sendai, Japan

⁴⁾Division of Advanced Prosthodontics, Tohoku University Graduate School of Dentistry, Sendai, Japan

(Received July 9, 2018; Accepted October 24, 2018)

Abstract: Oral rehabilitation with prosthodontic treatment considerably influences the well-being and quality of life of patients after ablative oral tumor surgery. This study evaluated the effects of implant-supported prostheses (ISPs) on oral health-related quality of life (OHRQoL) and chewing ability in 10 patients who requested ISPs after mandibular oral tumor resection. OHRQoL was assessed using the Japanese version of the Oral Health Impact Profile (OHIP-49) before and one year after ISP placement. Chewing ability, including self-assessed masticatory ability and occlusal force, was examined at one year after ISP placement. The initial mean total OHIP-49 score of 65.3 ± 9.79 decreased to 46.0 ± 8.14 at one year after ISP placement. Mean OHIP-49 score decreased in all domains, whereas self-assessed masticatory ability increased within one year of ISP placement. There were no significant differences between prosthesis types with respect to the mean OHIP-49 score or self-assessed masticatory ability. In conclusion, ISP

placement improves OHRQoL and the self-assessed masticatory ability. Moreover, the prosthesis type might not significantly affect OHRQoL.

Keywords: oral health-related quality of life; oral rehabilitation; oral tumor; dental implant; occlusal force.

Introduction

Postoperative rehabilitation of facial esthetics and oral function is a major clinical challenge in patients undergoing oral tumor resection. Deformity and critical intraoral structure loss caused by tumor resection often impair facial esthetics and oral functions, such as mastication, speech, and swallowing. Conventional removable prostheses are often used for oral rehabilitation; however, postoperative sequelae in the oral cavity (e.g., loss of bone height and vestibular space, reduced number of remaining teeth, xerostomia, trismus, and mobility of the flap skin paddle) compromise the retention and stability of the prostheses, thereby resulting in reduced masticatory and psychosocial function, and osseointegrated implants have been used to alleviate these drawbacks (1,2). Dental implants reportedly improve the prosthesis stability, masticatory ability, and quality of life (QoL) (3) of healthy patients (4,5); however, limited information is available regarding the treatment outcomes in patients

Correspondence to Dr. Naoko Sato, Tohoku University Hospital, Maxillofacial Prosthetics Clinic, 4-1 Seiryomachi, Aoba-ku, Sendai, Miyagi 980-8575, Japan
Fax: +81-022-717-8371 E-mail: kotani-n@dent.tohoku.ac.jp

J-STAGE Advance Publication: July 24, 2019
doi.org/10.2334/josnusd.18-0234
DN/JST.JSTAGE/josnusd/18-0234

Table 1 Patient characteristics

Patient No.	Age (years)	Gender	Type of lesion	Primary site A: anterior P: posterior	Mandibular resection	Additional treatment	Reconstruction	Bone augmentation for implantation	Number of implants	Follow up after implantation y: year; m: months	Prosthetic type
1	75	M	Malignant	Left P	Marginal	Chemo/Radio	Abdominal FTSG	None	2	5 y 3 m	IOD
2	69	M	Malignant	Right P	Marginal		Abdominal FTSG	None	3	5 y 0 m	IOD
3	60	M	Malignant	Left P-Right P +Tongue	Marginal		RAMC free flap	None	3 (4) 1 failure	5 y 4 m	IOD
4	68	F	Malignant	Left P-Right A	Segmental		Fibula free flap	None	3	3 y 1 m	IOD
5	49	F	Malignant	Left P	Segmental	Chemo	LDMC, Ilium	PCBM-MESH	3	3 y 1 m	IFP
6	56	M	Benign	Left P	Segmental		LDMC, Ilium	PCBM-MESH	3	3 y 4 m	IFP
7	56	F	Benign	Left P	Segmental		PCBM-MESH	(PCBM-MESH)	2	4 y 5 m	IFP
8	25	F	Benign	A	Segmental		PCBM-MESH	(PCBM-MESH)	3	3 y 0 m	IFP
9	23	M	Benign	Right P	Marginal		Block bone graft	(Block bone graft)	2	4 y 4 m	IFP
10	69	M	Benign	Left P-Right A	Marginal		Reconstruction plate	PCBM-MESH	6	3 y 0 m	IFP

Chemo: chemotherapy; radio: radiation therapy; FTSG: full thickness skin graft; RAMC: rectus abdominis musculocutaneous free flap; PCBM-MESH: autogenous particulate bone marrow graft combined with titanium mesh; IFP: implant-supported fixed prosthesis; IOD: implant overdenture.

Fig. 1 Study design.

CD: complete denture; RPD: removable partial denture; IOD: implant overdenture; IFP: implant-supported fixed prosthesis.

who have undergone tumor surgery (6).

Since chewing ability greatly influences dietary choices and nutritional intake, it is important in maintaining general health (7). Objective methods, such as masticatory ability and occlusal force (8,9), and subjective methods, such as patient self-assessment (10,11), help evaluate chewing ability. The relationship between occlusal force and patients' perceptions of chewing ability has been widely examined. Some studies have reported no significant relationship between these parameters, whereas others have reported a strong association. Few studies have also assessed implant-retained prostheses in patients with cancer.

Although recurrence and survival rates have been traditionally emphasized as measures of treatment outcomes in patients with cancer, improvement in oral health-related quality of life (OHRQoL) has become the primary treatment goal (12). A consensus exists that patient-based outcomes must be examined to assess the success of implant placement. OHRQoL outcomes and self-assessed chewing ability become more helpful and important when patients are deciding to undergo prosthetic treatment. However, to date, limited information

is available regarding patient-based outcomes of implant placement in patients with cancer.

This study evaluated the changes in OHRQoL and self-assessed masticatory ability and investigated the relationship between the self-assessed masticatory ability and occlusal force in patients that underwent oral tumor resection and mandibular implant-supported prosthesis (ISP) placement.

Materials and Methods

This study was approved by the Ethics Committee of the Tohoku University Graduate School of Dentistry prior to study initiation (Approval number: #24-10) in 2012. All methods were conducted in compliance with the Declaration of Helsinki.

Patients

A total of 10 Japanese patients who underwent surgical resection of benign and malignant mandibular tumors followed by ISP placement at the Tohoku University Hospital between 2012 and 2017 were included (Table 1; Fig. 1).

Fig. 2 (A) Change in the total OHIP-49 score from baseline to 1 year after implant-supported prostheses placement. (B) Change in the self-assessed masticatory ability from baseline to 1 year after ISP placement. Data are presented as mean $\pm$ standard deviation (SD) ($n = 10$). * $P < 0.05$, ** $P < 0.01$.

OHRQoL assessment

The Japanese version of the Oral Health Impact Profile 49 (OHIP-49) was used to assess OHRQoL before and one year after ISP placement (13). The OHIP-49 evaluates the responder's perceived oral health in the following seven conceptual domains: functional limitation, pain, psychological discomfort, physical disability, psychological disability, social disability, and handicap. The patients coded each of the 49 questions as follows: 0 = never, 1 = rarely, 2 = occasionally, 3 = fairly often, and 4 = very often. Scores from each domain of the OHIP-49 were added up to obtain the total score. Lower scores indicated fewer oral health problems.

Self-assessed masticatory ability

The self-assessed masticatory ability was examined via a questionnaire that included 20 foods selected from among 100 common Japanese foods (10). The patients evaluated whether they were able to chew each of the foods without difficulty. The total number of chewable foods indicated the self-assessed masticatory ability. Higher scores indicated better masticatory ability.

Occlusal force

The Dental Prescale 50RH System (Fujifilm Co., Tokyo, Japan), which is well-documented by Kurita et al. (14), was used to measure the occlusal force. Patients were seated with the Camper's plane parallel to the floor as a reference and were instructed to bite the test film for 3 s using maximum bite force; this procedure was repeated thrice. The horseshoe-shaped test film contained microcapsules that ruptured under occlusal pressure to release a red dye. The integrated occlusal load (N) was measured using a scanning device (Occluzer 709; GC Co., Tokyo, Japan).

Fig. 3 Change in the total OHIP-49 score and in the score in each OHIP-49 domain from baseline to 1 year after ISP placement. Data are presented as mean $\pm$ SD ($n = 10$). * $P < 0.05$, ** $P < 0.01$.

Statistical analysis

The statistical significance of changes in the total OHIP-49 score, the OHIP-49 score in each domain, and the self-assessed masticatory ability following ISP placement was assessed using the Wilcoxon signed-rank test. The total OHIP-49 scores and self-assessed masticatory ability in the implant overdenture (IOD) vs. the implant-supported fixed prosthesis (IFP) groups were compared using the Mann-Whitney *U*-test. All statistical analyses were conducted using the SPSS Statistics 20.0 software (IBM; Chicago, IL, USA). $P < 0.05$ was considered statistically significant.

Results

A total of 31 mandibular implants were placed via various reconstruction methods within a mean of 41.6 months after tumor surgery (Table 1). One patient who was administered 40-Gy irradiation over the tumor bed received two implants in the remnant mandible 5 years after radiotherapy; no other patients underwent radiotherapy. Of all the placed implants, 30 survived and 1 failed 19 months after implantation. The failed implant was observed in a patient who underwent subtotal glossectomy, marginal mandibular resection, reconstruction with a rectus abdominis musculocutaneous free flap without radiotherapy, and vestibuloplasty for implantation (Table 1). The 3- to 5-year implant survival rate was 96.8%.

The initial mean total OHIP-49 score of 65.3 ± 9.79 decreased to 46.0 ± 8.14 at 1 year after ISP placement ($P < 0.01$; Wilcoxon signed-rank test; Fig. 2A). ISP placement significantly reduced the mean OHIP-49 scores in the domains of functional limitation, physical discomfort, and physical disability ($P < 0.01$, $P < 0.05$, and $P < 0.05$, respectively; all Wilcoxon signed-rank tests; Fig. 3). The

Fig. 4 (A) The total OHIP-49 score at baseline based on the type of prosthesis. (B) The total OHIP-49 score 1 year after ISP placement based on the type of prosthesis. Data are presented as mean $\pm$ SD. * $P < 0.05$, ** $P < 0.01$.

Fig. 5 (A) Self-assessed masticatory ability at baseline based on the type of prosthesis. (B) Self-assessed masticatory ability 1 year after ISP placement based on the type of prosthesis. Data are presented as mean $\pm$ SD. * $P < 0.05$, ** $P < 0.01$.

mean OHIP-49 scores in the domains of physical pain, psychological disability, social disability, and handicap tended to be lower after ISP placement (no significant difference). There were no significant differences in the mean OHIP-49 scores of patients with IODs vs. IFPs at baseline or 1 year after ISP placement (Fig. 4A, B).

The initial mean self-assessed masticatory ability of 54.5 ± 9.79 increased to 68.0 ± 8.37 at 1 year after ISP placement ($P < 0.05$; Wilcoxon signed-rank test; Fig. 2B). The mean self-assessed masticatory ability in patients with IFPs was not significantly different from that in patients with IODs at baseline or at 1 year after ISP placement (Fig. 5A, B). There was no correlation between the self-assessed masticatory ability and occlusal force (Fig. 6). The mean occlusal force levels tended to be lower for IODs than for IFPs.

Discussion

Our study demonstrated that ISP placement reduced the OHIP-49 scores and increased the self-assessed masticatory ability in patients after oral mandibular

Fig. 6 Integrated occlusal load and self-assessed masticatory ability 1 year after ISP placement.

IFP: implant-supported fixed prosthesis; IOD: implant overdenture.

tumor resection. There were no significant differences in the total OHIP-49 scores or self-assessed masticatory abilities between IOD and IFP at baseline or at 1 year after ISP placement. In addition, there were no correlations between the self-assessed masticatory ability and occlusal force at 1 year after implantation. These results suggested that ISP treatment improved the OHRQoL and masticatory ability of patients after oral tumor resection and that the prosthesis type might not significantly affect the OHRQoL.

Prosthetic rehabilitation significantly influences the OHRQoL. A previous Japanese cohort study (15) demonstrated that OHRQoL assessed with the OHIP-49 score was related to denture quality in patients who wore removable partial dentures (RPDs). The mean total OHIP-49 scores were 51.6 and 42.5 for patients with RPDs of poor and good quality, respectively (15). Furuyama et al. (16) reported a mean total OHIP-49 score of 21.0 for implant-retained fixed dentures and 38.0 for RPDs. Gates et al. (3) examined the OHRQoL effects of RPDs and implant-supported RPDs placed in partially edentulous mandibles of healthy patients and reported that the initial mean total OHIP-49 score of 61.9 decreased to 37.1 after the placement of the RPDs and to 21.0 after the placement of implant-supported RPDs. In this study, the mean total OHIP-49 score of 72.2 at baseline decreased to 47.3 at 1 year after ISP placement for patients with oral tumors. The mean total OHIP-49 scores remained quite high even after implantation; however, direct comparison of the scores with those reported in other studies was difficult owing to differences in the patients' dental statuses and disease backgrounds. These results emphasized the profound effects of oral tumor resection on the OHRQoL and indicated significant improvements in the OHRQoL after ISP placement.

To date, many studies have reported the beneficial outcomes of implant-retained prostheses in comparison

with traditional removable prostheses (3-5). ISP placement reduces psychological distress and disabling symptoms to an extent greater than that by traditional removable prostheses in healthy patients. The patients' psychological outcomes were improved owing to the prosthetic stability achieved with implant placement. In this study, ISP placement improved the OHRQoLs in the domains of functional limitation, physical discomfort, and physical disability; however, it did not significantly improve the psychological disability-related OHRQoL. These results highlight the profound psychological impact of oral tumor resection on patients.

The decision regarding IOD or IFP placement was based on the patient's request and his or her disease background as well as anatomical and functional limitations. IFPs require a larger number of implants, adequate anatomy, and good oral hygiene; of note, IODs can be used in many cases wherein IFPs are unsuitable. Muller et al. (17) assessed the positive effects of oral implants on the maximum bite force and chewing efficiency and reported that the type of ISPs, such as overdenture or fixed denture, may influence the magnitude of the effects. In this study, although the mean self-assessed masticatory abilities and occlusal forces tended to be lower for IODs than for IFPs, no significant differences were observed in the mean OHIP-49 scores for IODs vs. IFPs at 1 year after ISP placement. These results suggested that, after ISP treatment, the type of prosthesis might influence the chewing ability but not the OHRQoL.

In this study, 30 of the 31 implants survived (survival rate: 96.8%) during the 3- to 5-year follow-up period. Our findings are consistent with those of previous studies in patients with head and neck cancer (18-20). The initial mean self-assessed masticatory ability of 47.9 ± 30.3 increased to 62.9 ± 27.8 at 1 year after ISP placement ($P < 0.01$; Wilcoxon signed-rank test; Fig. 2B). There was no correlation between the self-assessed masticatory ability and occlusal force (Fig. 6); moreover, the mean values tended to be lower for IODs than for IFPs.

Critical anatomic changes that occur in the oral cavity owing to ablative oral tumor resection and reconstruction make it difficult to place implants and maintain good oral hygiene. For most cases of ablative oral tumor surgery, bone augmentation and soft tissue management, including vestibuloplasty, are essential for the placement of implants in the ideal position for prosthetic restoration. Moreover, these procedures are necessary to avoid placing implants at different angulations and vertical heights owing to anatomical limitations of the alveolar bone. In five cases (four segmental and one marginal mandibular resection), the tumor resection sites were

augmented with autogenous particulate bone marrow grafts combined with a titanium mesh (21). None of those cases had a failed implant, peri-implant mucositis, or peri-implantitis. Despite the short follow-up period and the small number of cases, our results indicated that particulate bone marrow grafts combined with a titanium mesh could be a reliable method for bone augmentation in tumor resection sites. Further long-term studies are necessary to confirm this finding. Patients with head and neck cancer often use conventional removable dentures owing to anxiety regarding cancer recurrence as well as reluctance to undergo further surgery. In four of the five patients with cancer in this study, implants were placed in the native bone without augmentation.

Dietary choices are typically influenced by patients' backgrounds and cultures. In this study, the self-assessed masticatory ability was evaluated via a questionnaire designed by Sato et al. for Japanese patients (10). A prior study examined the correlation between satisfaction regarding the masticatory function and self-assessed masticatory ability in 110 wearers of complete dentures. The mean masticatory ability scores for 51 satisfied, 38 fairly satisfied, and 11 dissatisfied patients were 59.6, 53.0, and 31.4, respectively, thereby suggesting that the masticatory ability scores corresponded with patient satisfaction in terms of the masticatory function. Therefore, the above-mentioned questionnaire is useful for chair-side evaluation of masticatory ability.

A trend suggested that the number of implants did not affect mean OHIP-49 scores and masticatory abilities at baseline and 1 year after ISP placement. Further studies with a larger cohort are warranted to clarify the effects of the number of implants on the OHIP-49 scores and masticatory abilities.

Korfage et al. (22) reported that QoL and oral function in patients with oral cancer were stable between 1 and 5 years postoperatively. Rogers et al. (23) concluded that QoL evaluation at 1 year postoperatively helps predict long-term success of implantation in patients with oral cancer. In this study, the OHRQoL and chewing ability were evaluated at 1 year after ISP placement. Despite the short follow-up period, our results indicate trends that may be present for the following 5 years.

Our results indicate that implant treatment may improve the OHRQoL and self-assessed masticatory ability of patients after oral tumor resection and that the prosthesis type might not significantly affect the OHRQoL. Because this study analyzed limited data from a small cohort and comprised a short follow-up period, further longitudinal studies with a larger cohort and a longer follow-up period are warranted to confirm the findings reported herein.

Acknowledgments

This study was supported by a Tohoku University Grant from the Ministry of Education, Culture, Sports, Science and Technology of Japan.

Conflict of interest

None declared.

References

1. Riediger D (1988) Restoration of masticatory function by microsurgically revascularized iliac crest bone grafts using enosseous implants. *Plast Reconstr Surg* 6, 861-877.
2. Urken ML, Buchbinder D, Weinberg H, Vickery C, Sheiner A, Biller HF (1989) Primary placement of osseointegrated implants in microvascular mandibular reconstruction. *Otolaryngol Head Neck Surg* 101, 56-73.
3. Gates WD 3rd, Cooper LF, Sanders AE, Reside GJ, De Kok IJ (2014) The effect of implant-supported removable partial dentures on oral health quality of life. *Clin Oral Implants Res* 25, 207-213.
4. Stellingsma K, Slagter AP, Stegenga B, Raghoobar GM, Meijer HJ (2005) Masticatory function in patients with an extremely resorbed mandible restored with mandibular implant-retained overdentures: comparison of three types of treatment protocols. *J Oral Rehabil* 32, 403-410.
5. van der Bilt A, Burgers M, van Kampen FM, Cune MS (2010) Mandibular implant-supported overdentures and oral function. *Clin Oral Implants Res* 21, 1209-1213.
6. Kumar VV, Jacob PC, Ebenezer S, Kuriakose MA, Kekatpure V, Baliarsing AS et al. (2016) Implant supported dental rehabilitation following segmental mandibular reconstruction- quality of life outcomes of a prospective randomized trial. *J Craniomaxillofac Surg* 44, 800-810.
7. Locker D (2002) Changes in chewing ability with ageing: a 7-year study of older adults. *J Oral Rehabil* 29, 1021-1029.
8. Okiyama S, Ikebe K, Nokubi T (2003) Association between masticatory performance and maximal occlusal force in young men. *J Oral Rehabil* 30, 278-282.
9. Speksnijder CM, Abbink JH, van der Glas HW, Janssen NG, van der Bilt A (2009) Mixing ability test compared with a comminution test in persons with normal and compromised masticatory performance. *Eur J Oral Sci* 117, 580-586.
10. Sato Y, Minagi S, Akagawa Y, Nagasawa T (1989) An evaluation of chewing function of complete denture wearers. *J Prosthet Dent* 62, 50-53.
11. Tsuga K, Carlsson GE, Osterberg T, Karlsson S (1998) Self-assessed masticatory ability in relation to maximal bite force and dental state in 80-year-old subjects. *J Oral Rehabil* 25, 117-124.
12. Zarb GA, Albrektsson T (1998) Consensus report: towards optimized treatment outcomes for dental implants. *J Prosthet Dent* 80, 641.
13. Yamazaki M, Inukai M, Baba K, John MT (2007) Japanese version of the Oral Health Impact Profile (OHIP-J). *J Oral Rehabil* 34, 159-168.
14. Kurita H, Ikeda K, Kurashina K (2000) Evaluation of the effect of a stabilization splint on occlusal force in patients with masticatory muscle disorders. *J Oral Rehabil* 27, 79-82.
15. Inukai M, Baba K, John MT, Igarashi Y (2008) Does removable partial denture quality affect individuals' oral health? *J Dent Res* 87, 736-739.
16. Furuyama C, Takaba M, Inukai M, Mulligan R, Igarashi Y, Baba K (2012) Oral health-related quality of life in patients treated by implant-supported fixed dentures and removable partial dentures. *Clin Oral Implants Res* 23, 958-962.
17. Muller F, Hernandez M, Grutter L, Aracil-Kessler L, Weingart D, Schimmel M (2012) Masseter muscle thickness, chewing efficiency and bite force in edentulous patients with fixed and removable implant-supported prostheses: a cross-sectional multicenter study. *Clin Oral Implants Res* 23, 144-150.
18. Gurlek A, Miller MJ, Jacob RF, Lively JA, Schusterman MA (1998) Functional results of dental restoration with osseointegrated implants after mandible reconstruction. *Plast Reconstr Surg* 101, 650-655, discussion 656-659.
19. Javed F, Al-Hezaimi K, Al-Rasheed A, Almas K, Romanos GE (2010) Implant survival rate after oral cancer therapy: a review. *Oral Oncol* 46, 854-859.
20. Hessling SA, Wehrhan F, Schmitt CM, Weber M, Schlittenbauer T, Scheer M (2015) Implant-based rehabilitation in oncology patients can be performed with high long-term success. *J Oral Maxillofac Surg* 73, 889-896.
21. Miyamoto I, Yamashita Y, Yamamoto N, Nogami S, Yamauchi K, Yoshiga D et al. (2014) Evaluation of mandibular reconstruction with particulate cancellous bone marrow and titanium mesh after mandibular resection due to tumor surgery. *Implant Dent* 23, 108-115.
22. Korfage A, Schoen PJ, Raghoobar GM, Bouma J, Burlage FR, Roodenburg JL et al. (2011) Five-year follow-up of oral functioning and quality of life in patients with oral cancer with implant-retained mandibular overdentures. *Head Neck* 33, 831-839.
23. Rogers SN, Hannah L, Lowe D, Magennis P (1999) Quality of life 5-10 years after primary surgery for oral and oropharyngeal cancer. *J Craniomaxillofac Surg* 27, 187-191.