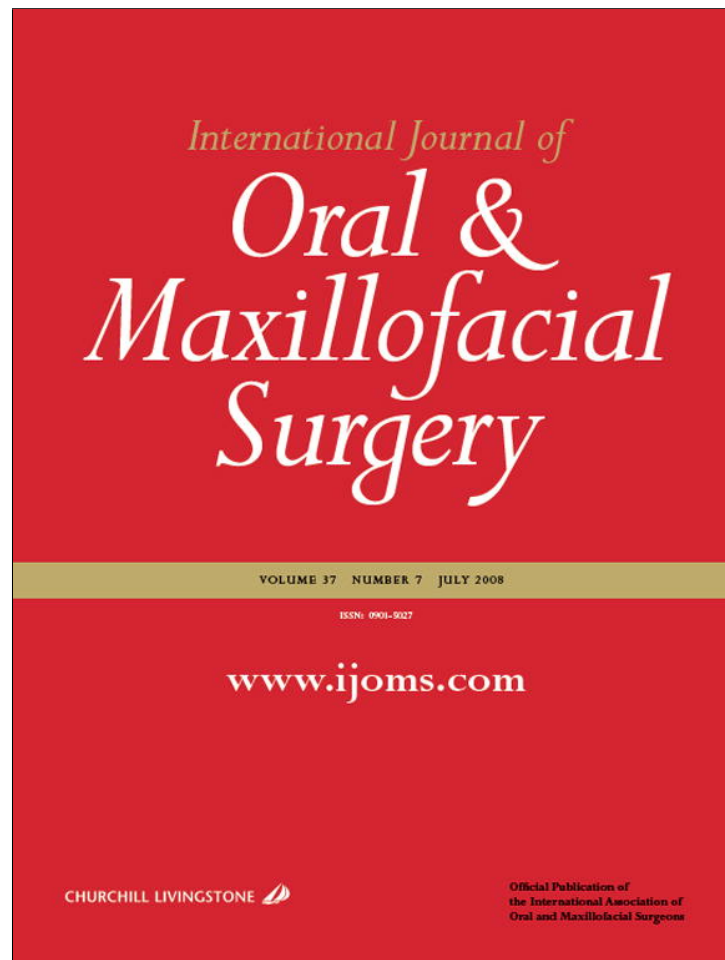


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Impact of perioperative hyperbaric oxygen therapy on the quality of life of maxillofacial patients who undergo surgery in irradiated fields[☆]

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Abstract. From 2001 to 2005, 66 patients referred for perioperative hyperbaric oxygen therapy (HBO₂) for debridement of necrotic tissue or prevention of radionecrosis were assessed with quality of life measures, before and after completion of HBO₂ and surgery. The Medical Outcomes Short Form 36 (SF-36) and Hospital Anxiety and Depression Scale (HADS) showed no significant changes. The European Organisation for Research and Treatment of Cancer Core (EORTC-C30) questionnaire showed significant improvement in pain, global health, and dyspnoea ($p = 0.011$; $p = 0.027$; $p = 0.008$, respectively). The Head and Neck sub-module (H&N35) identified significant improvements in teeth, dry mouth and social contact ($p = 0.002$; $p = 0.038$; $p = 0.029$, respectively). The University of Washington Scale (UW), showed significant changes in relation to chewing and shoulders ($p = 0.031$; $p = 0.047$). When sub-group analysis using 'osteoradionecrosis' and 'dental extraction or implants' was performed on the EORTC and UW data, variations in the patterns of significance were found. Adjunctive HBO₂ should be considered for the treatment and prevention of some of the long-term complications of radiotherapy.

Keywords: hyperbaric oxygenation; quality of life; radiotherapy.

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In 2005, 4559 people were newly registered as having cancer in the head and

neck region (ICD-00 code; C00-C14) in the UK²¹. Radiotherapy is widely used in the treatment of a range of primary and metastatic neoplasms in the head and neck region. Between 60% and 80% of all people with head and neck cancers, and

nearly 100% of people with T3/4 staged disease in the UK, receive radiotherapy either as their primary therapy or as an adjunct to surgery and chemotherapy¹³. Treatments are carefully planned to minimise exposure of surrounding normal tis-

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sues to ionizing radiation, but, there is inevitably some transient or permanent tissue damage to the surrounding structures. The resulting complications are often associated with swallowing, taste, chewing, sensory and motor function and pain, and adversely affect the patients' quality of life (QoL). Studies suggest that short-term morbidity is generally stable after as little as 1 year, but that it can take up to 3 years for some QoL measures to return to near pre-cancer levels⁴. Despite this, some factors, including fibrosis, sensation of taste and smell, dry mouth, sticky saliva and sexuality, are particularly resistant to these gradual improvements. There is anecdotal evidence that hyperbaric oxygen therapy (HBO₂) may improve some of these issues.

Surgical intervention in a heavily irradiated field may result in delayed wound healing, dehiscence or infection^{12,22}. HBO₂ is widely proposed to reduce associated risks^{7,9,11,15,19} although a review, retrospective analysis and a recent study did not support its use^{1,14,25}. Recently, treatment combining pentoxifylline and tocopherol has been found to be of use in the treatment of radiation-induced fibrosis and may prove beneficial in the treatment of radiation tissue damage⁶. The use of HBO₂ in this therapeutic area remains a topic of debate. Comprehensive literature reviews in 2002 and 2004^{9,10} indicated that HBO₂ is an effective treatment for established radiation tissue damage at multiple anatomical sites. The research of Marx and others^{9-11,17,18} supports the theory that HBO₂ acts as an adjunct to healing in irradiated tissue by stimulating angiogenesis and fibroplasia. Data from a randomised clinical trial¹⁸ supports the use of HBO₂ as a prophylactic measure when tooth removal is performed in an irradiated area. The use of HBO₂ in the placement of osseointegrated dental implants in an irradiated area is supported by numerous studies, which have recently been comprehensively reviewed by Granström¹¹. These findings have culminated in patients receiving HBO₂ pre and post (peri) operatively in many centres.

There is a growing body of work that assesses the impact of treatment for head and neck cancers and several questionnaires and surveys have been developed to assess the QoL in this patient group^{2,3,16,24,26,27}. No significant research has been conducted to investigate the changes in QoL in these patients as a result of adjunctive HBO₂. The authors conducted a cohort study of patients who received adjunctive HBO₂ peri-operatively to treat the complications of prior

radiotherapy to establish the impact of this treatment on QoL.

Materials and methods

Ethics

Ethical approval was granted from the Local Research Ethics Committee following British Psychological Society Guidelines and the Declaration of Helsinki. The study was explained via an information sheet and questions were answered. Written consent was obtained.

Participants

From 2001 to 2005, 66 patients (48 males and 18 females; mean age 56.6 years) referred consecutively for HBO₂ following radiotherapy to head and neck cancers were recruited to complete questionnaires before commencing their HBO₂ therapy and then again on completion of their therapy. Thirty-eight volunteers were referred for treatment to cover dental extraction or intraoral implant placement, and 28 were having treatment for 'osteoradionecrosis'.

Inclusion and exclusion criteria

All patients were over the age of 18 years and spoke English as their first language.

None of the patients had previously undergone HBO₂. Patients were referred for peri-operative HBO₂ for either debridement of necrotic tissue, or prevention of radionecrosis due to dental extraction or for intraoral implant placement within an irradiated field. All referring consultants were asked for additional information or comments regarding patient inclusion or exclusion from the trial prior to attendance at the hyperbaric unit.

HBO₂ regimen

Completing patients received between 14 and 40 (mean = 26.4, SD = 4.3) therapies prior to surgical interventions, and between 6 and 23 (mean = 16.3, SD = 3.5) therapies following surgery, in a multiplace chamber at the Hyperbaric Medical Centre in Plymouth, UK. All were treated at 2.2 ATA (12 m) for a total of 90 minutes breathing 100% oxygen, which was administered in 2 oxygen breathing periods of 45 minutes each, separated by a 5 minute air break (Fig. 1). Treatments were conducted on 5 working days each week. Oxygen was delivered via an Amron Oxygen Treatment Hood, or a Sea-Long Series 7000 Mask.

Questionnaires

There are no QoL questionnaires designed to be used specifically in the field of hyperbaric medicine. The measures used in this research have been developed and validated in settings such as outpatient clinics and in the hospital environment, and were deemed appropriate for the assessment of change in this study.

The Hospital Anxiety and Depression Scale (HADS)³⁰ questionnaire is a self-administered scale composed of statements relevant to either generalized 'anxiety' or 'depression', the latter being largely (but not entirely) composed of reflections of the state of anhedonia (the inability to gain pleasure from normally pleasurable experiences). Each item has a 4-point (0-3) response category with possible scores ranging from 0 to 21 for anxiety and 0 to 21 for depression. A score of 0 to 7 on either scale indicates the respondent falls within 'normal' ranges for anxiety and depression; 8-11 is mild; 12-15 is moderate; and 16-21 is a severe level of either trait.

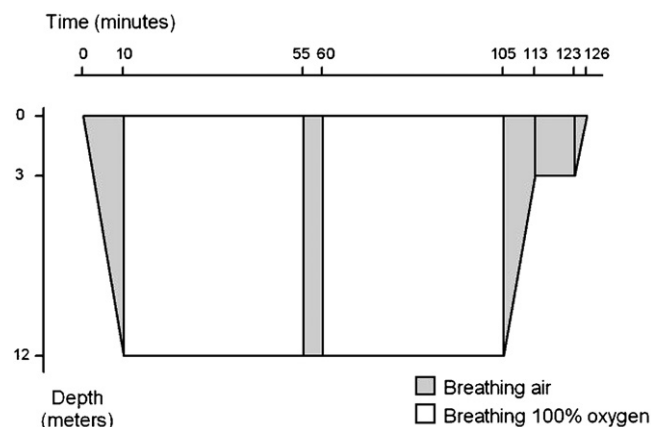


Fig. 1. Treatment profile.

The Medical Outcomes Short Form 36 (SF-36)²⁸ questionnaire is a self-administered instrument constructed to represent 8 of the most important health concepts: physical functioning, role-physical, bodily pain, general health, vitality, social functioning, role-emotional and mental health. Each question has between 3 and 6 response options using a Likert-type scale. The SF-36 is referred to as a generic measure as it assesses health concepts that represent basic human values that are relevant to everyone's functional status and well-being²⁷. Such measures are termed generic, and are universally valued because they are not age, disease or treatment specific. Generic health measures assess health-related QoL outcomes, namely those known to be most directly affected by disease and treatment.

The University of Washington Quality of Life Version 4 (UW-QOL)²⁴ questionnaire is a self-administered instrument consisting of 15 questions; 12 are disease-specific items (pain, appearance, activity, recreation, swallowing, chewing, speech, shoulder, taste, saliva, mood and anxiety), and 3 are general questions. The general questions were not considered in this study because they relate directly to the participants' experience of cancer and changes over a shorter period of time (7 days) than that covered by the study. Each of the 12 included questions has 3–6 response options using a Likert-type scale. Each item is scored from 0 to 100, with higher scores indicating better QoL. This results in a summary score of 0–1200 for disease-specific items.

The European Organization for Research and Treatment of Cancer (EORTC)⁸ is a modular instrument designed to bridge the roles of disease-specific and global QoL scales. It is a patient-based, self-administered multidimensional instrument. Version 3.0 of the EORTC QLQ-C30 core questionnaire consists of 30 questions organised into 5 domains: physical functioning, role functioning, cognitive functioning, emotional functioning, and social functioning; 3 symptom scales: fatigue, pain, nausea and vomiting; a global scale (Global Health Status/QoL), and 6 single items (dyspnoea, appetite loss, insomnia, constipation, diarrhoea, and financial difficulties). The EORTC Head and Neck (QLQ-H&N35)² questionnaire, consists of 35 questions organised into 7 domains: pain, swallowing, senses problems, speech problems, trouble with social eating, trouble with social contact, and less sexuality; as well as 11 single items (teeth, opening mouth, dry mouth, sticky saliva, coughing,

felt ill, pain killers, nutritional supplements, feeding tube, weight loss, weight gain).

The participants completed the questionnaires unsupervised.

Analysis

Analysis was conducted on the responses from the 66 (48 males and 18 females; mean age 56.6 years) participants who completed both pre- and post-questionnaires, using the *t*-test in SPSS (Version 15.0). Assumptions of normality were tested and found to be valid. Stepwise regression was used to assess the relationship between QoL measures and the length of time from treatment for cancer to HBO₂.

Results

All participants completed the questionnaire battery on both occasions. Participants were on average 6 years 5 months (min 5 months: max 27 years 8 months: St Dev, 5.6) post cancer diagnosis. The regression analysis yielded no association with QoL outcome and time from cancer.

Analysis using HADS revealed that there were no significant differences in anxiety or depression (Table 1). The mean values for both sub-scales at both time points fall within 'normal' as defined by the questionnaire (0–7). The range of scores from HADS post HBO₂ was 0–15 on the anxiety sub-scale and 0–13 on the depression sub-scale. When the whole dataset was split into the 4 classifications outlined in HADS, it was found that 13% of participants reached moderate levels of anxiety (none reached severe) and 2% reached the moderate categories on depression (none reached severe).

Using the SF-36 no significant improvements were found (Table 2).

The UW-QoL Scale indicated a significant decline in chewing for the participants as a whole for the duration of this

study. The extraction or implants sub-group also showed significant improvement in relation to 'shoulder' with a reduction in 'chewing' (Table 3).

Changes in QoL were evident using the EORTC QLQ-C30 (Table 4) where all patients showed significant improvement in 'Global Health Status/QoL', 'pain' and 'dyspnoea'. The improvements in 'pain' were also evident in the extraction or implants sub-group.

The EORTC QLQ-H&N35 identified significant ameliorations in relation to 'teeth' and 'dry mouth'. The differences with 'teeth' were also manifest in the extraction or implants sub-group. The debridement group showed significant improvements in 'opening mouth' and 'pain killers'. This questionnaire also revealed some declines in QoL. 'Social contact' declined significantly in the whole data set and in the extraction or implants sub-group. Worsening of sexuality was evident in the debridement sub-group (Table 5).

Not all participants completed all questions on all questionnaires at both time points. The most noticeable example was on HADS; the number of people completing this questionnaire to a degree that allows statistical analysis was 56 on both subscales. In most cases where the questionnaire was not fully completed only one question was not answered (although it was not always the same question). No consistent reason was given for non-completion, although one participant 'did not like' the questionnaire so completed the others and not HADS. The non-completion of questions only occurred to the same extent in one sub-scale of one other questionnaire. Fifty-nine people responded to the questions regarding sexuality on the EORTC QLQ-H&N35. These patients tended to indicate that they were either not married or widowed, and on occasion noting that they no longer 'wanted' or 'were able to have' sex. A similar response rate has been experienced using these two questionnaires in

Table 1. Statistics for Hospital Anxiety and Depression Scale (HADS) scores

HADS	N	t	DF	T ₁	T ₂	T ₁ -T ₂	p
Anxiety – All	56	0.073	55	5.96	5.93	0.03	0.942
Extraction or implants	30	-0.086	29	6.83	6.90	0.07	0.932
'osteoradionecrosis'	25	0.270	24	4.92	4.76	-0.16	0.790
Depression – All	56	-1.153	55	4.36	4.80	0.44	0.254
Extraction or implants	31	-1.270	30	4.35	5.03	0.68	0.790
'osteoradionecrosis'	25	-0.282	24	4.36	4.52	0.16	0.780

N is the number of participants data used in the calculation, t is the critical value used in combination with degrees of freedom to assess significance, DF is degrees of freedom, which is the number of scores that are free to vary in calculating the statistic. p is the level of significance, T₁ = time point 1, T₂ = time point 2. A lower score represents a reduced level of anxiety and depression.

Table 2. Statistics for Medical Outcomes Short Form 36 (SF-36) scores

SF-36	N	t	DF	T ₁	T ₂	T ₁ -T ₂	p
Physical functioning – All	65	0.623	64	44.89	44.47	-0.42	0.535
Extraction or implants 'osteoradionecrosis'	37 28	-0.143 0.965	36 27	44.41 45.53	44.52 44.41	1.11 -1.12	0.887 0.343
Role-physical – All	62	-0.765	61	35.13	36.23	1.10	0.447
Extraction or implants 'osteoradionecrosis'	36 26	-0.069 -1.164	35 25	37.19 32.27	37.33 34.72	0.14 2.45	0.946 0.256
Bodily pain – All	65	-1.143	64	42.76	44.21	1.45	0.257
Extraction or implants 'osteoradionecrosis'	37 28	-1.493 -0.226	36 27	43.52 41.74	45.69 42.26	2.17 0.52	0.144 0.823
General health – All	66	-1.150	65	43.25	44.30	1.05	0.254
Extraction or implants 'osteoradionecrosis'	38 28	-1.118 -0.511	37 27	40.90 46.43	42.13 47.23	1.23 0.80	0.271 0.613
Vitality – All	65	-0.480	64	47.29	47.86	0.57	0.633
Extraction or implants 'osteoradionecrosis'	38 27	-0.488 -0.174	37 26	46.42 48.51	47.16 48.85	0.74 0.34	0.628 0.863
Social functioning – All	63	0.327	62	42.91	42.48	-0.43	0.745
Extraction or implants 'osteoradionecrosis'	37 26	-0.442 0.970	36 25	42.70 43.21	43.44 41.12	0.74 -2.09	0.661 0.341
Role-emotional – All	64	-0.307	63	33.59	34.13	0.54	0.760
Extraction or implants 'osteoradionecrosis'	38 26	-0.455 0.000	37 25	35.52 30.76	36.44 30.76	0.92 0.00	0.652 1.000
Mental health – All	64	-1.320	63	48.29	49.83	1.54	0.192
Extraction or implants 'osteoradionecrosis'	38 26	-0.958 -0.894	37 25	46.60 50.77	47.93 52.61	1.33 1.84	0.344 0.380

N is the number of participants data used in the calculation, t is the critical value used in combination with degrees of freedom to assess significance, DF is degrees of freedom, which is the number of scores that are free to vary in calculating the statistic. p is the level of significance. T₁ = time point 1, T₂ = time point 2. A higher score indicates better quality of life.

other studies of similar patient group (S. Rogers, pers. comm.).

Of the 66 participants in this study 6 (9%) had been discharged from hospital follow up or their referring consultants could not supply information. The data for the remaining 60 is of varied quality, but can be broadly categorised into; healed, ongoing problems, improved and healing slowly, occasionally shedding sequestra, or cancer recurrence/died (Table 6). The Hyperbaric Medical Centre in Plymouth is a registered charity and as such is outside the National Health Service. This can lead to difficulties in obtaining complete and detailed follow-up information on all the patients treated.

Discussion

QoL measures have been widely used in the assessment of patients with head and neck malignancy. They are a valuable tool since these cancers, and the treatment that patients receive, can have a significant impact on individuals' QoL. There are no data regarding improvements in QoL in this patient group following treatment with adjunctive HBO₂.

Previous QoL studies involving head and neck cancer patients who did not receive HBO₂ have recruited about 100 patients^{5,23,29}. A formal power calculation was not performed since there is no previous data in this field involving HBO₂.

In the light of these findings the authors could take the research further by constructing a control group. Control groups in HBO₂ studies are often controversial and numerous strategies have been used. These include blinded treatments, sham treatments and the use of normal or rarefied air (to simulate surface oxygen partial pressure) at typical HBO₂ treatment pressures. These control group strategies require significant operational and financial commitment. Owing to the nature and workload of the authors' unit, the inclusion of a control group was not feasible. With this in mind a repeated measures design was chosen for the study, providing some degree of internal control to the data collection. Multi-centre studies could address these problems and allow for the addition of functional measures.

The authors feel that the improvements in QoL described may be attributed to the combination of HBO₂ and surgery. After the initial cancer treatment there is often a high level of depressive symptomatology that impairs QoL⁴. Although many facets of QoL approach normal, some factors, including sensation of taste and smell, dry mouth, and sticky saliva are resistant to improvement. In this study, the mechanism of the referral and treatment process prevented the authors from assessing the stability of QoL measures in their patient group; however the mean average of the patients assessed was 6 years post diag-

nosis and subsequent treatment. Given the suggestion by CHANDU et al.⁴ that short-term morbidity can be generally stable after 1 year, and nearing pre-cancer levels by 3 years, the authors think that it is reasonable to assume QoL in these patients to be stable prior to HBO₂ and surgery.

HADS has been shown²⁰ to have good psychometric properties in terms of factor structure, sub-scale inter-correlation, homogeneity and internal consistency. The properties of HADS have been found to be robust across a wide spectrum of sub-samples, including groups with somatic problems, mental problems and different strata defined by age, education and gender. This questionnaire failed to demonstrate any significant differences in the present study, however a few participants fell outside the 'normal' ranges of the questionnaire.

The SF-36 is often used in medical trials as a stand-alone measure and has been shown to be both reliable and valid in a clinical setting. Although not used in a hyperbaric study with this patient group previously, there is no evidence to suggest that it is not appropriate for these purposes. The lack of significant changes in this study using the SF-36 may be due to the global nature of the questionnaire and that the changes experienced by the participants are attributable to the combination of surgery and HBO₂.

Table 3. Statistics for University of Washington Quality of Life Version 4 (UW-QoL) scores

UoW	N	t	DF	T ₁	T ₂	T ₁ -T ₂	p
UW 1 – Pain - All	65	-1.540	64	60.00	64.62	4.62	0.128
Extraction or implants	37	-1.348	36	61.49	66.89	5.40	0.186
'osteoradionecrosis'	28	-0.779	27	58.04	61.61	3.57	0.443
UW 2 – Appearance - All	65	0.252	64	76.92	76.15	-0.77	0.802
Extraction or implants	37	0.320	36	78.38	77.03	-1.35	0.750
'osteoradionecrosis'	28	0.000	27	75.00	75.00	0.00	1.000
UW 3 – Activity – All	65	-0.780	64	67.23	68.85	1.62	0.438
Extraction or implants	37	-2.021	36	66.22	70.95	4.73	0.051
'osteoradionecrosis'	28	0.697	27	68.57	66.07	-2.50	0.492
UW 4 – Recreation – All	65	1.731	64	72.62	69.23	-3.39	0.088
Extraction or implants	37	0.522	36	73.51	72.30	-1.21	0.605
'osteoradionecrosis'	28	1.888	27	71.43	65.18	-6.25	0.070
UW 5 – Swallowing – All	65	0.863	64	53.08	46.92	-2.16	0.391
Extraction or implants	37	0.542	36	74.86	73.24	-1.62	0.591
'osteoradionecrosis'	28	0.665	27	74.29	71.43	-2.86	0.512
UW 6 – Chewing – All	65	2.049	64	53.08	46.92	-6.16	0.045
Extraction or implants	37	2.744	36	59.46	48.65	-10.81	0.009
'osteoradionecrosis'	28	0.000	27	44.64	44.64	0.00	1.000
UW 7 – Speech – All	65	-0.422	64	77.92	78.92	1.00	0.674
Extraction or implants	37	0.378	36	80.81	79.46	-1.35	0.708
'osteoradionecrosis'	28	-1.476	27	74.11	78.21	4.10	0.151
UW 8 – Shoulder – All	65	-0.952	64	70.31	72.85	2.54	0.345
Extraction or implants	37	-2.055	36	67.57	74.59	7.02	0.047
'osteoradionecrosis'	28	0.841	27	73.93	70.54	-3.39	0.408
UW 9 – Taste – All	65	-0.246	64	62.62	63.23	0.61	0.806
Extraction or implants	37	0.470	36	64.86	63.51	-1.35	0.642
'osteoradionecrosis'	28	-0.731	27	59.64	62.86	3.22	0.471
UW 10 – Saliva – All	65	-1.877	64	48.62	53.69	5.07	0.065
Extraction or implants	37	-1.154	36	45.95	50.27	4.32	0.256
'osteoradionecrosis'	28	-1.545	27	52.14	58.21	6.07	0.134
UW 11 – Mood – All	61	0.743	60	75.33	73.36	-1.97	0.460
Extraction or implants	33	0.170	32	72.58	71.97	-0.61	0.866
'osteoradionecrosis'	28	0.891	27	78.57	75.00	-3.57	0.381
UW 12 - Anxiety – All	60	0.747	59	73.33	71.33	-2.00	0.458
Extraction or implants	33	0.675	32	70.30	67.88	-2.42	0.866
'osteoradionecrosis'	27	0.362	26	77.04	75.56	-1.48	0.381
UW Total – All	60	-0.063	59	794.83	795.75	0.92	0.950
Extraction or implants	33	-0.327	32	788.18	794.39	6.21	0.745
'osteoradionecrosis'	27	0.243	26	802.96	797.41	-5.55	0.810

N is the number of participants data used in the calculation, t is the critical value used in combination with degrees of freedom to assess significance, DF is degrees of freedom, which is the number of scores that are free to vary in calculating the statistic. p is the level of significance. T₁ = time point 1, T₂ = time point 2. A higher score indicates better quality of life.

UW-QOL is a short instrument best administered, as it was here, alongside a general QoL measure. The reason for this is its clinical nature; by combining the

UW-QOL scale with another, greater specificity and contextualisation can be achieved. This has supplied proven reliability, responsiveness and validity and has

demonstrated itself to be a useful instrument for surgically treated head and neck cancer patients. This questionnaire is designed for use with people currently

Table 4. Statistics for European Organisation for Research and Treatment of Cancer Core (EORTC QLQ-C30) data

EORTC QLQ-C30		N	t	DF	T ₁	T ₂	T ₁ -T ₂	p
5 Domains	Physical functioning* – All	64	1.088	63	80.00	78.75	-1.25	0.281
	Extraction or implants	36	0.644	35	79.81	79.07	-0.74	0.524
	'osteoradionecrosis'	28	0.869	27	80.24	78.33	-1.91	0.392
	Role functioning* – All	62	0.720	61	74.46	72.04	-2.42	0.474
	Extraction or implants	35	0.695	34	74.29	71.90	-2.38	0.492
	'osteoradionecrosis'	27	0.386	26	74.69	72.22	-2.47	0.703
	Cognitive functioning* – All	64	0.925	63	79.69	78.12	-1.56	0.359
	Extraction or implants	36	1.000	35	75.93	73.61	-2.32	0.324
	'osteoradionecrosis'	28	0.238	27	84.52	83.93	-0.59	0.813
	Emotional functioning* – All	63	-1.151	62	73.55	75.93	2.38	0.254
	Extraction or implants	36	-0.919	35	70.37	72.69	2.32	0.365
	'osteoradionecrosis'	27	-0.700	26	77.78	80.25	2.47	0.490
	Social functioning* – All	64	0.000	63	69.79	69.79	0.00	1.000
	Extraction or implants	36	0.117	35	71.90	71.43	-0.47	0.908
	'osteoradionecrosis'	28	0.000	27	67.33	67.33	0.00	1.000

Table 4 (Continued)

	EORTC QLQ-C30	N	t	DF	T ₁	T ₂	T ₁ -T ₂	p
Symptoms Scales	Fatigue [†] – All	62	-1.240	61	30.82	34.23	3.41	0.220
	Extraction or implants	35	-0.976	34	33.33	36.19	2.86	0.336
	'osteoradionecrosis'	27	-0.806	26	27.57	31.69	4.12	0.428
	Pain [†] – All	63	2.633	62	37.83	29.89	-7.94	0.011
	Extraction or implants	35	2.130	34	36.67	30.48	-6.19	0.040
	'osteoradionecrosis'	28	1.753	27	39.29	29.17	-10.12	0.091
	Nausea and vomiting [†] – All	63	-0.159	62	9.25	9.52	0.26	0.874
	Extraction or implants	35	-0.215	34	10.48	10.95	0.47	0.831
	'osteoradionecrosis'	28	0.000	27	7.74	7.74	0.00	1.000
Global Scales	Global Health Status/ QoL [*] – All	63	-2.266	62	60.45	66.01	5.56	0.027
	Extraction or implants	35	-1.813	34	59.29	65.95	6.66	0.079
	'osteoradionecrosis'	28	-1.342	27	61.90	66.07	4.17	0.191
Single Item Scales	Dyspnoea [†] – All	64	2.722	63	15.63	7.29	-8.34	0.008
	Extraction or implants	36	1.848	35	15.74	8.33	-7.41	0.073
	'osteoradionecrosis'	28	1.982	27	15.48	5.95	-9.53	0.058
	Appetite loss [†] – All	64	0.129	63	23.96	23.44	-0.52	0.898
	Extraction or implants	36	-0.183	35	25.00	25.93	0.93	0.856
	'osteoradionecrosis'	28	0.359	27	22.61	20.24	-2.38	0.722
	Insomnia [†] – All	63	0.000	62	32.80	32.80	0.00	1.000
	Extraction or implants	36	-1.972	35	32.41	37.96	5.55	0.057
	'osteoradionecrosis'	27	1.363	26	33.33	25.93	-7.40	0.185
	Constipation [†] – All	64	0.869	63	16.15	13.54	-2.61	0.388
	Extraction or implants	36	-0.239	35	14.81	15.74	0.93	0.812
	'osteoradionecrosis'	28	1.536	27	17.86	10.71	-7.15	0.136
	Diarrhoea [†] – All	64	1.012	63	26.04	19.27	-6.77	0.315
	Extraction or implants	36	1.046	35	34.26	22.22	-12.04	0.303
	'osteoradionecrosis'	28	0.000	27	15.48	15.48	0.00	1.000
	Financial impact [†] – All	64	-0.841	63	32.29	35.93	3.65	0.404
	Extraction or implants	36	-1.540	35	27.78	35.19	7.41	0.132
	'osteoradionecrosis'	28	0.153	27	38.10	36.90	-1.20	0.879

N is the number of participants data used in the calculation, t is the critical value used in combination with degrees of freedom to assess significance, DF is degrees of freedom, which is the number of scores that are free to vary in calculating the statistic. p is the level of significance. T₁ = time point 1, T₂ = time point 2.

* Higher score indicates better function.

† Higher score indicates more symptoms.

experiencing head and neck cancer, therefore it may not be surprising that only one significant difference was found for the group as a whole (chewing) because they are on average 6 years post cancer treat-

ment. No changes were noted in the deb-ridement sub-group, but the extraction and implant sub-group showed the same decline in chewing as the group as a whole. This decline is possibly a result

of many of the patients undergoing dental extractions having no, or fewer, teeth after surgery or very recent implant placement. The reported improvement in 'shoulder' in the implants and extraction can not be

Table 5. Statistics for European Organization for Research and Treatment of Cancer, Head and Neck (EORTC QLQ-H&N35) data

	EORTC QLQ-H&N35	N	t	DF	T ₁	T ₂	T ₁ -T ₂	p
7 Domains	Pain - All	62	1.267	61	35.89	31.99	-3.90	0.210
	Extraction or implants	34	0.637	33	33.58	31.13	-2.45	0.528
	'osteoradionecrosis'	28	1.127	27	38.69	33.04	-5.65	0.270
	Swallowing - All	63	0.281	62	21.30	20.77	-0.53	0.780
	Extraction or implants	35	0.107	34	21.67	21.43	-0.24	0.915
	'osteoradionecrosis'	28	0.275	27	20.83	19.94	-0.89	0.785
	Senses problems – All	62	0.508	61	28.23	26.61	0.38	0.614
	Extraction or implants	35	0.122	34	27.62	27.14	-0.48	0.903
	'osteoradionecrosis'	27	0.578	26	29.01	25.93	-3.08	0.568
	Speech problems – All	61	0.467	60	22.77	21.86	-0.91	0.642
	Extraction or implants	34	-0.264	33	20.92	21.57	0.65	0.794
	'osteoradionecrosis'	27	0.925	26	25.10	22.22	-2.88	0.364
	Trouble with social eating – All	63	-0.358	62	37.57	38.89	0.38	0.721
	Extraction or implants	36	-1.439	35	32.87	38.19	6.05	0.159
	'osteoradionecrosis'	27	0.571	26	43.83	39.81	-4.02	0.573
	Trouble with social contact - All	62	-2.243	61	11.94	16.88	4.95	0.029
	Extraction or implants	36	-2.981	35	10.37	18.15	7.78	0.005
	'osteoradionecrosis'	26	-0.274	25	14.10	15.13	1.03	0.787
	Less sexuality – All	59	-0.710	58	36.16	38.42	2.26	0.481
	Extraction or implants	34	0.955	33	32.84	28.92	-3.92	0.347
	'osteoradionecrosis'	25	-2.317	24	40.67	51.33	10.66	0.029

Table 5 (Continued)

	EORTC QLQ-H&N35	N	t	DF	T ₁	T ₂	T ₁ -T ₂	p
Single Item Scales	Teeth – All	63	3.178	62	57.14	41.27	-15.87	0.002
	Extraction or implants	35	2.487	34	69.52	51.43	-18.09	0.018
	‘osteoradionecrosis’	28	1.950	27	41.67	28.57	-13.10	0.062
	Opening mouth – All	62	1.196	61	55.38	50.54	-4.84	0.236
	Extraction or implants	34	-0.387	33	47.06	49.02	1.43	0.701
	‘osteoradionecrosis’	28	2.091	27	65.48	52.38	-13.10	0.046
	Dry mouth – All	64	2.116	63	60.94	53.13	-7.81	0.038
	Extraction or implants	36	1.464	35	63.89	55.56	-8.33	0.152
	‘osteoradionecrosis’	28	1.652	27	57.14	50.00	7.14	0.110
	Sticky saliva – All	61	0.942	60	38.25	33.88	-4.37	0.350
	Extraction or implants	34	0.463	33	33.33	30.39	-2.94	0.646
	‘osteoradionecrosis’	27	0.895	26	44.44	38.27	-6.17	0.379
	Coughing – All	62	0.388	61	29.03	27.42	-1.61	0.699
	Extraction or implants	35	1.244	34	39.05	31.43	-7.62	0.222
	‘osteoradionecrosis’	27	-1.224	26	16.05	22.22	6.17	0.232
	Felt ill – All	63	1.183	62	25.40	21.16	-4.24	0.241
	Extraction or implants	36	1.313	35	29.63	23.15	-6.48	0.198
	‘osteoradionecrosis’	27	0.238	26	19.75	18.52	-1.28	0.814
	Pain killers – All	63	0.903	62	74.60	69.84	-4.76	0.370
	Extraction or implants	36	-0.813	35	66.67	72.22	5.55	0.422
	‘osteoradionecrosis’	27	2.431	26	85.19	66.67	-18.52	0.022
	Nutritional supplements – All	64	-0.830	63	31.25	35.94	4.69	0.410
	Extraction or implants	36	-0.813	35	25.00	30.56	5.56	0.422
	‘osteoradionecrosis’	28	-0.372	27	39.29	42.86	3.57	0.713
	Feeding tube – All	64	1.000	63	14.06	10.94	-3.12	0.321
	Extraction or implants	36	1.435	35	11.11	5.56	-5.55	0.160
	‘osteoradionecrosis’	28	0.000	27	17.86	17.86	0.00	1.000
	Weight loss – All	64	0.000	63	21.88	21.88	0.00	1.000
	Extraction or implants	36	-1.673	35	11.11	22.22	11.11	0.103
	‘osteoradionecrosis’	28	1.441	27	35.71	21.43	-14.28	0.161
	Weight gain – All	63	-0.275	62	15.87	17.46	1.59	0.784
	Extraction or implants	35	0.000	34	20.00	20.00	0.00	1.000
	‘osteoradionecrosis’	28	-0.441	27	10.71	14.29	3.58	0.663

N is the number of participants data used in the calculation, t is the critical value used in combination with degrees of freedom to assess significance, DF is degrees of freedom, which is the number of scores that are free to vary in calculating the statistic. p is the level of significance. T₁ = time point 1, T₂ = time point 2. For all items and scales, high scores indicate more problems.

attributed to the surgery experienced by the participants.

EORTC QLQ-C30 is a well developed, reliable general QoL instrument for cancer patients. Although this questionnaire is cancer specific it does have a global element, which shows significant improvement. The other two significant improvements (pain and dyspnoea) are explained more fully when judged by the sub-groups, with pain being significantly reduced in the extraction or implant

group while no significant differences were found in the ‘osteoradionecrosis’ group.

The head and neck cancer specific module EORTC QLQ-H&N35 was developed with the input of patients and has high content validity and sensibility. It has proved to be sensitive to change in this study indicating significant change in social contact, teeth, opening mouth, dry mouth, pain killers and sexuality. As previously noted, changes in this study could

be attributed in part to the surgery undergone by these patients. The improvement in relation to teeth may be connected to the removal of carious teeth and this is born out by the significance being evident in the extraction and implant sub-group. The positive change in ‘opening mouth’ in the debridement group may be due to a reduction in trismus. What brings about the change in trismus is an interesting question. It could be that the surgical intervention has facilitated greater mobility, allowing mouth opening with more comfort. Another explanation is that participants experience a loosening of fibrotic tissue following HBO₂. Further investigation with a similar patient group not having a surgical intervention, could help answer this question. The improvement in relation to teeth may be connected to the reduction in xerostomia and the removal of carious teeth. The authors could not identify any intervention, other than HBO₂, that would have significantly improved the patients with ‘dry mouth’. This could mean that the patients had a greater amount or improved consistency

Table 6. Follow-up information from participants

	Dental extraction or implant placement	‘osteoradionecrosis’
Discharge or lost to follow up	4	2
Healed	31	15
Ongoing problems	2	4
Occasionally shedding sequestra	1	0
Improved or healing slowly	0	2
Cancer recurrence or died	0	5
Total in each group	38	28

PB conceived the idea for the study. SAH, PB and DC contributed to the design and planning of the research. SAH was responsible for data collection. SAH analysed the data. SAH wrote the first draft of the manuscript. PB coordinated funding for the project. All authors edited and approved the final version of the manuscript.

of saliva, which allows for a greater protection of the teeth. This aspect has significant potential implication for the long-term health of patients' oral cavities and requires further investigation. The reduction in social contact and sexuality is not surprising given the requirement for most of the patients to be away from home during their treatments, up to three weeks at a time. This would be best addressed by the provision of more hyperbaric facilities, therefore allowing patients to return home each day.

In conclusion, this study suggests that a combination of HBO₂ and surgery contributes to an improved QoL in these patients and thus psychological status of the patient over the course of their continued care.

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