Survival rates of dental implants in patients with head and neck pathologies: 12-year single-operator study

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Objective. To evaluate the survival rates of dental implants placed in patients with head and neck pathologies treated with resective surgery with or without free flap reconstruction, radiotherapy alone, and/or chemotherapy.

Study Design. In this study, we retrospectively analyzed the survival of intraoral dental implants placed by the same surgeon over a 12-year period from 2007 to 2019. These implants were followed up clinically and radiographically for a period of 36 months postoperatively and throughout the restorative phase.

Results. A total of 190 patients with a total of 739 dental implants, comprising both intraoral and zygomatic implants, were included in this study. Overall, the dental implant survival rate was 95%, with a similar rate for dental implants placed in irradiated and nonirradiated bone (90% vs 93%). A lower implant survival rate was noted in implants placed in transplanted bone (79%). In cases of implant failure (n = 17), 35% (n = 6) of protheses survived and remained functional.

Conclusions. Our findings support the placement of dental implants in patients with benign and malignant pathologies of the head and neck to improve their quality of life. However, we highlight the need for careful surgical planning and placement by experienced clinicians. (Oral Surg Oral Med Oral Pathol Oral Radiol 2022;134:28–35)

Annually, about 12,000 new head and neck cancer cases are diagnosed in the United Kingdom.[1] Head and neck cancer consists of a group of malignant tumors affecting the oral cavity, pharynx, and larynx.[2] Beyond this, patients also present with a range of odontogenic and nonodontogenic tumors of the jaw, the most common being ameloblastomas.[3] Treatment modalities for pathologies affecting the head and neck can be broadly categorized into resective surgery (with or without reconstruction) with potential adjunctive chemotherapy or radiotherapy. Tumor resection often leads to discontinuity of facial structures, which, if left unrestored, can cause major facial deformity and loss of function.[4] Modern reconstructive techniques with vascularized free flap reconstruction have been shown to be a reliable method to reconstruct these defects.[5]

Due to the increased risk of osteoradionecrosis (ORN) of the jaw following dental extractions, teeth with a poor to guarded prognosis are recommended for removal during surgery or before radiotherapy. This, along with resective surgery, often leaves patients with multiple missing teeth. Conventionally, removable prostheses are used to replace these missing structures and obturate defects and ultimately to restore oral function in this cohort of patients. The consequences of cancer therapy (e.g., oral mucositis, loss of alveolar height from premature dental extractions, trismus, xerostomia) significantly affect the retention and stability of the prosthesis, thereby resulting in reduced masticatory and psychosocial function.[6] Failure to restore facial aesthetics and function usually contributes to the overall morbidity of cancer therapy and decreases the quality of life of patients.[7] With a rising incidence of head and neck cancer and decreasing mortality rate, there is an ever-growing number of patients presenting with this oral rehabilitation challenge.[1]

Secure anchorage of prostheses with dental implants has been shown to improve the stability of the appliance, masticatory ability, and quality of life.[8] Masticatory ability has a known impact on dietary choices and nutritional intake; both factors play a vital role in patients' general health.[9] The success of dental implants depends on both hard and soft tissue integration around the dental implant. Often, after tumor resection, insufficient bone remains to allow optimal osseointegration of dental implants.[10] Bony reconstruction with nonvascularized bone graft or a composite free flap is often required to enable successful implant placement.[11] Advancements in computer-guided surgical planning have motivated surgeons to consider jaw reconstruction with simultaneous implant placement to achieve early functional rehabilitation.[12]

Statement of Clinical Relevance

Overall, the survival rate of dental implants placed in patients with head and neck pathologies was 95%, demonstrating a rate similar to that for placement in ideal conditions. This encourages oral rehabilitation in this patient cohort because it can improve quality of life.

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Controversy persists regarding the impact of cancer therapy on osseointegration of dental implants. Some studies have cautioned against the placement of dental implants in irradiated bone due to the associated vascular changes, which compromise bony healing.[13] Animal studies have demonstrated the negative effect of chemotherapeutic agents (i.e., cisplatin) on bone formation during the osseointegration phase.[12] Despite this, recent studies have reported high survival rates of dental implants in patients after head and neck cancer therapy.[14,15] In view of the persisting controversy over the osseointegration of dental implants placed in patients after cancer treatment, the purpose of our analysis was to assess the survival rates of dental implants in patients with head and neck pathologies treated with resective surgery with or without free flap reconstruction, radiotherapy, and/or chemotherapy.

MATERIALS AND METHODS

Institutional approval was obtained to carry out this retrospective cohort study. The medical records of all the head and neck oncology patients who had dental implants placed by a specific surgeon between 2007 and 2019 were retrieved. The inclusion criteria were as follows:

1. Patients with a pathology in the head and neck region (benign or malignant) that had been treated and were enrolled in the oral rehabilitation program
2. Implants placed by a specific surgeon at the Oral Surgery Department at Guy's Hospital
3. Prosthetic rehabilitation with the prosthodontic team at Guy's Hospital
4. Time frame between 2007 and 2019

We excluded the following cases:

1. Did not have their final prosthesis fitted
2. Failed to attend the 36-month follow-up period after dental implant placement

Demographic data (i.e., age, sex, smoking status), cancer site and type, treatment modality (including protocols, duration, and agents used), dental implant system used, implant placement site, and timing of placement were gathered. This study did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data collection

Data were reviewed retrospectively over a 12-year period. The data were collected by 3 authors of the paper after agreeing on the criteria. The data were then validated by an individual who cross-checked information. In total, 190 patients with a total of 739 dental implants (comprising both intraoral and zygomatic implants) were included in this study. The patients had a variety of treatment modalities for their primary pathology, including surgical resection (with or without reconstruction), radiotherapy, and/or chemotherapy. These implants were followed up clinically and radiographically for a period of 36 months postoperatively and during the restorative phase by the implant surgeon and/or registrar in oral surgery under supervision. "Implant survival" in this study was defined as the presence of a dental implant intraorally. "Prosthesis survival" was defined as the presence of a functional prosthesis intraorally. In the latter case, it was possible for one or more implants to fail but the prothesis to remain functional. "Implant failure" was defined as an implant that was removed or planned for removal for any reason.

Patients and treatments

Although most patients in this study received their cancer treatment at Guy's Hospital, some were referred from peripheral sites for oral rehabilitation after cancer therapy. All patients were assessed, and treatment was planned by a multidisciplinary team before commencing oral rehabilitation. All the dental implants in this study were placed by the same surgeon, who, at the time of commencing data collection, was a senior consultant in oral surgery, whereas all prosthodontic restoration of dental implants were carried out by and/or under the direct supervision of a consultant in prosthodontics.

A variety of implants were placed using either the Astra Tech or Nobel Biocare implant system and following the standard implant protocol. All cases had a conventional flap raised to visualize the surgical field. The osteotomy sites were prepared according to the implant protocol and the quality and quantity of bone in the site at the time of preparation. Postoperative antibiotics (Co-amoxiclav 625 mg 3 times daily for 1 week unless contraindicated) and chlorhexidine 0.2% mouthwash were prescribed as standard. Most implants in this study (79%; n = 150) were placed using a one-stage approach to prevent the need for further soft tissue surgery. The patients were all reviewed clinically at 1 month after implant placement and then at 3 months, clinically and radiographically, before referral to the prosthodontics department.

All dental implants were maintained in primary care. Patients were encouraged to see their general dental practitioner for regular implant maintenance and monitoring. Dental implants were examined every 6 months in the implant clinic for oral hygiene, periodontal status, and implant status. In cases where implants were noted to be poorly cared for, a correspondence letter

Table I. Characteristics of included patients and implant restoration

Patients	*% (n)*
Sex	
Male	63 (119)
Female	37 (71)
Age, y, mean	66
Smoking status	
Nonsmoker	55 (105)
Smoker	23 (44)
Ex-smoker	22 (41)
Adjunctive therapy	
Bone graft	4 (8)
Soft tissue graft	1 (2)
Platelet-rich fibrin	1 (2)
Osteoradionecrosis prophylaxis	2 (3)
Restoration type	
Fixed bridge	36 (69)
Crowns	6 (11)
Implant supported overdenture	54 (102)
Mixed	3 (6)
Missing	1 (2)

was sent to the general dental practitioner to request urgent implant maintenance and cleaning.

RESULTS

A total of 212 clinical records were identified and reviewed. After exclusions, 190 patients who had 739 implants in total were included in this study. There was an average of 4 implants per patient (range 1−10) and a male predominance, with a male-to-female ratio of about 2:1, which reflects the sex distribution of head and neck cancers in the population (Table I).[1] The average age at the time of implant placement was 66 years. The majority of patients had previously been diagnosed with and treated for a squamous cell carcinoma (Figure 1), with the most common primary site being the tongue, followed by the mandible, tonsils, and floor of the mouth (Figure 2). Pathologies included in the "other" category comprised adenocarcinoma, adenoid cystic carcinoma, odontogenic fibromyxoma, mucoepidermoid carcinoma, myofibroma, and pleomorphic adenoma (Figure 1). A total of 72 patients were treated with surgery alone, 64 received adjunctive radiotherapy, and 54 had adjunctive chemoradiation. Most patients (77%; n = 146) were nonsmokers or ex-smokers at the time of implant placement.

All dental implants were placed more than 12 months after radiotherapy. In 22% (n = 41) of patients, implants were inserted in a 2-stage surgical approach, whereas the rest were placed in one stage, with a healing abutment placed at the time of surgery. BioOss bone grafting material was used in 8 patients, whereas soft tissue grafting and platelet-rich fibrin were used in 2 patients, respectively (Table I). Dental implants were restored with a range of prostheses, with the most common being implant supported overdentures (54%; n = 102) followed by fixed bridges (36%; n = 69) and crowns (6%; n = 11) (Table I).

Overall, 39 dental implants placed in 17 patients failed over the study period, returning an overall dental implant survival rate of 95%. In patients who experienced implant failure, the median ratio of implant failure to total implants placed was 1:2 (range 1−6 failed implants per patient). The survival of implants in patients who did not have radiotherapy (93%) was not

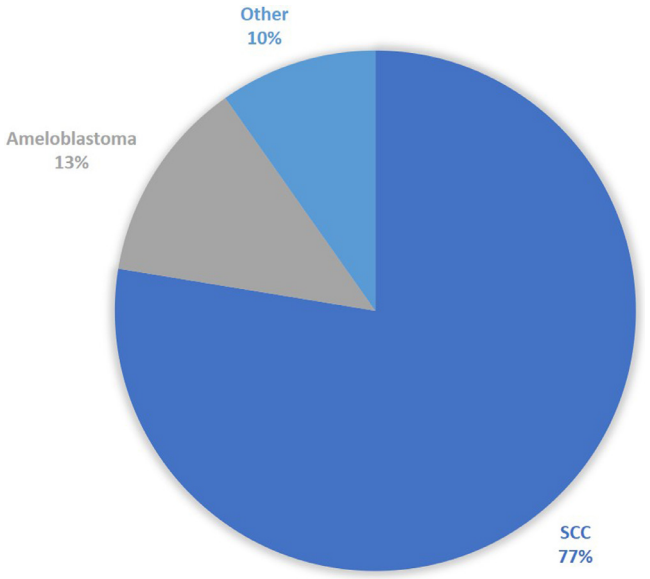


Fig. 1. Distribution of head and neck pathology. SCC: squamous cell carcinoma.

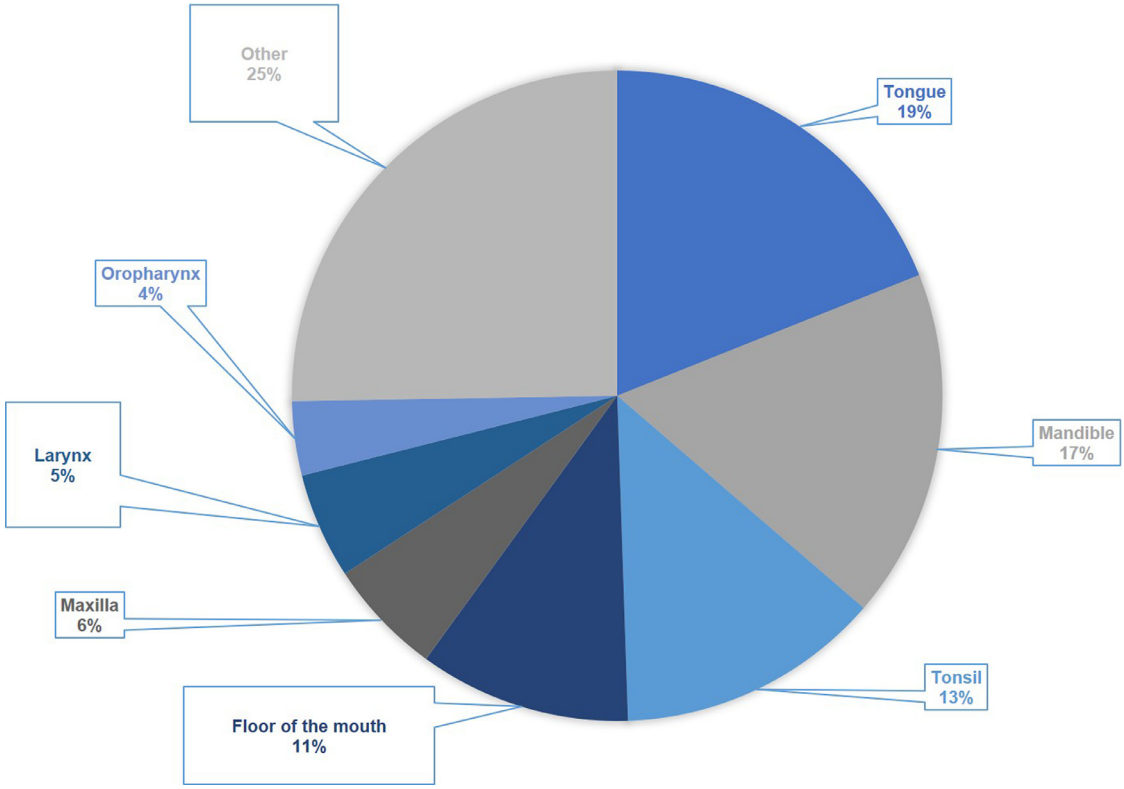


Fig. 2. Site distribution of primary pathology.

statistically significantly different from those who underwent radiotherapy (90%) (P = .55) (Table II). The nature of the primary disease had little influence on the survival of dental implants with similar survival rates of dental implants in patients with malignant (91%) versus benign (92%) pathologies of the head and neck; this difference was not statistically significant (P = .64) (Table II). The survival rate of implants was similar for cases restored with crowns, implant-supported overdentures, and fixed bridges (91%, 89%, and 93%, respectively) (Table III). Overall, out of the 17 cases of implant failure, 6 implant-retained prostheses survived (Table III).

Of the 739 implants placed, 632 were Astra implants, and 107 were Nobel Biocare implants. There was no statistical difference in survival rates based on the 2 implant systems used: Astra (96%) vs Nobel Biocare (93%) (P = .50). The most common flap used for reconstruction was the fibula free flap. Looking specifically at survival of dental implants placed in a fibula free flap, a survival rate of 79% (11 of 14) was noted.

Of the 190 patients, 2 experienced ORN after dental implant placement. Both had a total of 4 implants placed, one restored with an implant supported overdenture and the other with fixed bridges.

DISCUSSION

Dental implants play a crucial role in the rehabilitation of patients after surgical management of pathologies of the head and neck. Implant-retained prostheses have the advantage of restoring function via a well-retained prosthesis while reducing the load on surrounding soft tissues.[6] Quality-of-life studies have demonstrated improvements in speech, eating comfort, swallowing, and emotional stability following oral rehabilitation with implant-based protheses.[15] A review of the published data on dental implant survival reported a 10-year estimated survival rate of 95-96%.[16,17] The data presented here show an overall survival rate of 95% at 36 months. These results are promising and would encourage the restoration of patients with head and neck cancer using dental implants, especially in favor of its positive impact on quality of life.

Commonly, head and neck cancers are treated with surgical resection and adjunctive radiotherapy.[18] Intensity-modulated radiotherapy is a form of external beam radiation and is the most used form of radiotherapy in head and neck cancers. The therapeutic radiation dose for tumors in the head and neck region is typically between 50 and 70 Gy.[19] In our study, patients received between 45 and 65 Gy, with the most common protocol

Table II. Implant survival based on smoking status, type of pathology, treatment modality, radiotherapy exposure, and type of prosthesis

	Failure	*Survival*	*Implant survival (%)*
Smoking status			
Nonsmoker	8	97	92
Current/ex-smoker	9	76	89
Type of pathology			
SCC	14	135	91
Ameloblastoma	2	22	92
Other	0	16	100
Treatment modality			
Surgery alone	5	67	93
Surgery + RT	2	62	97
Surgery + chemo-RT	9	45	83
RT			
No RT	5	67	93
RT	12	106	90
Type of prosthesis			
Crowns	1	10	91
ISOD	11	91	89
Fixed bridges	5	64	93
Mixed	0	6	100

ISOD, implant supported overdenture; *RT*, radiotherapy; *SCC*, squamous cell carcinoma.

being 65 Gy in 30 fractions over 6 weeks, which is in line with UK national guidelines.[19]

Controversy persists regarding the effect of radiation on the survival of dental implants. In their systematic review, Chambrone et al.[13] concluded that irradiated patients were at a significantly increased risk of implant failure. However, more recent studies published have reported 5-year survival rates of more than 89% of dental implants placed in irradiated bone, which was supported by the findings of our study revealing a 90% survival rate.[15,20,21] This high survival rate is likely associated with the detailed preoperative treatment planning performed for all irradiated patients. Three-dimensional imaging paired with radiation mapping is routinely performed to determine the optimal sites for dental implant placement and areas at high risk of developing ORN (Figure 3). Sites with radiation exposure <50 Gy are preferred for implant placement. Radiotherapy is known to negatively affect the bone microvasculature, which has implications for healing and osseointegration.[22,23] Radiation exposure <50 Gy is selected on the basis of evidence that supports increased failure rates and risk of complications associated with implants placed in bony regions irradiated beyond 55 Gy.[24,25] The authors recognize new evidence in this field suggesting a lower threshold of 30 Gy causing inflammation of the bony microvasculature even 12 months after completion of radiotherapy.[23,26] This effect was also demonstrated in animal models, along with evidence of increased fibrosis and osteoclast activity after radiotherapy exposure.[22] Although there is no general agreement on the minimum delay in implant placement after radiotherapy, the evidence suggests improved survival rates with longer intervals.[24] In all cases in this study, a minimum duration of 12 months after radiotherapy elapsed before implant placement.

Smoking is a well-documented factor in the failure of osseointegration of dental implants.[27] Its effect on implant failure has been hypothesized to be associated with disruptions in osteogenesis and angiogenesis.[28] Nicotine has been shown to inhibit gene expression of several enzymes involved in osteoblast proliferation and differentiation and to have direct effects on blood vessels, causing vasoconstriction and reducing blood perfusion.[29,30] These factors have an impact on the bony remodeling pathway and increase the risk of postoperative infections. This could explain the higher incidence of implant failure of 20% among smokers and ex-smokers.[15]

Fibula flaps are often the flap of choice for jaw reconstruction due to their length, form, and cortical structure. Fourteen patients in this study had dental implants placed in a fibula free flap (FFF). Three of the 14 patients experienced implant failure, for an overall implant survival rate of 79%. In all 3 cases, patients underwent resection of ameloblastomas and reconstruction with FFF. Because this is a benign disease, none of these cases were complicated by chemotherapy or radiotherapy. This suggests lower dental implant survival in transplanted bone than in native bone, a finding supported by work by Khadembaschi et al.[31,32] Short bone height and lower bone density have been described as a potential cause of this increased failure rate.[33,34] Barber et al. found that morselization of the remnants of fibula and impaction into the marrow space

Table III. Implant survival and prosthesis survival based on type of prosthesis

Implant survival	*Prosthesis*					*Total*
	Crown	*ISOD*	*Fixed bridge*	*Mixed*	*Missing*	
Survival	10	91	64	6	2	173
Failure	1	11	5	0	0	17
Prothesis survival	0/1	4/11	2/5	–	–	6/17 (35%)
Implant survival rate	91%	89%	93%	100%	–	

ISOD, implant supported overdenture.

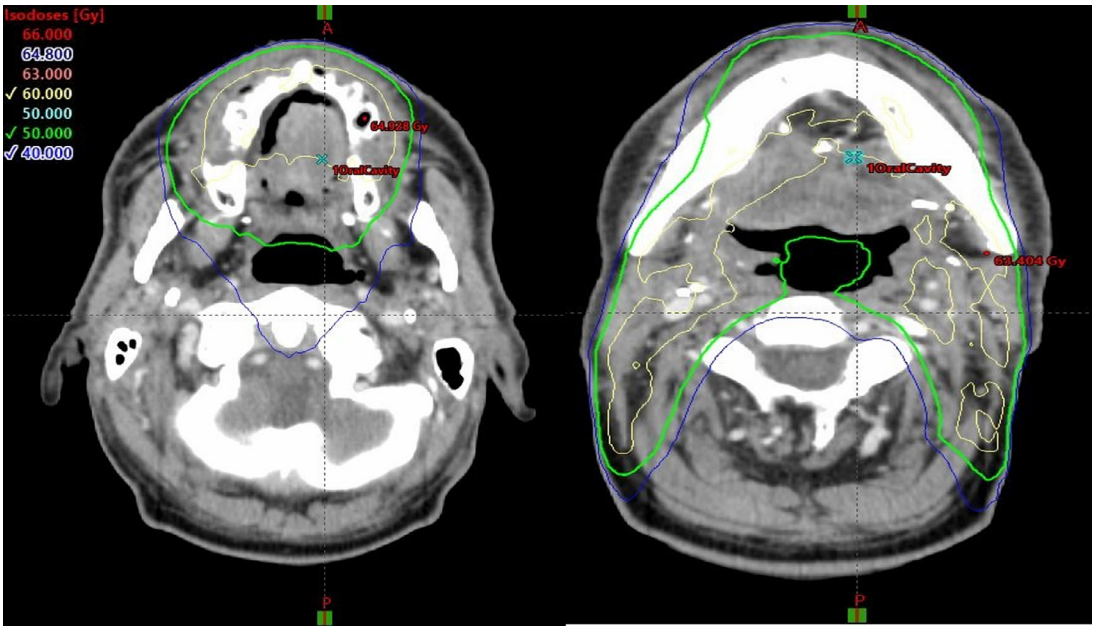


Fig. 3. Radiation mapping of maxilla and mandible.

of the fibula bone before inset significantly improves dental implant success rates at 5 years.[35] This suggests that bone density could be influencing long-term implant survival.

In this study, although a high survival rate of dental implants was noted, we caution that this is reliant upon careful surgical planning. Before all dental implant placements, patients were reviewed and discussed in a multidisciplinary team meeting (prosthodontics and oral surgery). Preoperative imaging (cone beam computed tomography) was carried out for bone analysis and surgical stent creation. The authors acknowledge that although a standardized surgical approach was not used across the 12-year study period, steady advancements in technology were adopted to improve patient outcomes.

Complications of dental implant placement

In our study, a low incidence of complications after dental implant placement was recorded. Two patients went on to develop ORN associated with dental implants. In both cases, patients received radiotherapy with concomitant chemotherapy. The radiotherapy protocol used in both cases was 65 Gy in 30 fractions over 6 weeks. In one case, the patient developed ORN almost immediately after dental implant placement; in the other case, the patient developed ORN at the 2-year review appointment after infection around the dental implant. In view of the challenges associated with the management of ORN of the jaw and the implications for patients' quality of life, there is a need to balance the risks of developing ORN with the benefits of oral rehabilitation. In our study, radiation mapping was used to identify bone sites with radiation exposure of <50 Gy. The authors recognize that although there is a historically quoted threshold of 40 Gy for which impaired osseous regeneration is noted, there is a need to balance this with the quality and quantity of bone for optimal osseointegration, and hence a compromise is often required.[26]

Concomitant chemotherapy administered during radiotherapy, termed "chemoradiation," has been shown to have additional benefits in locoregional treatment and hence is often considered as part of initial cancer therapy.[36] Our findings revealed higher implant failure rates in the chemoradiation group than in the radiotherapy-alone group (83% vs 97%). The exact impact of chemotherapy on osseointegration is poorly understood, largely due to wide variations in the drugs used, dosage, and regimen. However, it is feasible to consider the effect chemotherapy has on reducing bone microvasculature. Recent work even suggests a possible role of chemotherapy in lowering the radiotherapy threshold for developing ORN.[23] Considering this, further provisions may need to be taken in this chemoradiation cohort of patients during dental implant placement to further reduce the risk of ORN.

Limitations

There are several limitations to this study. The first is that all patients were asked to seek out the care of their

general dental practitioner for implant maintenance and care, so we cannot confirm if patients were ensuring that these implants were maintained to a high standard. Failure to care for their implants could have affected surrounding bone loss and ultimately could have led to failure of the implant. Second, the authors recognize that the surgical approach to dental implant placement has evolved over the past 12 years, and, as such, the surgical approach and techniques are likely to have varied over time despite the same surgeon performing this procedure. Next, this study looked at the functional survival of dental implants and did not consider success. Hence, there is a lack of discussion about the prevalence of peri-implant mucositis and peri-implant bone levels within this patient cohort.

This study is unique in that a major confounding factor regarding survival is operator variability, which has been controlled for. Because all implants were placed by the same surgeon and reviewed following the same protocol, concerns about variation in the surgical skill of the operator and follow-up protocols were eliminated.

CONCLUSION

This study demonstrates that the placement of dental implants in patients with head and neck pathologies can show survival rates similar to those for placement in ideal conditions. However, we highlight that the cases need to be planned carefully by a multidisciplinary team and that the implants need to be placed and restored by experienced clinicians.

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