Survival rate and complication-free survival rate of implant-retained prostheses in the oral rehabilitation of patients with head and neck cancer

Laverty, Dominic P; Addison, Owen; Sharma, Praveen; Newsum, David; Bateman, Geoffrey

DOI:
10.1016/j.prosdent.2022.06.010

Document Version
Peer reviewed version

Citation for published version (Harvard):
Laverty, DP, Addison, O, Sharma, P, Newsum, D & Bateman, G 2022, 'Survival rate and complication-free survival rate of implant-retained prostheses in the oral rehabilitation of patients with head and neck cancer: a retrospective evaluation of a cohort from a regional service', *The Journal of Prosthetic Dentistry*. https://doi.org/10.1016/j.prosdent.2022.06.010

JPD-21-1295

CLINICAL RESEARCH

Survival rate and complication-free survival rate of implant-retained prostheses in the oral rehabilitation of patients with head and neck cancer: A retrospective evaluation of a cohort from a regional service

Dominic P. Laverty, BDS(Hons), MFDS RCS, MSc(Res), MPros RCS, FDS(Rest Dent)RCS,[a] Owen Addison, BDS, FDS(Rest Dent)RCS, PhD,[b] Praveen Sharma, BDS, FDS(Rest Dent)RCS, PhD,[c] David Newsum, BDS, MFDS RCS, MSc, MRCPS, MRD RCS, FDS(Rest Dent)RCS,[d] Geoffrey Bateman, BDS, FDS(Rest Dent)RCS[e]

[a]Consultant in Restorative Dentistry. Restorative Department, University of Birmingham School of Dentistry, Birmingham Dental Hospital, Birmingham, UK.

[b]Professor of Oral Rehabilitation. Centre for Clinical, Oral and Translational Sciences, King's College London, London, UK.

[c]Associate Professor & Honorary Consultant in Restorative Dentistry. University of Birmingham School of Dentistry, Birmingham Dental Hospital, Birmingham, UK.

[d]Consultant in Restorative Dentistry. Restorative Department, University of Birmingham School of Dentistry, Birmingham Dental Hospital, Birmingham, UK.

[e]Private practice. West Midlands, UK.

ABSTRACT

Statement of problem. Literature reporting on the prosthetic survival and complications of implant-retained prostheses in patients with head and neck cancer is sparse.

Purpose. The purpose of this retrospective study was to present the survival rates and complication-free survival rates of both fixed and removable implant-retained oral prostheses in patients with head and neck cancer while also reporting on the frequency and causes of failure and complications for each prosthesis type.

Material and methods. A retrospective analysis was performed of the prosthetic survival rates and complication-free survival rates of implant-retained oral prostheses and the frequency and causes of failure and complications in patients with head and neck cancer treated in a regional unit from 2012 to 2017. Differences in categorical and continuous data were assessed for statistical significance by using the Pearson chi-square test, Fisher exact test, *t* test, and analysis of variance as appropriate. Cox proportional hazard regression models were fitted to evaluate the association between prostheses type, clinical and medical factors, and the outcomes of survival and complication-free survival. Descriptive statistics were used to analyze the frequency and type of prosthetic complications.

Results. The sample was composed of 153 patients diagnosed with head and neck cancer who had completed implant-retained prosthodontic rehabilitation and had been provided with 221 prostheses. The 5-year survival rate was maxillary fixed prostheses (87%), mandibular fixed (79%), maxillary removable (66%), and mandibular removable (50%). Hazard ratios were calculated showing that the 5-year survival rate of a mandibular removable prosthesis (HR=5.1; 95%CI 1.60 to 16.25) (*P*=.006) was greater in comparison with a maxillary fixed prosthesis (HR=1.0). The 5-year complication free-survival rate was highest for mandibular fixed prostheses (62%) followed by maxillary fixed (58%), maxillary removable (36%), and

mandibular removable (29%). Hazard ratios showed that the 5-year survival rate of maxillary removable (HR=1.91; 95%CI 1.01 to 3.66) (*P*=.048) and mandibular removable prosthesis (HR=2.29; 95%CI 1.23 to 4.25) (*P*=.009) were greater than with a maxillary fixed prosthesis (HR=1.0). Variables of radiotherapy, grafting, age, and sex on the survival rate and complication-free survival rate were assessed but were not statistically significant.

Conclusions. This evaluation indicated that fixed implant-retained prostheses had a higher 5-year survival rate and 5-year complication-free survival rate in comparison with removable implant-retained prostheses in patients with head and neck cancer.

CLINICAL IMPLICATIONS.

The results of this study demonstrate that fixed implant-retained prostheses have a higher 5-year survival rate and complication-free survival rate in comparison with removable implant-retained prostheses. They also demonstrate the risk of prosthodontic failure and complications and thus the high maintenance burden of such prostheses for this patient cohort.

Prosthodontic treatment of patients diagnosed with head and neck cancer is challenging because of altered anatomy, irradiation-induced xerostomia and associated fragile mucosa, the presence of vulnerable tissues, impaired oral function, and a lack of emotional resilience to tolerate such treatment.[1-3] As conventional prostheses can be of limited benefit in these circumstances, implant-retained prostheses are often indicated[4,5] and are increasingly used in the oral rehabilitation of patients with head and neck cancer.[6-8] However, most of the outcome reports of oral rehabilitation in patients with head and neck cancer have focused on implant survival and quality of life measures as opposed to prosthesis success or survival.[9-19] Therefore,

given the increasing use of dental implants in this patient group,[20] there is a need for such studies to better inform clinicians and patients.

The aim of this study was to present the survival rates and complication-free survival rates of both fixed and removable implant-retained oral prostheses and the frequency of failures and complications for each prosthesis type of patients with head and neck cancer treated in a tertiary center. The research hypothesis was that the prostheses type (fixed or removable) and clinical and medical factors (grafting, radiotherapy, and chemotherapy) would impact the survival rates and complication-free survival rates of implant-retained oral prostheses in patients with head and neck cancer.

MATERIAL AND METHODS

The study was performed by examining retrospectively the treatment records of patients diagnosed with head and neck cancer who had been provided with an implant-retained prosthesis as part of oral and dental rehabilitation in the Restorative Dentistry department at Birmingham Dental Hospital (BDH), Birmingham, United Kingdom. BDH is a tertiary care unit which covers a mainly urban population of 5.5 million people within the West Midlands region of the United Kingdom. The service was led by a single consultant in restorative dentistry (G.B., then D.N.) during this period. Approval for this service evaluation was given by the Birmingham Community Healthcare NHS Foundation Trust Research and Development team (Birmingham, UK).

Treatment was linked to care provided by the oral and maxillofacial surgical teams at BDH or at University Hospitals Birmingham (UHB). Despite the variability in disease

presentation and in its management, a consistent coordinated care pathway was followed leading to oral and dental rehabilitation including multidisciplinary planning.

The prosthodontic restoration and maintenance of the dental implants was undertaken by the restorative team at BDH. The type of prosthesis the patient received was usually planned during implant surgery planning. All technical and dental laboratory procedures were carried out or prescribed by dental laboratory technicians at BDH. The work prescribed is sent to external dental laboratories (for example, Atlantis suprastructures are sent to Dentsply Sirona Implants, Hasselt, Belgium). Patients were reviewed at least annually, but the recall interval was determined by the treating clinician at the most recent appointment. The patients are provided with either fixed (single implant-supported crowns or implant-supported fixed prostheses) or removable implant-retained prostheses by using an attachment (LOCATOR; Zest Dental Solutions).

Inclusion criteria for the study were patients diagnosed with benign or malignant head and neck tumors who had been provided with an implant-retained fixed or removable intraoral prosthesis and had been followed up on at least 1 occasion after the delivery or fitting of the prosthesis between November 2012 and May 2017. The study included implant-retained prostheses that had been provided at an earlier date within the unit but had been followed up during this time period. Any subsequent replacement or additional implant-retained prosthesis other than the first prosthesis provided were excluded, as were patients from whom the minimum data set could not be collected (Table 1).

Patients were identified from an electronic patient management system (RiO EPR iSoft; Servelec). The clinical records of all potential patients were retrieved and reviewed at both BDH and at UHB. These comprised a combination of paper medical records, scanned paper medical

records (Digital record center; Iron Mountain), and electronic medical records (CS R4 Clinical+ PMS; Carestream and Clinical Portal; UHB). The data were collected for patients treated over a continuous period (November 2012 to May 2017). Anonymized data were extracted by 1 researcher (D.P.L.) and entered on a spreadsheet (Excel; Microsoft Corp) as shown in Table 1.

Prosthetic survival was defined separately for fixed and removable prostheses. For removable prosthesis survival: prosthesis being used by the patient; for fixed prosthesis survival: prosthesis in situ. The prosthetic survival time was defined as the time from the date of restoration of the implant(s) to the date of the first prosthetic failure or last follow-up, whichever occurred first. Prosthetic complication-free survival was defined as a prosthesis deemed to have survived without encountering a complication requiring adjustment, modification, or partial replacement of the prosthesis. The prosthetic complication-free survival time was determined as the time from the date of restoration of the implants to the date of the first prosthetic complication or last follow-up date, whichever occurred first, without the prosthesis failing before this date. Prosthetic complications were grouped into implant and implant-based prosthetic components, repair of prosthesis, and adjustment of prosthesis.

The data were collected for patients that met the inclusion criteria and then analyzed. A sample size calculation was not conducted. Differences in categorical and continuous data were assessed for statistical significance by using the Pearson chi-square, Fisher exact test, *t* test, and analysis of variance (ANOVA) as appropriate. Cox proportional hazards (CPH) regression models were fitted to evaluate the association between prosthesis type (fixed or removable) and clinical and medical factors (grafting, radiotherapy, chemotherapy) and survival and complication-free survival, independent of potential confounders of age and sex. The CPH assumption was tested by using graphical methods. Descriptive statistics were used to analyze

the frequency and type of prosthetic complications. The timing of prosthetic failure and the time to the first prosthetic complication was calculated from the date of prosthetic restoration to the date of the event. Analyses were carried out by using a statistical software program (Stata/IC v14.0; StataCorp LP) and by 3 researchers (P.S., D.P.L., O.A.).

RESULTS

A total of 167 patients were identified for inclusion in this study. Fourteen patients were excluded from the analysis because the minimum data set was not available or no follow-up had occurred after delivery of their prostheses. Therefore, a total of 153 participants were included for analysis. A total of 713 intraoral implants were placed with 30 implant failures during the observation period, as have previously been reported.[21] The 153 participants had been rehabilitated with 221 prostheses with a mean ±standard deviation follow-up of 2.6 ±1.9 years (range 0.1 to 8.8 years). The type and anatomic site of the prosthesis provided are shown in Table 2. The prostheses were grouped into maxillary fixed, mandibular fixed, maxillary removable, and mandibular removable. Participants in these groups did not vary significantly in their age (P=.081), sex (P=.518), or the need for grafting (P=.037). However, patients who were rehabilitated with a mandibular fixed prosthesis were less likely to have received radiotherapy compared with the other groups (P=.003) as shown in Table 3.

All prosthesis types had reduced survival rates over time as shown in the Kaplan-Meier curves as seen in Figure 1. CPH regression models adjusting for age and sex were used to report the 5-year survival rate and identify the hazard ratio for each prosthesis type. This revealed that the 5-year survival rate was highest for maxillary fixed prostheses (87%) followed by mandibular fixed (79%) and maxillary removable (66%) and lowest for mandibular removable

(50%) (Fig. 2). For the calculation of hazard ratios, the maxillary fixed prosthesis was used as the reference (HR=1.0). The results compared with maxillary fixed prostheses were: mandibular fixed (HR=1.71; 95% confidence interval [CI] 0.47 to 6.21), maxillary removable (HR=3.05; 95%CI 0.83 to 11.15) and mandibular removable (HR=5.1; 95%CI 1.60 to 16.25). The mandibular removable prostheses had clinically significant higher rates of failure (*P*=.006). Variables of radiotherapy, grafting, age, and sex were assessed for their effect on overall prosthesis survival rate by using the CPH regression model. A 23% increased HR of failure was found in participants who received radiotherapy, and a 65% increased HR of failure was found in grafted sites, but these were not statistically significant (Table 4).

All prosthesis types had reduced complication-free survival rates over time as shown in the Kaplan-Meier curves (Fig. 3). CPH regression models adjusting for age and sex were used to report the 5-year complication-free survival rate and identify the hazard ratio for each prosthesis type. This revealed that the 5-year complication-free survival rate was highest for mandibular fixed prostheses (62%), followed by maxillary fixed (58%) and maxillary removable prostheses (36%), and that the lowest complication-free survival rate was found for mandibular removable prostheses (29%) (Fig. 4). For the calculation of hazard ratios, the maxillary fixed prosthesis was used as the reference (HR=1.0). The results show that, compared with maxillary fixed prostheses, mandibular fixed (HR=0.88; 95%CI 0.43 to 1.79) prostheses had the highest complication-free survival rate, followed by the maxillary fixed (HR=1.0), maxillary removable (HR=1.91; 95%CI 1.01 to 3.66), and mandibular removable (HR=2.29; 95%CI 1.23 to 4.25) prosthesis. The mandibular removable (*P*=.009) and maxillary removable prosthesis (*P*=.048) had clinically significant higher rates of failure. Variables of radiotherapy, grafting, age, and sex were assessed for their effect on the overall complication-free survival rate of the prosthesis by

using the CPH regression model. A 6% increased HR of failure was found in patients who received radiotherapy, and 72% increased HR of failure was found in grafted sites, but these were not statistically significant (Table 5).

A total of 51 fixed maxillary prostheses were provided: 50 fixed implant-supported partial dentures and 1 single unit implant-supported crown. No complete arch fixed implant-retained prostheses were provided. The mean ±standard deviation follow-up was 3.2 ±2.1 years (range 0.2-8.8 years). Two fixed maxillary prostheses failed during the observational period (Table 6). Complications that occurred during the observational period are shown in Table 6.

A total of 52 fixed mandibular prostheses were provided, all of which were fixed implant-supported partial dentures. No complete arch fixed implant-retained prostheses were provided. The mean ±standard deviation follow-up was 3.1 ±2.0years (range 0.19-6.8 years). Five fixed mandibular prostheses failed during the observational period (Table 6). Complications that occurred during the observational period are shown in Table 6.

A total of 52 removable maxillary prostheses were provided, all of which were implant-retained overdentures using an attachment system (LOCATOR; Zest Dental Solutions) with a mean ±standard deviation follow-up of 2.1 ±1.8 years (range 0.15-8.8 years). Five removable maxillary prostheses failed during the observational period (Table 7). Complications that occurred during the observational period are shown in Table 7. A total of 66 removable mandibular prostheses were provided, all of which were implant-retained overdentures using an attachment system (LOCATOR; Zest Dental Solutions) with a mean ±standard deviation follow-up of 2.1 ±1.6 years (range 0.11 to 6.2 years). Thirteen removable mandibular prostheses failed during the observational period (Table 7). Complications that occurred during the observational period are shown in Table 7.

DISCUSSION

The research hypothesis was partially accepted. The 5-year survival rate was significantly reduced for mandibular removable prostheses as was the 5-year complication-free survival rate for both maxillary and mandibular removable prostheses. However, variables of radiotherapy, grafting, age, and sex were not found to be statistically significant for their effect on the 5-year survival rate and 5-year complication-free survival rate.

The 5-year prosthetic survival rate was found to decline for all prosthesis types over the observational period, with the lowest survival rate for mandibular removable prostheses. Studies reporting on the survival rate of implant-retained prostheses in this patient group are sparse, and those studies reported prosthesis survival as an additional rather than a primary study outcome.[9-19] For patients diagnosed with head and neck cancer, Shaw et al[10] reported failure of 12 implant retained prostheses (17% prosthesis failure) with a follow-up of 3.5 years. Nelson et al[11] reported 100% survival rate of the 78 removable- and 25 fixed-implant retained prostheses that were followed-up for 10.3 years.[11] Other studies[3,12] have reported prosthetic failure in this patient group but have not quantified such events to allow comparison. In the present study, fixed- in comparison with removable-implant-retained prostheses were found to have a higher 5-year survival rate, consistent with other studies.[3,10,12] The most common cause of failure of removable implant-retained prostheses was reported to be related to a lack of tolerance or the inability of the patient to adapt to the prosthesis.[3,10,12,18] In the present study, the most common cause of failure for fixed implant-retained prostheses was because of repeated fracture of the prosthetic teeth, consistent with other studies.[14,19] The variables of radiotherapy and grafting were not associated with a statistically significant increased risk of failure. Such variables and their effects on

prosthetic survival rates have not previously been reported. In a study with increased sample size, both radiotherapy and grafting might have an impact either directly or indirectly (via implant failure) on prosthetic survival, because both of these treatment modalities can lead to a less favorable intraoral environment that does not lend itself well to prosthetic rehabilitation.[1-3]

The 5-year complication-free survival rate was found to decline for all prosthesis types over the observational period, with the lowest complication-free survival rate for mandibular removable prostheses. Removable implant-retained prostheses had a higher frequency of complications, consistent with previous studies.[11,13,14] Nelson et al,[11] and later (with the same patient group), Doll et al[13] reported higher prosthetic complications and increased maintenance needs for removable- in comparison with fixed-implant-retained prostheses.[11,13] Such observations were similarly reported by Fang et al.[14] The most common complication with a removable implant overdenture in this study was related to the LOCATOR retention system, as has been reported by Nelson et al.[11] The frequent need for the modification and relining of removable implant-retained prostheses was found and was also reported in other studies.[4,16] This was commonly because the prosthesis had a suboptimal fit or was subsequent to intraoral soft tissue overgrowth (both cancerous and noncancerous). Additionally, Shaw et al[10] and Teoh et al[15] reported failure of the prosthesis because of soft tissue overgrowth and the need for prosthesis replacement.[10,15] Additionally, a number of removable prostheses in the study fractured during the observational period, a previously reported but uncommon complication.[14,17,18]

When assessing the maintenance and complications associated with fixed implant-retained prostheses in the present study, the most common complication was related to fracture of the prosthesis. This was found to be a recurring event within the same group of patients. Fracture of fixed implant-retained prostheses in similar patients has been reported by Zou et al,[19]

and Fang et al[14] reported the fracture of fixed implant prostheses with chipping of the porcelain in 4 patients and the wear or fracture of acrylic resin in 1 patient of the 57 patients in the study.[14] The need for adjustment of fixed implant prostheses to improve access for oral hygiene measures was found in the present study, also reported previously.[10,19] Variables of radiotherapy, grafting, age, and sex were assessed for their effect on the overall complication-free survival rate; however, none of these were found to be statistically significant. The authors are unaware of previous reports of such variables or their effects on prosthetic complications, making comparisons impossible.

Limitations of this evaluation included its retrospective design, with some data not being recorded, and a risk of reporting bias, meaning failure and complications may have been underreported. As the evaluation reported on a specific regional center, the results cannot be extrapolated beyond this environment, thereby reducing its external validity and generalizability. Consensus is also lacking on the standardization of the minimum data set required for measuring outcomes and on the most appropriate way of analyzing data and endpoints. A further limitation is the small number of patients in various subgroups, making comparisons at this level without statistical power.

Future research should be aimed at providing a clear consensus on defining outcome measures such as prosthodontic failure and prosthodontic complications. A consensus is also needed on the standardization of the minimum data set required for measuring outcomes and on the most appropriate way to statistically analyze the data and endpoints. Such a consensus would facilitate standardization and enable the comparison of studies, including statistical analysis. To understand these complications, larger, well-designed prospective studies are required.

CONCLUSIONS

Based on the findings of this retrospective study, the following conclusions were drawn:

1. The 5-year survival rate was maxillary fixed prostheses (87%), mandibular fixed (79%), maxillary removable (66%) prostheses, and mandibular removable (50%) prostheses. Prosthesis survival rates declined over time. Overall survival was reduced for removable- in comparison with fixed-implant-retained prostheses, which was shown to be statistically significant for mandibular removable prostheses.
2. The 5-year complication-free survival rate was mandibular fixed prostheses (62%), maxillary fixed prostheses (58%), maxillary removable (36%) prostheses, and mandibular removable prostheses (29%). Complication-free survival rates declined over time. Overall complication-free survival rates declined for removable- in comparison with fixed-implant-retained prosthesis, which was shown to be statistically significant for both maxillary and mandibular removable prostheses.
3. No statistically significant effects were found for the variables of radiotherapy, grafting, age, and sex on the 5-year survival rate and 5-year complication-free survival rates of the prostheses. Patient who received radiotherapy had an increased HR of failure for both the 5-year survival rate (23% increased HR of failure) and the 5-year complication-free survival rate (6% increased HR of failure) of the prosthesis. Patients who received grafting had an increased HR of failure for both the 5-year survival rate (65% increased HR of failure) and the 5-year complication-free survival rate (72% increased HR of failure) of the prosthesis.

4. Implant-based prosthetic treatment for this patient group can be unsuccessful and can involve a high maintenance burden in the form of the management of prosthetic complications and failure.

REFERENCES

1. Eckert SE, Desjardins RP, Keller EE, Tolman DE. Endosseous implants in an irradiated tissue bed. J Prosthet Dent 1996;76:45–9.

2. Visch LL, van Waas MA, Schmitz PI, Levendag PC. A clinical evaluation of implants in irradiated oral cancer patients. J Dent Res 2002;81:856–9.

3. Barrowman RA, Wilson PR, Wiesenfeld D. Oral rehabilitation with dental implants after cancer treatment. Aust Dent J 2011;56:160–5.

4. Mericske-Stern R, Perren R, Raveh J. Life table analysis and clinical evaluation of oral implants supporting prostheses after resection of malignant tumors. Int J Oral Maxillofac Implants 1999;14:673–80.

5. Weischer T, Mohr C. Ten-year experience in oral implant rehabilitation of cancer patients: treatment concept and proposed criteria for success. Int J Oral Maxillofac Implants 1999;14:521–8.

6. Müller F, Schädler M, Wahlmann U, Newton JP The use of implant-supported prostheses in the functional and psychosocial rehabilitation of tumor patients. Int J Prosthodont 2004;17:512–7.

7. Schoen PJ, Reintsema H, Raghoebar GM, Vissink A, Roodenburg JLN. The use of implant retained mandibular prostheses in the oral rehabilitation of head and neck cancer patients. A review and rationale for treatment planning. Oral Oncology 2004;40:862–71.

8. Hessling SA, Wehrhan F, Schmitt CM, Weber M, Schlittenbauer T, Scheer M. Implant-based rehabilitation in oncology patients can be performed with high long-term success. J Oral Maxillofac Surg 2015;73:889–96.

9. Granstrom G. Osseointegration in irradiated cancer patients: an analysis with respect to implant failures. J Oral Maxillofac Surg 2005;63:579–85.

10. Shaw RJ, Sutton AF, Cawood JI, Howell RA, Lowe D, Brown JS, et al. Oral rehabilitation after treatment for head and neck malignancy. Head Neck 2005;27:459–70.

11. Nelson K, Heberer S, Glatzer C. Survival analysis and clinical evaluation of implant-retained prostheses in oral cancer resection patients over a mean follow-up period of 10 years. J Prosthet Dent 2007;98:405–10.

12. Cotic J, Jamsek J, Kuhar M, Ihan Hren N, Kansky A, Özcan M, et al. Implant-prosthetic rehabilitation after radiation treatment in head and neck cancer patients: a case-series report of outcome. Radiol Oncol 2016;7:94–100.

13. Doll C, Nack C, Raguse JD, Stricker A, Duttenhoefer F, Nelson K, et al. Survival analysis of dental implants and implant-retained prostheses in oral cancer patients up to 20 years. Clin Oral Investig 2015;19:1347–52.

14. Fang W, Liu YP, Ma Q, Liu BL, Zhao Y. Long-term results of mandibular reconstruction of continuity defects with fibula free flap and implant-borne dental rehabilitation. Int J Oral Maxillofac Implants 2015;30:169–78.

15. Teoh KH, Huryn JM, Patel S, Halpern J, Tunick S, Wong HB, et al. Implant prosthodontic rehabilitation of fibula free-flap reconstructed mandibles: a Memorial Sloan-Kettering Cancer Center review of prognostic factors and implant outcomes. Int J Oral Maxillofac Implants 2005;20:738–46.

16. Linsen SS, Martini M, Stark H. Long-term results of endosteal implants following radical oral cancer surgery with and without adjuvant radiation therapy. Clin Implant Dent Relat Res 2012;14:250–8.

17. Parbo N, Murra NT, Andersen K, Buhl J, Kiil B, Nørholt SE. Outcome of partial mandibular reconstruction with fibula grafts and implant-supported prostheses. Int J Oral Maxillofac Surg 2013;42:1403–8.

18. Cuesta-Gil M, Ochandiano Caicoya S, Riba-García F, Duarte Ruiz B, Navarro Cuéllar C, Navarro Vila C. Oral rehabilitation with osseointegrated implants in oncologic patients. J Oral Maxillofac Surg 2009;67:2485–96.

19. Zou D, Huang W, Wang F, Wang S, Zhang Z, Zhang C, et al. Autologous ilium grafts: long-term results on immediate or staged functional rehabilitation of mandibular segmental defects using dental implants after tumor resection. Clin Implant Dent Relat Res 2015;17:779–89.

20. Alani A, Owens J, Dewan K, Summerwill A. A national survey of oral and maxillofacial surgeons' attitudes towards the treatment and dental rehabilitation of oral cancer patients. Br Dent J 2009;207:540–1.

21. Laverty DP, Addison O, Wubie BA, Heo G, Parmar S, Martin T, et al. Outcomes of implant-based oral rehabilitation in head and neck oncology patients-a retrospective evaluation of a large, single regional service cohort. Int J Implant Dent 2019;5;5–8.

Corresponding author:

Mr Dominic P. Laverty

Department of Restorative Dentistry

Birmingham Dental Hospital

5 Mill Pool Way

Birmingham

UNITED KINGDOM

B5 7EG

Email: Dominic.laverty1@nhs.net

TABLES

Table 1. Data collection (minimum data set)

Demographics
• Sex • Age • Oncological diagnosis • TNM classification and staging
Treatment
• Whether patient had surgery • Radiotherapy (dose and site) • Chemotherapy (drug types and dosages) • Nature of surgical reconstruction • Type of microvascular free flap or graft used
Implant
• Number of implants placed • Date(s) of implant placement • Site of implant placement
Prosthetic rehabilitation
• Date of restoration of implants • Site of oral rehabilitation (maxilla or mandible) • Classification of prosthesis (fixed or removable)

• Details of prosthesis provided (single implant-supported crowns or implant-supported fixed prostheses or removable implant-retained prosthesis and the retention system used) • Date of prosthetic failure • Type and cause of the prosthetic failure • Date of first prosthetic complication • Type and cause of all reported prosthetic complications
Dates
• Date of last follow-up or, where appropriate, date of death

TNM, Tumor, nodes, metastases.

Table 2. Demographics of study population

Demographics	**N=153**
Age	63.3 years (Range:32-88)
Male	N= 101 (66%)
Cancer Type	
Squamous cell carcinoma	118 (77.1%)
Adenoid cystic carcinoma	7 (4.6%)
Ameloblastoma	5 (3.3%)
Unspecified carcinoma or tumor	5 (3.3%)
Malignant melanoma	2 (1.3%)
Osteogenic sarcoma	2 (1.3%)
Mucoepidermoid	2 (1.3%)
Pleomorphic adenoma	2 (1.3%)
Basal cell carcinoma	2 (1.3%)
Adenocarcinoma	2 (1.3%)
Primitive neuroectodermal tumor	1 (0.7%)
Chondrosarcoma	1 (0.7%)
Odontogenic keratocyst	1 (0.7%)
Lymphoma	1 (0.7%)
Dendritic cell sarcoma	1 (0.7%)
Pindborg tumor	1 (0.7%)
TNM staging	
I	20 (13.1%)

II	20 (13.1%)
III	12 (7.8%)
IVA	55 (35.9%)
IVB	1 (0.7%)
IVC	1 (0.7%)
Unknown	44 (28.8%)
Treatment modality	
No Surgery	18 (11.8%)
Surgery and no reconstruction	51 (33.3%)
Surgery and reconstruction with free flap or autogenous bone graft	84 (54.9%)
Radiotherapy	72 (47.0%)
Chemoradiotherapy	25 (16.3%)
Chemotherapy	0 (0.0%)
Neither (radiotherapy nor chemotherapy)	56 (36.6%)
Type of tissues used for surgical reconstruction	
Fibula	26
Radial	29
Deep circumflex iliac artery flap (DCIA)	11
Scapula	8
Anterolateral thigh flap (ALT)	6
Iliac crest (nonvascular)	3
Pectoralis Major	2

Type of prostheses	
Maxillary fixed	51 (23.1%)
Mandibular fixed	52 (23.5%)
Maxillary removable	52 (23.5%)
Mandibular removable	66 (29.9%)
Anatomic site of prosthetic restoration	
Bi-maxillary reconstructions	68 (44.4%)
Mandibular reconstructions	51 (33.3%)
Maxillary reconstructions	34 (22.2%)

Table 3. Univariate analysis of prosthesis demographics

	Prostheses (n=221)	**Max Fx (n=51)**	**Mand Fx (n=52)**	**Max Rem (n=52)**	**Mand Rem (n=66)**	***P***
Age (years)	63.7 (11.1)	62.8 (11.4)	64.5 (10.6)	65.9 (10.0)	65.9 (11.1)	.081
Male %	70.7	68.6	63.5	76.9	69.7	.518
Radiotherapy %	70.1	78.4	50.0	71.2	78.8	.003
Grafted %	53.9	60.8	59.6	48.1	48.5	.370

(Differences in categorical and continuous data assessed for statistical significance using Pearson chi-square and analysis of variance (ANOVA) as appropriate. All numbers means (SD) unless stated otherwise).

Max Fx, maxillary fixed; Mand Fx, mandibular fixed; Max Rem, maxillary removable; Mand Rem, mandibular removable; SD, standard deviation.

Table 4. Hazard ratios (Cox proportional hazards regression) for prosthesis survival for prosthesis type, radiotherapy, grafting, age, and sex

Variables	**HR**	**95% CI**		***P***
Prosthesis type		Lower Limit	Upper Limit	
Max Fx	1			
Mand Fx	1.71	0.47	6.21	.414
Max Rem	3.05	0.83	11.15	.092
Mand Rem	5.1	1.60	16.25	.006
Radiotherapy				
No	1			
Yes	1.23	0.49	3.08	.662
Grafting				
No	1			
Yes	1.65	0.75	3.65	.213
Age	0.97	0.93	1.01	.113
Male				
No	1			
Yes	0.85	0.34	2.13	.726

Max Fx, maxillary fixed; Mand Fx, mandibular fixed; Max Rem, maxillary removable; Mand Rem, mandibular removable.

Table 5. Hazard ratios (Cox proportional hazards regression) for prosthesis complication-free survival for prosthesis type, radiotherapy, grafting, age, and sex

Variables	**HR**	**95% CI**		***P***
Prosthesis type		Lower Limit	Upper Limit	
Max Fx	1			
Mand Fx	0.88	0.43	1.79	.717
Max Rem	1.91	1.01	3.66	.048
Mand Rem	2.29	1.23	4.25	.009
Radiotherapy				
No	1			
Yes	1.06	0.61	1.85	.833
Grafting				
No	1			
Yes	0.72	0.46	1.14	.161
Age	0.99	0.97	1.01	.466
Male				
No	1			
Yes	1.34	0.77	2.31	.3

Max Fx, maxillary fixed; Mand Fx, mandibular fixed; Max Rem, maxillary removable; Mand Rem, mandibular removable.

Table 6. Type of complication and failure associated with maxillary and mandibular fixed implant-based prostheses

	MAXILLARY FIXED PROSTHESES			MANDIBULAR FIXED PROSTHESES		
Type of Complication or Maintenance associated with Fixed Reconstruction	**No. of Prostheses**	**% of all Maxillary Prostheses**	**No. of events**	**No. of Prostheses**	**% of all Mandibular Prostheses**	**No. of events**
TOTAL NUMBER OF PROSTHESIS	**51**			**52**		
COMPLICATIONS						
Implant Components						
Loose Abutment screw	4	7.8	4	5	9.6	7
Repair of Prosthesis						
Fracture of prosthesis	9	17.6	20	6	11.5	14
Adjustment of Prosthesis						
Adjustment to prosthesis to improve oral hygiene measures	2	3.9	2	0	0	0
Fixed reconstruction sectioned and reduced posterior extension as uncomfortable for patient	0	0	0	1	1.9	1
TOTAL COMPLICATIONS	**15**		**26**	**12**		**22**
PROSTHESIS FAILURE						
Loss and Replacement of the Prosthesis						
Replaced with another fixed implant prosthesis due to repeated fracture of teeth	0	0	0	3	5.8	3
Replaced with a removable implant prosthesis due to repeated fracture of teeth	2	3.9	2	0	0	0
Replaced with a removable implant prosthesis to improve access for oral hygiene measures	0	0	0	1	1.9	1
Loss of Prosthesis						
Fixed reconstruction removed due to cancer recurrence	0	0	0	1	1.9	1
TOTAL FAILURE	**2**	**3.9**	**2**	**5**	**9.6**	**5**

Table 7. Type of complication and failure associated with maxillary and mandibular removable implant-based prostheses

	MAXILLARY REMOVABLE PROSTHESES			**MANDIBULAR REMOVABLE PROSTHESES**		
Type of Complication or Maintenance associated with Removable Reconstruction	**No. of Prostheses**	**% of all maxillary Prostheses**	**No. of events**	**No. of Prostheses**	**% of all mandibular Prostheses**	**No. of events**
Total No. of Prosthesis	**52**			**66**		
COMPLICATION						
Implant Components						
LOCATOR abutment required tightening	3	5.8	3	4	6.1	5
LOCATOR insert (male component) replaced	12	23.1	20	14	21.2	27
LOCATOR abutment removed	0	0	0	1	1.5	1
LOCATOR Denture Cap (housing) replaced	2	3.8	2	1	1.5	1
Repair of Prosthesis						
Fracture of prosthesis – minor	2	3.8	2	2	4.5	3
Fracture of prosthesis – major (through and through)	2	3.8	2	2	4.5	2
Adjustment of Prosthesis						
Adjustment of prosthesis after implant failure	2	3.8	2	0	0	0
Adjustment of prosthesis after further implant placement	0	0	0	1	1.5	1
Reline of prosthesis because of poor fit	0	0	0	1	1.5	1
Reline of prosthesis because of cancer recurrence	1	1.9	3	1	1.5	1
Gross adjustment of prosthesis	4	7.7	4	4	6.1	4
TOTAL COMPLICATIONS	**28**		**38**	**31**		**46**
PROSTHESIS FAILURE						
Loss and Replacement of the Prosthesis						
Replaced with removable implant retained prosthesis because of technical inadequacies	1	1.9	1	3	4.5	3
Replaced with removable implant retained prosthesis because of implant failure	1	1.9	1	1	1.5	1

Replaced with removable implant retained prosthesis because prosthesis loss	1	1.9	1	2	3	2
Replaced with fixed implant prosthesis because of patient intolerance with removable implant prosthesis	1	1.9	1	3	4.5	3
Loss of Prosthesis						
Patient unable to tolerate removable implant prosthesis patient opted for no further treatment	1	1.9	1	2	3	2
Patient unable to tolerate removable implant prosthesis after implant failure	0	0	0	2	3	2
TOTAL FAILURE	**5**	**9.6%**	**5**	**13**	**19.7%**	**13**

FIGURES

Figure 1. Kaplan-Meier survival curve and life table analysis: Survival for each prosthesis type.

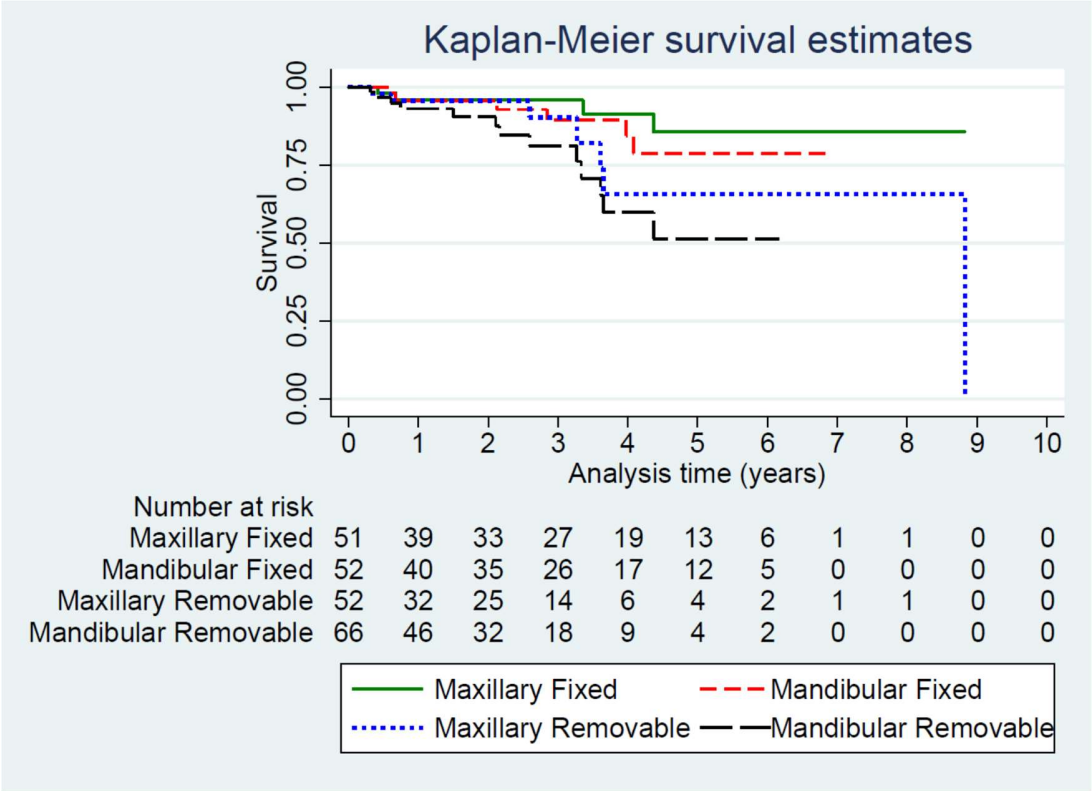
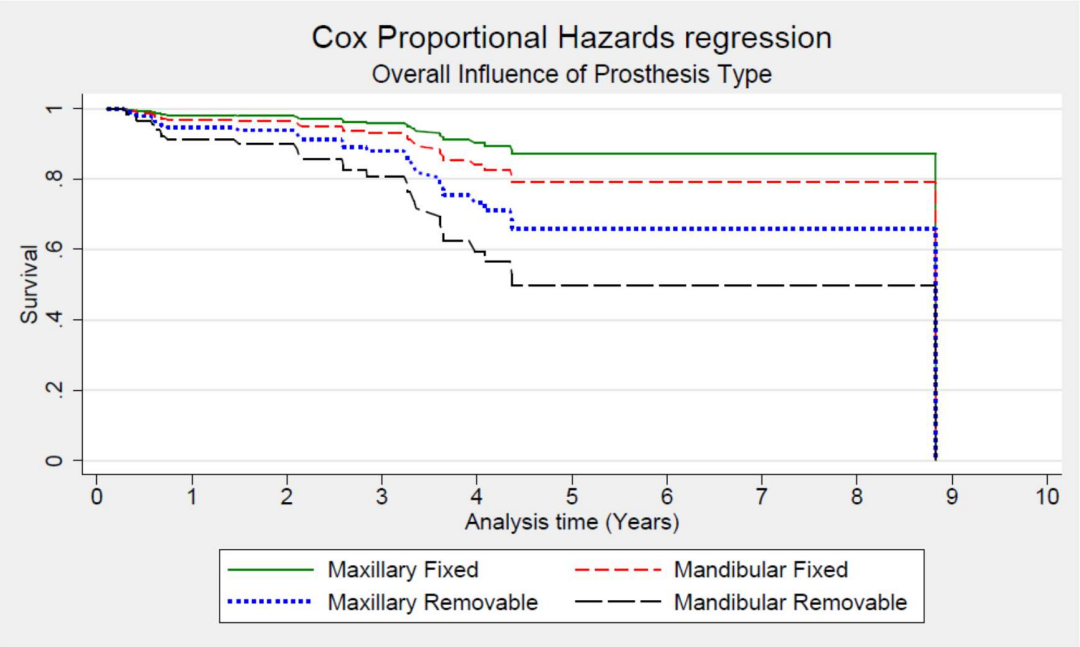


Figure 2: Cox proportional hazards regression adjusting for age and sex: Overall influence of prosthesis type on prosthesis survival and 5-year survival for each prosthesis type.



Prosthesis type:	5-year survival proportion
Maxillary Fixed	0.87
Mandibular Fixed	0.79
Maxillary Removable	0.66
Mandibular Removable	0.5

Figure 3: Kaplan-Meier survival curve and life table analysis: Complication-free survival for each prosthesis type.

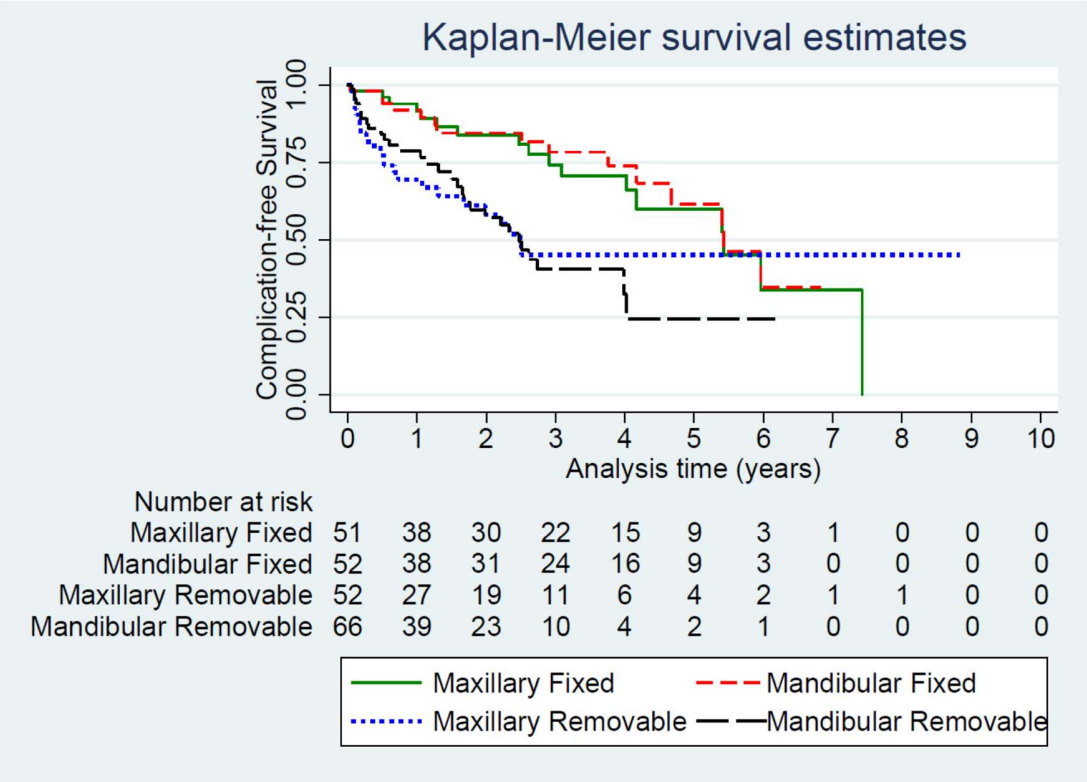
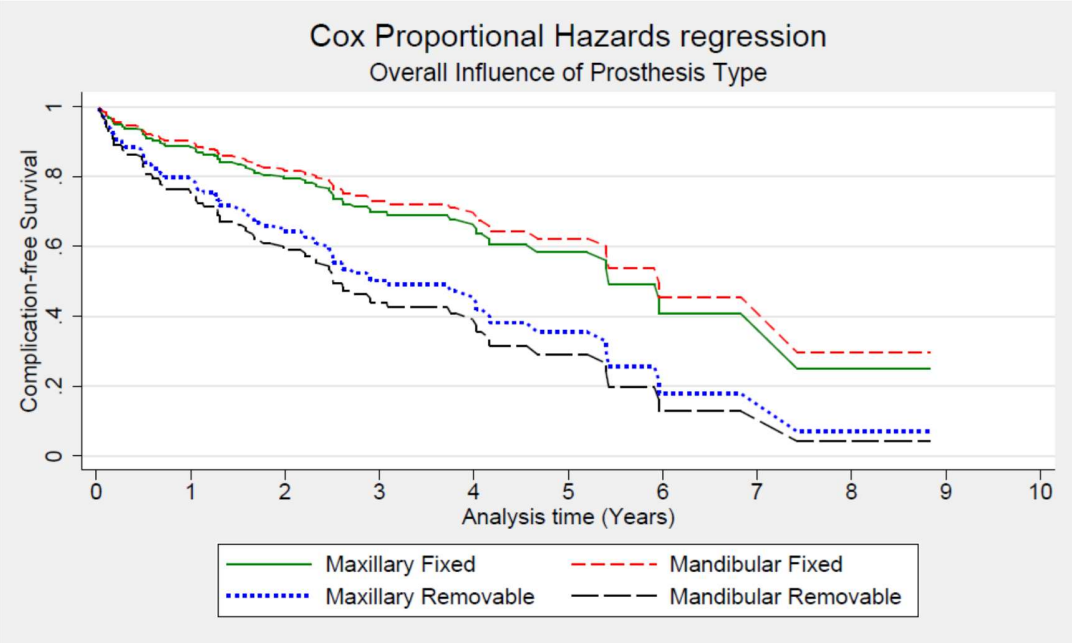


Figure 4: Cox proportional hazards regression adjusting for age and sex: Overall influence of prosthesis type on prosthesis complication-free survival and 5-year complication-free survival for each prosthesis type.



Prosthesis type:	5-year complication-free survival proportion
Maxillary Fixed	0.58
Mandibular Fixed	0.62
Maxillary Removable	0.36
Mandibular Removable	0.29