Survival of Dental Implants in Irradiated Head and Neck Cancer Patients: A Retrospective Analysis

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ABSTRACT

Purpose: To study the long-term survival of dental implants placed in irradiated bone in subjects who received radiation for head and neck cancer.

Materials and Method: A retrospective chart review was conducted for all patients who received dental implants following radiation treatment for head and neck cancer between May 1, 1987 through July 1, 2008. Only patients irradiated with a radiation dose of 50 Gy or greater and those who received dental implants in the irradiated field after head and neck radiation were included in the study. The associations between implant survival and patient/implant characteristics were estimated by fitting univariate marginal Cox proportional hazards models.

Results: A total of 48 patients who had prior head and neck radiation had 271 dental implants placed during May 1987 to July 2008. The estimated survival at 1, 5, and 10 years was 98.9%, 89.9%, and 72.3%, respectively. Implants placed in the maxilla were more likely to fail than implants placed in the mandible ($p = .002$).There was also a tendency for implants placed in the posterior region to fail compared with those placed in the anterior region ($p = .051$).

Conclusion: Dental implants placed in irradiated bone have a greater risk for failure. Survival is significantly influenced by the location of the implant (maxilla or mandible, anterior or posterior).

KEY WORDS: cancer, dental implants, radiation therapy

INTRODUCTION

Advanced squamous cell cancers of the head and neck are commonly treated with a combination of modalities such as surgery, radiation, and/or chemotherapy. Each modality presents with its own risks, side effects and benefits. Commonly, surgical treatment results in loss of vital structures or anatomical deformities[1] while the long-term side effects of radiation therapy can result in mucositis, xerostomia, periodontal attachment loss, dental caries, trismus, and osteoradionecrosis.[2]

Dental implants have a vital role to play in the rehabilitation of head and neck cancer patients. Dental implants improve quality of life by allowing reconstruction of tumor defects, proper retention of removable prostheses and reducing the overloading of vulnerable soft tissues.[3] These implants can be placed either in native bone or in grafted bone depending on the extent of the defect and restorative treatment plan. Bone grafts typically used for reconstruction include iliac crest,[4] scapula, rib, and fibula.[5]

Whether dental implants are placed in native or grafted bone, radiation exposure may cause a delay in wound healing. Head and neck radiation can result in damage to the osteoclasts and reduce proliferation of bone marrow, collagen, and blood vessels.[6] Radiotherapy also causes endarteritis that leads to hypoxia, hypocellularity, and hypovascularity, which compromises bone healing.[6] The extent of changes also depend upon dose, field, and type of radiation treatment.[7]

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All these can lead to reduced remodeling and reduced viability which affects osseointegration of dental implants.

There is limited data available about the long-term success of dental implants placed in patients with head and neck cancer who have received radiation therapy. Furthermore, there is much variation among these data, in the success rate reported. Success rate as high as 99% in the mandible was reported by Keller et al.[8] in patients who received radiotherapy, whereas rates as low as 70% were reported by Ryu et al.[9] A similar variation is seen in implants placed in the maxilla. The reported success rates vary from as high as 100%[10] to as low as 40%.[11]

Jisander et al.[12] reported that patients who received less than 50 Gy radiation have a higher success rate compared with the group of patients who received more than 50 Gy. Similarly, Visch et al.[13] reported a 71% survival of implants in tissues irradiated with greater than 50 Gy compared with 84% in tissues that received less than 50 Gy. Studies also reported implant failures at varying intervals of time after radiotherapy. The majority of studies reported implant failures within 36 months after radiation therapy.[10,14]

As most of the head and neck cancer patients receive radiation therapy prior to implant placement, it is important to study the survival of dental implants as osseointegration may be affected by the time interval between radiation therapy and implant placement.

The primary aim of this study was to specifically analyze factors that would predict for long-term survival of dental implants placed in previously radiated fields.

MATERIALS AND METHODS

A retrospective chart review was conducted for all patients who received dental implants following radiation treatment for head and neck cancer at the Mayo Clinic, Rochester, Minnesota between May 1, 1987 through July 1, 2008. Approval for the study was given by the Mayo Clinic Institutional Review Board. According to Minnesota state laws, any patient who had denied access of their medical records for research purposes was not included. Data was collected from patients' medical records. Only patients irradiated with a radiation dose of 50 Gy or greater and those who received dental implants in the radiated field after head and neck radiation were included in the study. The abstracted data included patient gender, diagnosis of cancer, date of initial radiation, radiation dose received, timing and sequence to dental surgery. For each implant, the abstracted data included date and age at implant placement, anatomic location, width and length of dental implant, time lapse between radiation and implant placement, and whether the implant was placed in native bone or grafted bone. Type of grafted bone in which implant was placed was also recorded. Survival of each implant was documented by its presence or absence in the oral cavity at the time of data collection. Implant failure was defined as its loss or explantation. The patient's records were followed until the last follow-up in the clinic and duration of follow-up was calculated from the time of placement to the date of failure or date of last follow-up. The Kaplan–Meier method was used to estimate the implant survival following placement. Associations between implant survival and patient/implant characteristics were estimated by fitting univariate marginal Cox proportional hazards models. The robust standard error method of Wei et al.[15] was used to account for the correlation between multiple implants within a patient. The associations were summarized by calculating hazard ratios (HR) and corresponding 95% confidence intervals (CI) using the robust standard errors. All calculated p-values were two-sided and p-values less than .05 were considered statistically significant. Analyses were performed using the SAS version 9.1 software package (SAS Institute, Inc., Cary, NC).

RESULTS

A total of 48 patients who had prior head and neck radiation had 271 dental implants placed between May 1987 to July 2008. The number of implants placed in each patient ranged from 1 to 27; 46 had 1 placement date (1 to 14 implants placed per patient), 1 patient had 2 placement dates (8 total implants), and 1 patient had 3 placement dates (27 total implants). The most frequent number of implants placed was 5, which occurred in 21 (44%) patients.

Twenty-nine of the 48 subjects were males and the mean age at the time of the first implant was 60.2 years (see Table 1). The median time interval between radiation and first implant placement was 3.4 years. The most common histologic tumor type identified was squamous cell carcinoma (43 of 48 patients), adenoid cystic carcinoma (3 of 48), basal cell carcinoma (1 of 48), and unknown primary head and neck carcinoma (1 of 48). Mean radiation dose received was 60.7 Gy with a range of 50.2 to 67.50 Gy.

TABLE 1 Summary of Patient and Radiation Characteristics

	Total ($N = 48$)
Age at first implant during the time period (years)	
Mean (SD)	60.2 (11.3)
Median	60.7
Range	(33.2–91.8)
Male gender	29 (60%)
Time between radiation and first implant (years)	
Median	3.4
IQR	1.2, 7.1
Radiation dose (Gy)	
Mean (SD)	60.7 (3.6)
Median	60.0
IQR	60.0, 60.6.0
Range	(50.2–67.5)

SD = standard deviation; IQR = interquartile range.

TABLE 2 Summary of Implant Characteristics

	Total ($N = 271$) (%)
Implant location	
Maxilla	62 (22.9)
Mandible	209 (77.1)
Implant location	
Anterior	235 (86.7)
Posterior	36 (13.3)
Type of bone	
Graft	59 (21.8)
Fibula	26
Iliac crest	29
Scapula	4
Native	212 (78.2)
Implant length (mm)	
7	1 (0.4)
8.5	4 (1.5)
10	19 (7)
11	1 (0.4)
11.5	5 (1.8)
13	33 (12.2)
15	142 (52.4)
18	65 (24)
20	1 (0.4)
Diameter (mm)	
3.3	1 (0.4)
3.75	97 (35.8)
4	135 (49.8)
5	38 (14)

Table 2 summarizes the implant characteristics. Eight patients had a total of 33 implants removed. A total of 62 implants were placed in the maxilla with 20 failures, and 209 implants placed in mandible with 13 failures. The mean (standard deviation, SD) time to failure/removal was 5.5 years, with a median of 5.5 years and range of 0.3 to 11.6 years. The remaining 238 implants were followed a mean (SD) of 3.2 (3.4) years (median = 1.9, range 0.4–16.9 years).

Table 3 summarizes the implant survival rates using the Kaplan–Meier method. The estimated survival free of failure at 1, 5, and 10 years was 98.9%, 89.9%, and 72.3%, respectively.

Tables 4–6 summarize the implant survival by following factors of interest which include location of implant, type of bone, radiation dose received, and time span between radiation and implant placement. Implants placed in the maxilla were more likely to fail than implants placed in the mandible ($p = .002$, Figure 1). At 2 and 5 years after placement, the survival of implants placed in the maxilla was 80.5%. In the mandible, the survival of implants at 2 and 5 years after placement was 99.5% and 93.6%, respectively. There was also a tendency for implants placed in the posterior region to be more likely to fail compared with those placed in the anterior region ($p = .051$, Figure 2). No statistically significant association of radiation dosage ($p = .53$) or time span between radiation and placement ($p = .63$) with implant failure was identified. There was no statistically significant difference between implant failure in native and grafted bone ($p = .76$) There was no statistically significant association between length or diameter of implant and its survival ($p = .16$ and $p = .15$, respectively).

TABLE 3 Kaplan-Meier Estimates of Survival-Free of Implant Failures

Years following Placement	Number of Implants Still at Risk	Cumulative Survival (%)
At 1 year	223	98.9
At 2 years	131	94.1
At 5 years	64	89.9
At 8 years	30	80.5
At 10 years	24	72.3

TABLE 4 Summary of Implant Survival by Factors of Interest

Variable	Number of Implants	Number of Failures	At 1 Year (%)	At 2 Years (%)	At 5 Years (%)	At 7 Years (%)
Implant location						
Maxilla	62	20	96.8	80.5	80.5	—*
Mandible	209	13	99.5	99.5	93.6	93.6
Implant location						
Anterior	235	22	99.5	96.2	91.4	86.5
Posterior	36	11	94.4	82.3	—	—
Type of bone						
Graft	59	8	98.3	96.4	83.3	83.3
Native	212	25	99.1	93.4	93.4	83.0
Gender						
Male	159	15	100	93.8	84.8	84.8
Female	112	18	97.3	94.9	94.9	81.7
Radiation dose (GY)						
≤60	189	27	98.4	95.8	91.5	84.3
>60	82	6	100.0	90.2	—	—
Time span between radiation & implant (days)						
≤518	66	14	98.5	98.5	98.5	71.1
519–1140	70	4	100.0	100.0	81.3	—
1141–2663	67	10	100.0	81.2	81.2	81.2
2664–5875	68	5	97.1	93.3	—	—

*Survival estimates are not provided when there are less than 10 implants still at risk.

Implants with a turned surface were 2.9 times more likely to fail; however, this difference did not reach statistical significance (95% CI 0.4–18.7, $p = .27$). Implants (turned) in the maxilla were more likely to fail than implants in the mandible ($p = .008$), and there was a tendency for implants in the posterior region to have a higher likelihood of failure compared with implants in the anterior region ($p = .089$). In addition, implants (turned) with a diameter of 3.75 or less had a higher likelihood of failing ($p = .022$) compared with implants with a diameter of 4 or 5.

DISCUSSION

Dental implant failure in patients receiving head and neck radiation is primarily a result of hard and soft tissue changes. Head and neck radiation brings about irreversible changes to the blood vessels and bone-forming cells, thus affecting bone turnover.[6]

TABLE 5 Kaplan-Meier Estimates of Survival-Free of Implant Failures by Length and Diameter of Implant

Variable	Number of Implants	Number of Failures	Survival-Free-of-Failure			
			At 1 Year (%)	2 Years (%)	5 Years (%)	7 Years (%)
Implant length(mm)						
≤13	63	16	96.7	79.6	79.6	75.2
>13	208	17	99.5	98.4	92.3	84.3
Implant diameter(mm)						
3.3 or 3.75	98	15	100	98.6	84.5	65.7
4 or 5	173	18	98.2	91.9	91.9	89.9

TABLE 6 Summary of the Patient/Implant Characteristics Evaluated for an Association with Implant Failure

Factor	HR (95% CI)	*p*-Value
Maxilla (vs. mandible)	6.0 (1.9–18.5)	0.002
Posterior (vs. anterior)	3.3 (0.99–10.8)	0.051
Native bone (vs. grafted bone)	1.2 (0.3–4.7)	0.76
Female (vs. male)	1.0 (0.3–3.6)	0.97
Dose > 60 Gy (vs ≤60 Gy)	1.9 (0.2–14.9)	0.53
Time Span in days between radiation and placement		0.63
>518	Referent	
519–1140	0.3 (0.04–2.8)	
1141–2663	1.2 (0.2–5.8)	
2664–5875	0.5 (0.1–2.2)	
Implant length ≤ 13 mm (vs >13 mm)	2.7 (0.7–10.9)	0.16
Diameter ≤ 3.75 mm (vs 4 or 5 mm)	2.2 (0.8–6.1)	0.15

HR, hazards ratio; CI, confidence interval.

Osseointegration of dental implants can be compromised as a result of changes brought about by radiation therapy.

An attempt has been made in the present study to evaluate long-term survival of dental implants in irradiated head and neck cancer patients. This study compared survival in relation to multiple variables. Survival was compared in maxilla and mandible. Implants placed in the maxilla were more likely to fail compared with those implants placed in mandible ($p = .002$). The difference in the bone density of the maxilla and mandible could account for better results in the mandible.[16–19] This finding is in agreement with the previous studies.[20–22] Eckert et al.[20] reported a survival of 64% in the maxilla and 99% in the mandible. Similarly, Niimi et al.[21] reported a survival of 77% in the maxilla and 96% in the maxilla. The results in this long-term study confirmed the short term findings in the previously described studies.

The study also demonstrated that when dental implants were placed in head and neck radiation patients, anatomic location was identified as a risk factor. There was a tendency for implants placed in the posterior region to be more likely to fail compared with those placed in the anterior region ($p = .051$). This is in contrast with the study by Granstrom[18] who reported no significant differences in the anterior and posterior regions. However, this is in agreement with previous

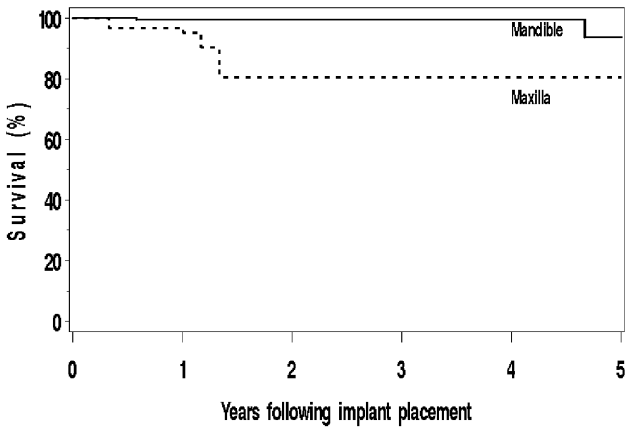

Figure 1 Kaplan–Meier curves for implant survival by arch type.

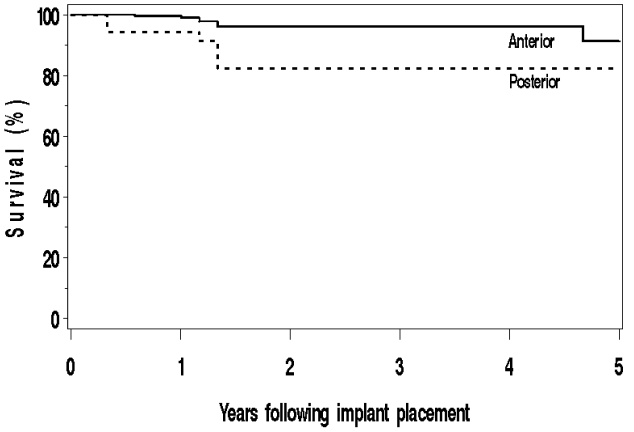

Figure 2 Kaplan–Meier curves for implant survival by location.

studies that have reported anatomic location and/or bone quality as a risk factor for failure of implants.[23,24] But these studies were conducted in subjects who have no history of head and neck radiation. Implants placed in Type IV bone which is present in posterior maxilla have higher failure rates compared with implants placed in other types of bone[23] which is in agreement with the results of this study.

Implant failure was also investigated in relation to radiation dosage and time span between radiation and implant placement. A total of 12 patients (82 implants) received a radiation dose greater than 60 Gy, and six failures occurred all in the same patient at 1.3 years. The maximum follow-up in this group was 2.8 years, and the survival at 2 years was 90.2%. In contrast, 36 patients (189 implants) received a radiation dose less than or equal to 60 Gy and the survival at 2 years was 95.8%.Implants placed in subjects who received radiation dose of less than 60 Gy had survival rate of 90.2% at 7 years compared with 84.3% in subjects who received radiation dose of greater than or equal to 60 Gy. Though not statistically significant, more failures were noted in subjects who received radiation dose of greater than 60 Gy which is in agreement with other studies.[14,20] This study was unable to identify any significant association between implant failure and time span between radiation therapy and implant placement. The majority of the failures occurred when implants were placed within 17 months of receiving radiation. Implants placed within 17 months of receiving radiation had 71.1% survival rate at 7 years. This is just an observation and a conclusion should not be drawn recommending waiting a specific amount of time between radiation therapy and implant placement. Previous studies report failures occurring within 6 months of receiving radiation.[7,10,14,24,25] Based on the conclusions from various studies, it is prudent to place implants after a wait period of 6 months of receiving head and neck radiation and also expect a higher failure rate when places in subjects who receive a radiation dose of greater than 50 Gy.

There was no statistically significant association between implant length and diameter and its survival in irradiated bone. There are no studies to the knowledge of the authors that compared implant length and diameter with survival in irradiated bone. Hence, we were unable to compare the data obtained from the present study to any other study.

There are always limitations associated with retrospective studies. Data about smoking and other systemic medical conditions could not be accounted for in all subjects during follow-up. Further prospective long-term controlled studies are necessary to support the conclusion of this study.

CONCLUSIONS

Based on this retrospective study the following observations were made:

- The estimated survival-free of failure at 1, 5, and 10 years was 98.9%, 89.9%, and 72.3%, respectively.
- Implants placed in maxilla failed more than implants placed in mandible.
- Implants placed in the posterior region failed more than the ones placed in the anterior region.
- No association was identified between survival and length, diameter, type of bone, and radiation dose received.

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