

Oral health-related quality of life in tumour patients treated with patient-specific dental implants

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Abstract. Dental rehabilitation after surgically acquired bone deficiency related to tumour treatment remains a challenge. The insertion of patient-specific implants geared to the contour of the remaining bone is a feasible method of supporting fixed or removable dentures. As oral health-related quality of life (OHRQoL) is of great interest in these cases, 12 individuals treated with patient-specific implants for severe bone deficiency were surveyed and their Oral Health Impact Profile (OHIP) scores after dental rehabilitation were evaluated. The OHIP-G53 questionnaire was used to measure overall treatment outcomes. The distribution of OHIP sum-scores for participants treated with patient-specific implants was almost homogeneous when compared to those cited in the literature for patients treated with conventional dental implants. OHIP items related to functional impairment and physical pain showed the highest scores (occurring occasionally), and financial loss related to treatment was frequently stated. Moreover, higher scores were detected in almost all OHIP dimensions for participants with patient-specific implant-supported removable dentures. Conversely, those treated with patient-specific dental implants and fixed dentures showed lower psychosocial impact scores and equal or superior OHRQoL. Hence, patient-specific dental implants, especially combined with fixed dentures, can lead to a positive OHRQoL in patients with severe bone deficiencies related to tumour therapy.

Key words: tumour treatment; patient-specific implants; preprosthetic surgery; dental rehabilitation; oral health impact profile; oral health-related quality of life.

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Dental rehabilitation after surgical tumour treatment is a key factor related to oral health-related quality of life (OHRQoL)¹. Acquired bone deficiencies can lead to anatomical situations preventing dental implant insertion and even prosthetic use, especially in cases where bone augmentation is not possible or desired, or where bone deficiency occurs secondarily due to failed bone augmentation

procedures². Advances in digital planning procedures, computer-aided design, and selective laser-melting (SLM) techniques have led to the fabrication of patient-specific implants, allowing for individual patient solutions (IPS) in the field of head and neck surgery^{3,4}. New concepts of implant-borne dental rehabilitation have been promoted in cases of severe bone deficiency to overcome the shortcomings

of conventional dental implants, and innovative line extensions in implant dentistry have recently been described^{5,6}. However, although the successful clinical use of these new possibilities has been reported, data on the post-treatment OHRQoL of these patients are lacking.

Several studies have focused on the factors influencing patient OHRQoL, especially those related to conventional fixed

or removable dentures^{7,8}. However, no one single factor has been found to be crucial for an acceptable post-treatment quality of life; rather, several physical, psychological, and social parameters influence a patient's subjective well-being after therapy⁹. Different instruments have been used to measure OHRQoL, and standardized protocols have been established in clinical trials^{10,11}. In the present study, the Oral Health Impact Profile (OHIP) questionnaire developed by Slade and Spencer was used to evaluate individual impairments after denture treatment and gain evidence of patient OHRQoL¹². The OHIP has been found to be reliable and valid for detailed measurement of the levels of dysfunction, discomfort, and disability associated with oral disorders, as well as the social impact associated with oral health.

In its original English version (OHIP-E49), the OHIP questionnaire consists of 49 items divided into seven dimensions concerning functional limitations, physical pain, psychological discomfort, physical disability, psychological disability, social disability, and personal handicaps. The OHIP is based on Locker's conceptual model of oral health, which has been pivotal in the development of oral health-related research¹³. Since the OHIP concept was implemented, the questionnaire has been translated into many languages and validated for different populations¹⁴. Additionally, despite the potential loss of information, several valid short versions have been developed to simplify its application in daily practice¹⁵. The OHIP aids clinical decision-making as well as research.

For the German population, the OHIP-G49 and OHIP-G53 (two long versions),

as well as several short versions, have been validated with regard to applicability, consistency, and reliability for the assessment of OHRQoL^{16,17}. German demographic factors and the questionnaire's dimensional structure have also been explored, and German population-based reference values, as well as a specific German classification related to dimension subgroups (psychosocial impact, orofacial pain, oral functions, and appearance), have been generated and validated for scientific analyses^{18–21}.

Although previous oral health investigations have used these instruments, the assessment of OHRQoL has been limited mostly to dentate patients, patients with conventional fixed or removable dentures, and edentulous patients with complete dentures; studies on the OHRQoL of patients treated with dental implants and implant-supported dentures are rare^{22,23}. Data concerning patient-specific dental implants applied in cases of severe bone deficiency and their impact on OHRQoL are lacking. Therefore, the aim of the present study was to investigate the OHIP and OHRQoL of individuals treated with patient-specific implants for dental rehabilitation due to acquired bone deficiency after tumour treatment.

Materials and methods

Patient characteristics

Twelve patients with an acquired severe bone deficiency of either the upper or lower jaw due to surgical tumour treatment were included in this observational

study. All participants received a patient-specific implant (IPS Implants Preprosthetic; KLS Martin Group, Tuttlingen, Germany) for dental rehabilitation (Fig. 1).

Patients who had suffered from a benign or malignant tumour lesion, independent of the tumour entity, and in whom primary or secondary bone augmentation of the defect site could not be performed for the insertion of conventional dental implants were included. After a tumour-free recall interval of at least 6 months, patient-specific dental implants and prosthetic implant-retained dentures were inserted for dental rehabilitation. The patients then had to pass clinical follow-up, this is referring to follow-up in which there were no changes to the pre-planned treatment. The oral health assessment was performed at a minimum of 2 months after insertion of the patient-specific implant/prosthetic denture. Six patients were supplied with patient-specific dental implant-supported fixed dentures and six were supplied with removable dentures.

Patients for whom dental treatment with a patient-specific dental implant and prosthetic implant-retained denture was not fulfilled as primarily pre-planned were excluded. These patients (two of the 14 patients initially identified) had to undergo revision due to the need for secondary surgical and prosthetic adjustment of certain implant parts during therapy (i.e., removal of an implant post or a part of the anchoring scaffold structure) as a consequence of postoperative infection or poor wound healing with the subsequent need for additional circumscribed soft

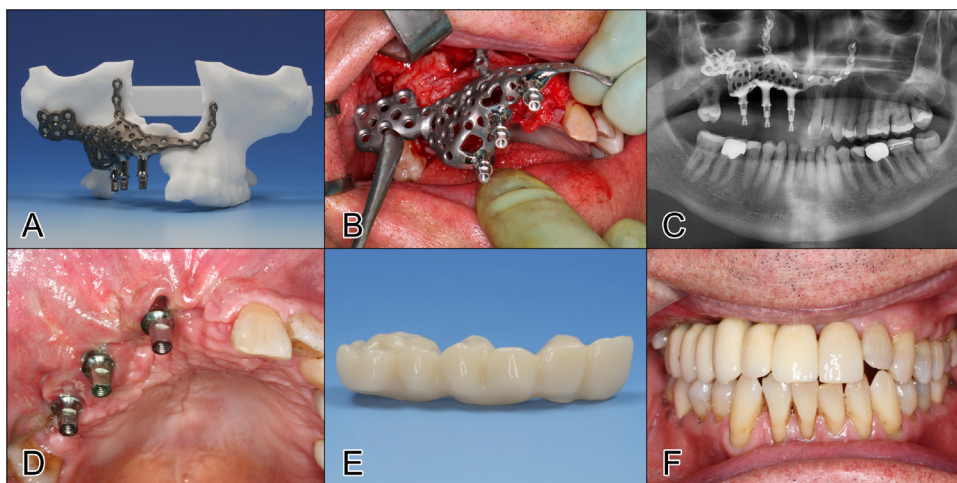


Fig. 1. Dental rehabilitation with a patient-specific dental implant (IPS Implants Preprosthetic) and implant-supported fixed prosthetic denture (dental bridge) in the right upper jaw. (A) Ready-made patient-specific dental implant manufactured using computer-aided design with corresponding stereolithographic model. (B) Intraoperative view of the patient-specific implant during insertion. (C) Postoperative panoramic radiograph. (D) Intraoral view with visible implant posts 9 months after insertion. (E) Prosthetic denture with dental bridge design. (F) Occlusion after insertion and fixation of the implant-supported fixed prosthetic denture in the right upper jaw.

tissue coverage in the course of treatment. Patients with severe bone deficiencies not related to tumour therapy were also excluded.

Relevant characteristics of all patients included are listed in [Table 1](#).

Oral Health Impact Profile and the OHIP-G53 questionnaire

The German OHIP-G53 version questionnaire was administered to all patients during a personal interview. The questionnaire included 49 questions plus four additional questions specific to the German population concerning different levels of dysfunction, discomfort, and disability associated with the three main functional status dimensions of oral health: social, psychological, and physical. The questionnaire was grouped into the seven original main dimensions (using the English classification, including 49 items): functional limitation (9 items), physical pain (9 items), psychological discomfort (5 items), physical disability (9 items), psychological disability (6 items), social disability (5 items), and handicap (6 items). Furthermore, a German-specific classification of dimensions referring to a reduced number of items (21 of 53 items) grouped according to psychosocial impact (9 items), orofacial pain (6 items), oral functions (3 items), and appearance (3 items) was included in the OHIP assessment. Scores were recorded for each question using a five-point Likert-like scale ranging from 0 to 4 (0 = never or not applicable, 1 = hardly ever, 2 = occasionally, 3 = fairly often, 4 = very often) to calculate patient-specific, single-item, and dimension sum-scores. Questions were asked with reference to oral health in the month prior to the interview.

Analysis of the questionnaire results and OHRQoL assessment

Analysis of the OHIP-G53 questionnaire results was performed using basic descriptive statistics. The patient-specific, single-item, and dimension sum-scores of all participants with patient-specific dental implants and the kind of implant-supported dentures (fixed or removable) used were examined. For patient-specific sum-scores (range 0–212; scale 0–4 × 53 items), the single-item scores in each patient case were added together and the mean value and range were calculated. Single-item sum-scores (range 0–4; scale 0–4 × 1 item) were calculated by adding all scores related to the item; mean values were also generated. Additionally, ranges were assessed within the minimum and maximum score of each single-item sum-score. A mean single-item sum-score value ≥ 1.5 was defined as an adverse impairment (Likert-type scale 2–4; occasionally to very often) and a value of 0.0 indicated no impairment (0, never or not applicable). Item-related dimension sum-scores were calculated using mean values for the English and German dimension classifications (ranges 0–20, 0–24, and 0–36, and 0–12, 0–24, and 0–36, respectively; scale 0–4 × number of items related to relative dimension). Patient OHRQoL was subsequently assessed with respect to patient-specific, single-item, and dimension sum-scores; higher scores represented poorer OHRQoL. Results were compared descriptively to those reported previously in the literature from OHIP assessments of patients treated with conventional dental implants.

Results

OHIP patient-specific sum-scores

The sum-scores ranged from 4 to 88 in patients treated with patient-specific dental implants; values ranged from 4 to

40 in patients supplied with implant-supported fixed dentures and from 19 to 88 in patients supplied with implant-supported removable dentures. Although the fixed denture group had the lowest score and the removable denture group had the highest score, no significant difference in distribution of scores was detected regarding the type of denture used ([Table 1](#)). When the minimum and maximum values referring to the kind of implant-retained denture were excluded from the analysis, the range differed (15–40). The overall mean patient-specific sum-score value was 31.0. A lower mean value was found in those patients with implant-supported fixed dentures when compared to those with removable dentures ([Supplementary Material Table S1](#)).

OHIP single-item sum-scores

The single-item sum-scores were evaluated for all 53 items of the OHIP questionnaire in all cases. None of the cases had missing data. Remarkable overall values for patient-specific dental implants and dentures were detected for questions on having trouble pronouncing words, problems with food catching during meals, impairments involving a sore jaw and sore spots, and non-specific financial loss (values 1.5 to 1.8). Concerning differences between implant-supported fixed and removable dentures, values ≥ 1.5 were found only in the group with fixed dentures for difficulty chewing, trouble pronouncing words, painful aching and painful gums, and unclear speech (values 1.5 to 1.8). For the group with removable dentures, food catching was the major adverse impairment; this was reported by all patients in this group (value 2.3, range 2–3). This was followed by feeling

Table 1. Patient characteristics and OHIP patient-specific sum-scores.

Patient number	Sex	Age (years)	Diagnosis	Treated jaw	Implant-supported denture	Patient-specific sum-score
1	Male	28	Osteosarcoma	Lower	Fixed	15
2	Male	72	KOT	Upper	Fixed	21
3	Female	56	ACC	Upper	Fixed	32
4	Female	51	Ameloblastoma	Lower	Fixed	4
5	Male	71	OSCC	Lower	Fixed	37
6	Male	30	Myxoma	Upper	Fixed	40
7	Male	70	OSCC	Lower	Removable	39
8	Female	78	BCC	Upper	Removable	26
9	Male	53	KOT	Upper	Removable	30
10	Female	73	OSCC	Upper	Removable	21
11	Female	76	OSCC	Upper	Removable	88
12	Female	74	OSCC	Upper	Removable	19

ACC, adenoid cystic carcinoma; BCC, basal cell carcinoma; KOT, keratocystic odontogenic tumour; OHIP, Oral Health Impact Profile; OSCC, oral squamous cell carcinoma.

uncomfortable when eating (value 1.7). Except for impairments concerning food catching during meals in patients with implant-retained removable dentures (value 2.3) and feeling uncomfortable when eating in patients with implant-retained fixed dentures (value 0.5), all mean single-item sum-scores concerning the aforementioned denture-related impairments were between 1.0 and 2.0 (1 = hardly ever, 2 = occasionally).

Among all patients with patient-specific dental implants, no impairments (value 0.0) were reported for worsened digestion or toothache. Patients with implant-supported fixed dentures reported no impairments related to stale breath, feeling miserable, remarkably less flavour in food, eating avoidance, unsatisfactory diet, necessity to interrupt meals, difficulties relaxing, feeling depressed, or being embarrassed due to dentures. Additionally, no impairments were noted among patients with fixed dentures for any of the items regarding social disability, being able to enjoy people's company, or functioning in daily life and work. With reference to the additional German items, patients with implant-retained fixed dentures further reported no avoidance of eating with others or noticeable temporomandibular joint noise. In contrast, patients with removable dentures reported considerably more impairments. In this group, only impairments due to noticing that a tooth did not look right, sensitive teeth, and reduced self-consciousness were lacking (**Supplementary Material** Table S1).

OHIP dimension sum-scores and OHRQoL

Regarding the English classification of dimension sum-scores, physical pain was found to have the highest impact on OHRQoL, whereas the mean values of dimension sum-scores were almost equally distributed between patients with implant-supported fixed and removable dentures compared to the mean value of all patients. Besides physical pain, for which the overall scores for those with patient-specific dental implants were almost equal to those concerning fixed and removable dentures, the use of removable implant-retained dentures led to remarkably higher scores in all other dimensions compared to implant-retained fixed dentures. In particular, no impairments in social disability (value 0.0) were detected in patients with fixed dentures. Conversely, those with patient-specific implant-supported fixed dentures reported higher OHRQoL.

Regarding the German classification of dimension sum-scores, orofacial pain had the highest mean values. Patients with implant-supported fixed dentures had a slightly higher mean value than those with removable dentures, which is concordant with the English classification results. In contrast, the psychosocial impact was markedly higher in patients with implant-supported removable dentures than in patients with fixed dentures (value 4.7 vs. 0.2, respectively). For those with implant-supported fixed dentures, this discrepancy underlined a higher OHRQoL, especially in terms of social and psychological impairments. Regarding oral function and appearance, almost no differences in dimension sum-scores related to the type of denture were detected (**Table 2**).

Discussion

This study investigated the OHIP and OHRQoL of tumour patients with acquired bone deficiencies due to surgical therapy treated with patient-specific implants for dental rehabilitation. In this regard, 12 of 14 tumour patients with primarily successful insertion of patient-specific dental implants and prosthetic implant-retained dentures as pre-planned dental treatment were included in the present study. As the evaluation focused on OHIP and OHRQoL in relation to a new method of dental rehabilitation, only patients with successful implementation of the primarily pre-planned surgical and prosthetic treatment were assessed. Therefore, although all 14 tumour patients finally achieved a stable anchored patient-specific implant-retained denture, two of them were excluded from the analysis

because their dental treatment did not proceed as primarily pre-planned; instead, they required secondary surgical and prosthetic adjustments during treatment.

With reference to the 12 patients included, an almost homogeneous distribution of the overall OHIP sum-scores was found, with slightly inferior outcomes with implant-retained removable dentures. The mean OHIP sum-score for all patient-specific implant-retained dentures was 31.0 (range 24.8–37.2). For fixed dentures, this is almost equal to the reference values of approximately 30% of German dentate patients; for removable dentures, it is almost equal to the reference values of approximately 30% of patients supplied with additional partial dentures²¹. It was found that functional impairment and physical pain were most common after treatment, independent of the type of prosthetic denture. Painful aching was especially associated with fixed implant-supported dentures and food catching with removable implant-supported dentures. Furthermore, physical and psychological disabilities, as well as psychosocial discomfort and handicaps in daily life, were reported to be more serious by patients with removable dentures.

Until now, few studies have focused on OHIP and OHRQoL after treatment with implant-supported dentures. Studies using the long versions of the German questionnaire are particularly limited²³. However, clinical trials have demonstrated that patients with implant-supported dentures experience a significantly improved quality of life^{24–27}. Kleis et al. investigated the treatment outcomes of implant-supported overdentures for the edentulous mandible with regard to different attachment systems²⁴. In their study of 43 patients,

Table 2. Mean values of OHIP dimension sum-scores for all implant-supported dentures.

Dimension sum-scores (English)			
	All dentures	Fixed dentures	Removable dentures
Functional limitation (9 items)	6.7	6.0	7.8
Physical pain (9 items)	8.1	8.2	8.0
Psychological discomfort (5 items)	1.7	1.2	2.2
Physical disability (9 items)	4.7	4.0	5.7
Psychological disability (6 items)	2.2	1.0	3.3
Social disability (5 items)	0.9	0.0	1.8
Handicap (6 items)	3.3	2.5	4.0
Dimension sum-scores (German)			
	All dentures	Fixed dentures	Removable dentures
Psychosocial impact (9 items)	2.4	0.2	4.7
Orofacial pain (6 items)	6.1	7.0	5.2
Oral functions (3 items)	3.8	3.8	3.8
Appearance (3 items)	0.9	0.8	1.0

OHIP, Oral Health Impact Profile.

they found significant improvements in OHRQoL 12 months after therapy compared to the preoperative status, with a mean total OHIP sum-score of 68.0 after the start of prosthetic use. In contrast, no significant differences were detected among implant attachment systems²⁴.

Reissmann et al. found a markedly lower OHIP sum-score (21.8) for implant-supported dentures, comparable to the mean OHIP sum-scores found in the present study for patient-specific implant-supported fixed dentures²⁵. Furthermore, substantial treatment induced a decrease in OHRQoL compared to the preoperative situation for included patients, who were treated with immediately loaded mandibular narrow-diameter implants²⁵. During a 5-year follow-up period, improvements in OHRQoL were noted for almost all OHIP dimensions²⁵.

Similar results were recorded by Schwinding et al., who investigated the short-term effects of immediate and delayed implant loading (i.e., 3 months after closed healing) in edentulous patients treated with a single mandibular implant for prosthetic dentures²⁶. Treatment outcomes were evaluated with a special focus on the loading protocol (immediate vs. delayed); OHIP-G49 sum-scores for both the immediate and delayed group ranged from 27.7 to 42.1, showing no significant differences between loading protocols at 1 and 4 months after therapy²⁶. Nevertheless, the single mandibular implant was associated with a positive impact on OHRQoL compared to the pre-treatment situation, and the mean OHIP sum-score range was almost identical to mean overall values for patient-specific dental implants in the present study.

Eitner et al. also assessed the preoperative, intermediate, and post-treatment OHIP; they collected data from 16 implant-therapy patients over a period of 6 months²⁷. Interestingly, physicians also assessed the OHRQoL and OHIP subscales using a visual analogue scale. The most prevalent problem reported by patients was being worried (psychological discomfort), which, in the present study, was not often reported. In contrast, functional limitations were reported most frequently by physicians. Comparable to our results, the authors found a mean OHIP sum-score of 29.5 after treatment²⁷.

Studies using short versions of the German questionnaire (OHIP-G14 and OHIP-G21) have revealed positive outcomes after implant-supported denture therapy. However, the scores are not directly comparable due to the reduced number of questions. Fischer et al. used the OHIP-G14 to show an almost equal OHRQoL after implant treatment in periodontally compromised patients compared

to healthy controls²⁸. They examined the relationship between patient satisfaction with the restoration and the number of dental implants used for treatment; no significant differences in OHIP sum-scores were found²⁸. A study by Mundt et al. further revealed no significant differences in OHIP, with respect to the implant type (i.e., mini-implants versus conventional implants), sex, or the jaw that was treated. Nevertheless, improvements in OHRQoL were observed in all groups after implant placement²⁹.

Using the OHIP-G21, Nickenig et al. identified a positive effect on OHRQoL for partially edentulous patients (including those with single-tooth gaps, free-end gaps, and almost completely reduced residual dentition) treated with conventional dental implants³⁰. The median OHIP sum-scores were evaluated in 343 patients, showing remarkably decreased scores ranging from 5.4 to 17.1 after implant-supported prosthodontic treatment. Furthermore, impairments related to psychological discomfort, appearance, oral function, and pain were addressed most frequently³⁰. As in the present study, functional impairments and physical pain had the highest occurrences. Painful aching was associated with fixed implant-supported dentures and food catching with removable implant-supported dentures. Problems related to both dimensions may frequently be associated with implant therapy. Previous studies have reported a high prevalence of food catching associated with conventional removable dentures²⁰. Furthermore, psychosocial discomfort seems to play an important role, as it was reported to be serious by patients. Fear related to appearance was not often reported by those with patient-specific dental implants, whereas non-specified financial loss relating to dental treatment (an item of personal handicap) was reported occasionally.

The results of the present study demonstrated that OHIP sum-scores, regardless of overall sum-scores or of single-item- or dimension-related assessment, could be used to evaluate new techniques such as patient-specific dental implants. Even in complex cases after tumour treatment, OHRQoL can be assessed, providing necessary information for the application of these modern treatment options. The study findings are comparable to OHIP results reported in the literature for conventional dental implant treatment, and although data concerning implant-supported denture therapy are still fragmented, they provide evidence for the association between patient-specific dental implant therapy outcomes and OHRQoL.

This study had a few limitations. The OHIP scores were evaluated only after the

completion of dental rehabilitation. As such, changes in OHRQoL compared to the pre-treatment situation were not captured. Additionally, since only a few patients were treated with patient-specific dental implants in selected cases of bone deficiency after tumour treatment, the study group in the present study was quite heterogeneous regarding diagnosis and patient age. Hence, the patients' individual OHRQoL might reflect differences between younger and older patients in their perception of physical and psychological disorders, functional limitations, social disabilities, and handicaps. Similarly, the existence of either a malignant or benign tumour might change individual patient attitudes to life and, as a consequence, their sense of self. In this context, several variables may influence OHRQoL in addition to the success of dental rehabilitation, such as a long treatment period, fear of recurrence, or non-oral health-related disorders. However, no observable differences were clinically asserted during follow-up with regard to patient age or diagnosis. Nevertheless, as the number of treated patients increases, these aspects will merit further consideration. Furthermore, investigations of other diseases associated with severe bone deficiencies that require unconventional dental implant treatment are needed. Lastly, due to the lack of comparative data, further follow-up of patients treated with patient-specific dental implants should be performed.

OHIP scores and the associated impact on OHRQoL require further evaluation, and the information should be made available to clinicians. The results of this study may serve as a reference for further investigations concerning dental rehabilitation after treatment with patient-specific dental implants. Furthermore, the findings provide new evidence of positive therapeutic outcomes in patients treated with patient-specific dental implants, which, with regard to OHRQoL and relating to the existing literature, is almost comparable to treatment with conventional dental implants. Therefore, treatment with patient-specific dental implants in cases of severe bone deficiency, especially when bone augmentation procedures have failed or insertion of conventional dental implants is not possible, may be a suitable therapy for dental rehabilitation.

Competing interests

The authors have no conflicts of interest to declare. All authors have reviewed the manuscript and agreed to the submission.

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Ethical approval

Ethical approval was obtained from the Ethics Committee of Hannover Medical School (Hannover, Germany) with judgement reference number 8552_BO_K_2019. The patients gave written consent to participate in this research and for the publication of clinical data and photographs.

Patient consent

Patients gave written consent to participate in this research and for publication of the clinical data and photographs.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.ijom.2020.01.011>.

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