A Systematic Review of Observational Studies Evaluating Implant Placement in the Maxillary Jaws of Medically Compromised Patients

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ABSTRACT

Background: Even though the efficacy of implant treatment and the excellent success rates that modern implant surfaces yield remain unchallenged, there is limited information available on implant success rates in medically compromised patients.

Purpose: The aim of this systematic review was to evaluate the survival of implants placed in the maxillary jaws of medically compromised patients.

Materials and Methods: Two reviewers using predefined selection criteria performed an electronic search complemented by a manual search, independently and in duplicate.

Results: After the final selection, 11 studies reporting on four distinct medical conditions were included out of 405 potentially eligible titles. In detail, three studies reported on implants placed in diabetic patients, six on implants placed in patients with a history of oral cancer, one on implants in patients with a history of epilepsy, and one on implants in patients with autoimmune rheumatoid arthritis.

Conclusions: Placement of maxillary implants in medically compromised patients seems to yield acceptable survival rates. Implant survival in well-controlled diabetic patients, patients diagnosed with rheumatoid arthritis, and patients treated for severe epilepsy is comparable to that in healthy patients. Implants placed in the maxillae of patients treated for oral cancer may attain osseointegration less predictably than in the mandible.

KEY WORDS: implantology, implant survival, maxillary reconstruction, survival rate

INTRODUCTION

As access to health and quality of life are globally improving, the aging of the population challenges clinicians to offer surgical implant treatment to medically compromised patients who demand high quality of life and longevity of treatment.¹ It is well established in the

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dental literature that implant rehabilitation is a successful treatment modality that significantly improves the oral health-related quality of life of patients of all ages.² Even though the efficacy of implant treatment and the excellent success rates that modern implant surfaces yield remain unchallenged, there is limited information available on implant success rates in medically compromised patients.³

Owing to the rapid advancements in medicine during the last century, the life expectancy of patients with systemic diseases has increased. Moderate or serious systemic diseases are now well controlled with medication, and affected patients frequently seek implant treatment to increase their quality of life.⁴ Indeed, the quality of life/risk from implant treatment ratio is currently considered as a decisive factor for the implant rehabilitation of medically compromised patients.⁴ The current consensus is that although

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implant placement is acceptable in patients with systemic health conditions, the level of evidence is still relatively low, and the final decision is based on each individual's disease-control level.⁴

Yet, even when medical treatment ensures life expectancy comparable to the general population, the host's response to wound healing and repair may deviate from the physiological norm on a cellular level.⁵ The potential for implant success to be imperiled by a compromised host's response has long concerned the implant community.⁶⁻⁹ The mechanisms that are implicated in implant failure in case of metabolic diseases have not been clearly elucidated. Currently available information indicates that bone quality may be a key determinant of implant success in compromised patients.^{10,11}

This finding is also true for the general population, as results of longitudinal clinical studies have revealed a distinctly lower survival rate for implants placed in the maxillary jaw, which, as a general rule, has inferior bone quality in comparison to the mandible.^{12–15}

Based on this consideration, the question whether maxillary implants are at a greater risk for failure when placed in medically compromised patients arises. The aim of this systematic review was to evaluate the survival of implants placed in the maxillary jaws of medically compromised patients.

MATERIALS AND METHODS

Search Strategy

For the identification of studies eligible for inclusion in this systematic review, an initial search was performed using two electronic databases: the PubMed database of the US National Library of Medicine and the Cochrane Central Register of Controlled Trials.¹⁶

The electronic databases were electronically searched using the following combinations of keywords and MeSH terms: "dental implants AND survival OR success AND compromised patients" and "implants AND medically compromised patients". The search included articles published from January 1990 up to and including September 2013.

In addition to the electronic search, manual searching of selected journal titles was performed, including the Journal of Periodontology, Journal of Clinical Periodontology, The International Journal of Oral and Maxillofacial Implants, The International Journal of Periodontics and Restorative Dentistry, Clinical Implant Dentistry and Related Research, Clinical Oral Implants Research, and Implant Dentistry, from January 1, 1990, up to September 30, 2013.

Both the electronic and manual searches were performed independently and in duplicate by two reviewers.

Selection Criteria

As the population of interest in the present study was humans with compromised medical history, the randomization of subjects to undergo a specific treatment protocol without taking the individual patient care needs into account in treatment planning considerations would be impractical, or even unethical for lifethreatening conditions such as oral cancer.¹⁷ Thus, the present review aimed at the inclusion of observational studies to answer the prespecified research question.¹⁸

The criteria for inclusion of studies for this review were organized by the PICO (Population, Intervention, Control, Outcome)¹⁹ approach as follows: Population – subjects in the included trials must have been humans with compromised medical history undergoing implant treatment; Intervention – the intervention of interest was implant placement in the maxilla, followed by either immediate or conventional loading with a fixed or removable prosthesis; Control – case– control studies and cohort studies that reported on implant survival at the study endpoint were included in our search; Outcome – implant survival at least 12 months post-loading was set as the primary outcome variable.

Studies were excluded if they reported on less than 10 patients or had less than 12 months of follow-up post-loading, if inadequate data for the calculation of implant survival were provided by the authors, if they were animal or in vitro studies, and if they were published in languages other than English.

At the first phase of selection, the titles and abstracts of all articles found through the electronic and manual searches were screened independently by two reviewers (A.I., G.K.). When studies met the inclusion criteria or when data from the abstracts were insufficient to determine eligibility, the full article was obtained.

Following the initial phase of selection, the fulltext articles of all relevant studies were scrutinized for final inclusion by the two reviewers. Interreviewer agreement was assessed using Cohen's kappa coefficient. In cases of missing data, an attempt was made to contact the authors for further information prior to the final decision for inclusion/exclusion of the study. If there was disagreement between the two reviewers, consensus was achieved by discussion with a third reviewer (G.R.). The reason for exclusion of each article at this phase was recorded. In case of duplicate reports from the same study, the most recent publication was included.

Data Extraction

Data were independently extracted by the two reviewers (G.K. and A.I.) using a specifically designed data collection form and were entered into two tables. One table included description of characteristics for each of the included studies, such as country of origin, study design, randomization, masking, and information on the loading protocol (immediate vs. conventional loading) and study population characteristics. A second table was used to extract data related to study outcomes. The primary outcome variable assessed was maxillary implant survival.

The quality assessment of all studies included in this systematic review was performed based on the Newcastle–Ottawa scale for assessment of selection, comparability, exposure, and statistical bias of observational studies, as described by Chambrone and colleagues^{18,20} (Supporting Information Figure S1).

RESULTS

Study Selection

Initial screening of electronic databases yielded 388 potentially relevant publications; 385 were retrieved from the search of PubMed, and 3 additional articles were retrieved from the search of CENTRAL. Hand searching of the selected journals added 17 publications for a total of 405 articles. Removal of duplicate reports from the same study population led to the inclusion of 398 studies in the first phase of screening. After screening of the titles and abstracts independently and in duplicate by the two reviewers, the full-text versions of 37 studies were retrieved for assessment of eligibility for inclusion in the systematic review. Interreviewer agreement at the first phase of selection was very high (k = 0.86).

During the second phase of selection, 26 studies were excluded due to lack of adequate follow-up (n = 3),^{21–23} lack of adequate sample size (n = 7),^{6,24–28} insufficient data on the medical conditions of the patient cohort (n = 2),^{29,30} insufficient age of the patient cohort (n = 1),³¹ report of mandibular implants only (n = 5),^{32–36} or inadequate data to calculate maxillary implant survival for the included patients $(n = 8)^{11,37-43}$ (k = 0.92) (Table 1).

The final selection included 11 studies reporting on four distinct medical conditions; thus, the included studies were categorized into four subgroups. In detail,

TABLE 1 Studies Excluded in the Second Phase of Selection with Reasons for the Exclusion of Each Study						
Reason for exclusion	Studies					
Less than 12 months of follow-up post-loading $(n = 3)$	Dowell and colleagues, ²¹ Memon and colleagues, ²² Balshi and Wolfinger ²³					
Less than 10 subjects receiving maxillary implants $(n = 7)$	Smith and colleagues, ⁶ Eckert and colleagues, ²⁴ Friberg and colleagues, ²⁵ Niimi and colleagues, ²⁶ Esser and Wagner, ²⁷ Turkyilmaz ²⁸					
Unspecified medical conditions $(n = 2)$	Jeffcoat, ³⁰ Grant and colleagues ²⁹					
Implant placement in patients less than 18 years of age $(n = 1)$	Bergendal and colleagues ³¹					
Only reported on mandibular implants $(n = 5)$	Landes and Kovacs, ³² Shernoff and colleagues, ³³ Stevenson and colleagues, ³⁴ Oliveira and colleagues, ³⁵ Peled and colleagues ³⁶					
Inadequate data for estimation of maxillary implant survival	Becker and colleagues, ¹¹ Nelson and colleagues, ³⁷ Morris and					
(n = 6)	colleagues, ³⁸ Abdulwassie and Dhanrajani, ³⁹ Attard and Zarb, ⁴⁰ Gu and Yu ⁴²					
Inadequate data for estimation of maxillary implant survival per medical condition $(n = 2)$	Moy and colleagues, ⁴¹ Van Steenberghe and colleagues ⁴³					

three studies reported on implants placed in diabetic patients,^{44–46} six on implants placed in patients with a history of oral cancer,^{47–52} one on implants in patients with a history of epilepsy,⁵³ and one on implants in patients with autoimmune rheumatoid arthritis⁵⁴ (Figure 1).

Study Characteristics

Study characteristics are listed in Tables 2 and 3.

Implant Survival in Diabetic Patients. Of the three selected studies on implant survival in diabetic patients,^{44–46} two were retrospective cohort studies,^{43,44} while one was a case–control study.⁴⁴ One study reported results from patients with type II diabetes,⁴⁵ while two included patients with type I and type II diabetes.^{44,46} The range of follow-up in this subgroup was 6–144 months. The longest follow-up was performed by Tawil and colleagues⁴⁵ in a cohort of well-controlled diabetic patients that had 136 maxillary implants in function for 1–12 years.

Bias assessment revealed that one of the three included studies was of high quality, while the remaining two had a medium risk of bias. The collected data did not allow for a meta-analysis due to the small number (n = 1) of controlled studies in this subgroup.

Implant Survival in Patients with Oral Cancer. Of the six studies on implant survival in patients with oral cancer,^{47–52} two of the selected studies had a retrospective design,^{47,52} while four were prospective cohort studies.^{48–51} All of the studies reported on cancer treatment utilizing radiotherapy and tumor resection when indicated, and two studies reported adjunctive treatment with hyperbaric oxygen (HBO).^{47,49} HBO was employed to counteract the negative effects of radiation on osseointegration by possibly affecting the local conditions of bone and soft tissues and improving the healing capacity of the irradiated bone. The range of follow-up in this subgroup ranged from 14 months up to 15 years. The longest follow-up was



Figure 1 Stages of the present systematic review.

TABLE 2 Main Characteristics of Studies Included After the Second Phase of Selection								
Study	Country	Medical condition	Funding	Study design				
Fiorellini and colleagues ⁴⁴	USA	Diabetes	None reported	Retrospective cohort study				
Farzad and colleagues ⁴⁶	Sweden	Diabetes	None reported	Retrospective cohort study				
Tawil and colleagues45	Lebanon	Diabetes	None reported	Case-control				
Visch and colleagues ⁵¹	Netherlands	Oral cancer	Institutional funding (Rotterdam)	Prospective cohort study				
Mericske-Stern and colleagues ⁴⁷	Switzerland	Oral cancer	None reported	Retrospective cohort study				
Barrowman and colleagues ⁴⁹	Australia	Oral cancer	None reported	Prospective cohort study				
Linsen and colleagues ⁵⁰	Germany	Oral cancer	None reported	Prospective cohort study				
Heberer and colleagues ⁴⁸	Germany	Oral cancer	Partially funded by Straumann AG, Basel, Switzerland	Prospective cohort study				
Buddula and colleagues ⁵²	USA	Oral cancer	None reported	Retrospective cohort study				
Cune and colleagues ⁵³	Netherlands	Severe epilepsy	None reported	Retrospective cohort study				
Krennmair and colleagues ⁵⁴	Austria	Rheumatoid arthritis	Self-funded/institutional funding	Retrospective cohort study				

TABLE 3 Methodological Evaluation of Included Studies

Church	Colortion	Commence	F	Chatiatian	Methodological
study	Selection	Comparability	Exposure	Statistics	quality
Diabetes					
Fiorellini and colleagues44	***		**		Low
Farzad and colleagues ⁴⁶	***		**		Low
Tawil and colleagues ⁴⁵	****	**	**	**	High
Oral cancer					
Visch and colleagues ⁵¹	****		***	**	High
Mericske-Stern and colleagues47	****		**	*	Medium
Barrowman and colleagues ⁴⁹	***		**		Low
Linsen and colleagues ⁵⁰	****		***	*	Medium
Heberer and colleagues ⁴⁸	****		**	*	Medium
Buddula and colleagues ⁵²	***		***	*	Medium
Severe epilepsy					
Cune and colleagues ⁵³	**		***	*	Medium
Rheumatoid arthritis					
Krennmair and colleagues ⁵⁴	***		***	*	Medium

One star was assigned for each methodological criterion that was fulfilled. Detailed description of the methodological criteria is presented in figure S1. Studies with less than 6 stars were considered to be of low methodological quality, medium methodological quality if having 6 to 8 stars while studies that had 9 or more stars were considered to be of high methodological quality according to Chambrone et al.¹⁸.

performed by Barrowman and colleagues,⁴⁹ who reported on 35 implants that were followed for 15 years.

Bias assessment revealed that one of the six included studies was high-quality,⁵¹ one as low-quality,⁴⁹ and the remaining four studies as medium-quality.^{47,48,50,52} The collected data did not allow for a meta-analysis due to the lack of controlled studies in this subgroup.

Implant Survival in Patients with Epilepsy. One longitudinal retrospective study was identified that followed 27 patients with 61 implants for 16 years.⁵³ Bias assessment revealed that the study had a medium risk of bias.

Implant Survival in Patients with Autoimmune Rheumatoid Arthritis. A single retrospective study evaluated 34 female patients with autoimmune rheumatoid arthritis.⁵⁴ Seventy-seven implants were placed in the maxillae of patients for indications ranging from single-tooth sites to complete edentulism. Patients were followed up for a period ranging from 1 to 7 years. Bias assessment revealed that the study had a medium risk of bias.

Results of Included Studies

Tables 4 and 5 summarize the outcomes of the included studies.

Implant Survival in Diabetic Patients. Results showed that implant survival rates in the maxillae of diabetic patients ranged from 85.5% to 95.6% for a total of 323 implants.44-46 The highest survival rate was reported by Tawil and colleagues.⁴⁵ In this study the authors followed 28 type II diabetic patients for 1 to 12 years and reported a 95.6% survival rate.45 In total, 136 implants were placed: 116 were placed following a conventional loading protocol and 20 with immediate loading. In the control group, 31 nondiabetic control patients received 129 implants: 109 implants following a conventional loading protocol and 20 with immediate loading. All patients received antibiotic treatment perioperatively. Results from comparison of the two groups showed that well-controlled diabetic patients with a mean glycated hemoglobin (HbA_{1c}) of 7.2% in the perioperative period had the same overall survival rate as control patients, irrespective of the loading protocol.45 Implant survival rate was also independent of age, gender, diabetes duration, and smoking in this well-controlled diabetic population. Levels of HbA1c were the most important factor affecting implant complication rate.45 One of the remaining studies reported survival rates greater than 90% in type II diabetics.⁴⁶ The lowest survival rate was reported by Fiorellini and colleagues (85.5%).⁴⁴ In this retrospective analysis, 131 implants were placed in patients with type I and type II diabetes at two clinical centers. Chart review results showed that 19 failures occurred for an overall success rate of 85.5% in the maxilla.⁴⁴ The mean time of functional loading was 4.1 ± 2.6 years. When failed implants were studied, it was found that most of the failures occurred within the first year of functional loading. No difference in survival rates was noted between the posterior or anterior maxilla or between the two centers. No differences in the responses of type I and type II diabetics were identified in terms of implant survival.⁴⁴

Not all of the studies discussed the loading protocol utilized for the delivery of the implant-supported restorations. Farzad and colleagues⁴⁶ reported that the majority of implants were placed using a two-stage placement protocol in combination with conventional loading, with only nine implants being immediately loaded in selected cases. Tawil and colleagues⁴⁵ performed both conventional and immediate loading. In the remaining study, mode of loading was not reported.⁴⁵

The two included studies that presented the highest success rates reported use of antibiotics in conjunction with implant placement procedures.^{45,46} HbA_{1c} percentages were only reported by one study as a surrogate for level of diabetes control.⁴⁵ In the remaining two studies, the authors reported that all patients had good glycemic control, based on serum glucose levels.^{44,46}

Implant Survival in Patients with Oral Cancer. Results showed that implant survival rates in the maxilla for patients with oral cancer ranged from 67.7% to 100% for a total of 321 maxillary implants. Three studies reported no failures in the respective study populations for 100% implant survival rates.47-49 Mericske-Stern and colleagues47 followed up 12 maxillary implants (ITI-Straumann, Basel, Switzerland), and Heberer and colleagues⁴⁸ followed-up 55 implants overall (28 modified and 27 conventional sandblasted acid-etched implants). Barrowman and colleagues⁴⁹ utilized a two-stage implant placement protocol to place 35 implants in the maxilla with no failures during the 15-year observational period. The lowest survival rate in patients with a history of oral cancer was reported by Buddula and colleagues.⁵² In this retrospective chart review, 62

		Adjunctive factors	All patients received radiotherapy	Some of the patients received	Some of the patients received HBO, radiotherapy, and/or	bone graft	All patients received radiotherapy and clindamycin	All patients received radiotherapy and some received bone graft	Some of the patients received HBO, radiotherapy, and/or bone	graft	NR	All patients received postoperative antibiotics		All patients received chlorhexidine and antibiotics, and some	patients received sinus lift and	bone graft	NR		Some patients received NSAIDs and/or glucocorticoids	
	Postloading	follow-up period	Up to 168 months	12–84 months	180 months		14.4 months	60 months	180 months		Up to 78 months	12 months		12–144 months			192 months		12–84 months	
		Implant type	Hydroxyapatite- coated	implants ITI (**********************************	Brånemark (Nobel	Biocare)	Straumann	NR	Brånemark (Nobel	Biocare)	Brånemark, Straumann	Brånemark (Nobel	Biocare)	Brånemark (Nobel	Biocare)		Straumann		Camlog	
	Loading	protocol	Conventional	NR	Conventional		early	NR	Conventional		NR	Conventional and	immediate	Conventional and	immediate		Conventional		Conventional	
		Implant sites	Anterior and posterior	NR	NR		NR	Anterior and posterior	NR		Anterior and posterior	Anterior and posterior	1	NR			Anterior and	posterior	Anterior and posterior	
	Implant survival	(%)	69.4	100	100		100	67.7	100		85.5	92.9		95.6			100		92.2	
d Studies	Failed maxillary	implants (<i>n</i>)	33	0	0		0	20	0		19	4		9			0		9	
ne Include	Maxillary implants	(<i>u</i>)	108	12	35		55	62	35		131	56		136			61		77	
sessment of th	Patients with maxillary	implants (<i>n</i>)	NR	NR	NR		NR	NR	NR		NR	NR		28			27		34	
TABLE 4 Outcomes As		Study	Diabetes Fiorellini and colleagues ⁴⁴	Farzad and colleagues ⁴⁶	Tawil and colleagues ⁴⁵	Oral cancer	Visch and colleagues ⁵¹	Mericske-Stern and colleagues ⁴⁷	Barrowman and colleagues ⁴⁹)	Linsen and colleagues ⁵⁰	Heberer and colleagues ⁴⁸	:	Buddula and colleagues ²²		Severe epilepsy	Cune and colleagues ⁵³	Rheumatoid arthritis	Krennmair and colleagues ⁵⁴	

TABLE 5 Conclusions of the Included Studies						
Study	Conclusions					
Diabetes						
Fiorellini and colleagues ⁴⁴	"Implant survival is significantly influenced by the location (maxilla versus mandible, 59% and 85%, respectively), by the incidence of bone-resection surgery in the jaw where the implant was installed and by the irradiation dose at the implant site (<50 Gray or >50 Gray)."					
Farzad and colleagues ⁴⁶	"Treatment with implant-supported prostheses seemed to be advantageous for patients who have undergone intraoral resections."					
Tawil and colleagues ⁴⁵ Oral cancer	"Dental implants provide an important role in the oral rehabilitation of oral cancer patients."					
Visch and colleagues ⁵¹	"Implants with chemically modified and conventional SLA titanium surface show high success rates in irradiated patients."					
Mericske-Stern and colleagues ⁴⁷	"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)."					
Barrowman and colleagues ⁴⁹	"Dental implants provide an important role in the oral rehabilitation of oral cancer patients."					
Linsen and colleagues ⁵⁰	"Survival rate of dental implants in controlled diabetic patients is lower than that documented for the general population, but there is still a reasonable success rate."					
Heberer and colleagues ⁴⁸	"Diabetics that undergo dental implant treatment do not encounter a higher failure rate than the normal population, if their plasma glucose level is normal or close to normal."					
Buddula and colleagues ⁵²	"Well- to fairly well-controlled diabetic patients with a mean HbA _{1c} of 7.2% in the perioperative period have the same overall survival rate as controls in conventional and advanced implant therapy. Implant survival rate is independent from age, gender, diabetes duration, and smoking in a well- to fairly well-controlled diabetic population."					
Severe epilepsy						
Cune and colleagues ⁵³	"Dental implant treatment in a population of patients with severe epilepsy and additional disabilities seems to be a viable treatment option."					
Rheumatoid arthritis						
Krennmair and colleagues ⁵⁴	"No atypical pattern of prosthodontic complications and maintenance efforts was observed for implants and implant prosthodontics in RA patients."					

implants were evaluated and 20 failures occurred, for an overall success rate of 67.7% in the maxilla. The implants were followed for a mean of 3.2 years and up to 16.9 years. No association was identified between survival and length, diameter, type of bone, or radiation dose received, even though there was a tendency for increased failure rates in patients receiving more than 50 Gy of radiation.⁵² The only predictor of implant failure was the location of the implant, with a greater tendency to fail for implants placed in the posterior maxillary region compared with those placed in anterior regions.⁵²

When the adjunctive HBO was considered, Barrowman and colleagues concluded that the high retention rates seen in their patient cohort might have been due to the HBO therapy rendered in their study.⁴⁹ Regarding loading protocols, most of the included studies reported utilizing a conventional loading protocol, while reported use of adjunctive systemic antibiotics was scarce.

Implant Survival in Patients with Epilepsy. The results of Cune and colleagues showed no failures of maxillary implants occurring among 27 patients, for an implant success rate of 100%.⁵³ The authors utilized a conventional loading protocol in both anterior and posterior areas, without any adjunctive treatment. Even though all patients were inpatients and were judged as having inadequate oral hygiene due to multiple disabilities, only mild inflammation of the peri-implant mucosa was noted in some of the patients despite the frequent use of antiepileptic medication, which has been shown to induce gingival hyperplasia.

Implant Survival in Patients with Autoimmune Rheumatoid Arthritis. Krennmair and colleagues retrospectively evaluated 34 female patients with a mean age of 58.1 years.⁵⁴ Seventy-seven Camlog implants (Camlog, Basel, Switzerland) of different lengths and diameters were placed in the maxillae of these patients. The implants were placed in both anterior and posterior sites following a conventional loading protocol. At the end of the follow-up, a 100% survival rate was reported. Patients included in this investigation had a diverse medication schedule ranging from no pharmacological therapy to medical treatment including nonsteroidal anti-inflammatory drugs, treatment with glucocorticoids, or a combination.

DISCUSSION

Summary of Evidence

The results of the present review show that survival rates of maxillary implants placed in medically compromised patients range from 65.5% to 100%. Survival of implants placed in patients with a medical history significant for oral cancer accounted for the lower end of the range. It should be noted that except for two studies that demonstrated less than 70% survival rates for maxillary implants,^{51,52} the remaining studies showed excellent implant survival, with three studies showing no implant loss. Visch and colleagues⁵¹ reported a 69.4% implant survival after up to 14 years of follow-up for 108 implants. In this study, almost half of the implants were placed in the posterior maxilla, and the vast majority of patients received more than 50 Gy of radiotherapy.⁵¹ Also, a large number of failed implants were placed in sites treated with partial maxillectomy. The authors attributed the low survival rates to the unfavorable site-related conditions associated with surgical resection (partial maxillectomy) such as prosthetic limitations due to bulky soft tissue areas and lack of keratinized tissue as well as reduced vascularization due to large doses of radiation exceeding the 50-Gy threshold.⁵¹ A greater risk for implant failure for the maxilla in comparison to the mandible was also reported.⁵¹ Similarly, Buddula and colleagues⁵² attributed the low survival rates noted in their study to a large percentage of implants being placed in the posterior maxilla.

The findings of the present systematic review are in accordance with the findings of a recent review by

Javed and colleagues,⁵⁵ who concluded that irradiation may have a negative impact on implant osseointegration, yet implants placed in patients with a history of oral cancer treatment can osseointegrate and remain functional. Loading protocols for implants placed in oral cancer patients were underreported in general. In two studies where some of the implants were immediately loaded, implant survival rates were greater than 90%, supporting the delivery of immediate prostheses.^{48,52} Indeed, histological results of immediate implant loading in the maxilla in a cancer patient who was also a smoker revealed excellent bone-to-implant contact that exceeded 50% in all implants, thus supporting the utilization of immediate loading in cancer patients.¹⁰

When the survival of implant placement in diabetic patients was assessed, results were very promising and ranged from 85.5% to 95.6%.44-46 The lower rate was reported in a study that included type I and type II diabetic patients, even though no association was identified between type of diabetes and implant failure.44 More recent studies showed excellent survival rates that were comparable to the rates of implants placed in healthy controls, even in complex cases that required bone-grafting procedures.^{45,46} HbA_{1c} levels were underreported in the included studies, but when utilized they were shown to be the only appropriate indicators for risk of postoperative complications, though not for implant survival.45 All three included studies reported on well-controlled diabetic patients.44-46 Our results are in agreement with the findings of a recent study that evaluated and compared the microbiological and immunological profiles of diabetic implant patients and compared them with those of healthy controls.⁵⁶ Results of this study showed that the microbiological profiles and salivary biomarkers in well-controlled diabetics and healthy individuals do not differ significantly, thus supporting the argument that implant placement is a predictable treatment modality in well-controlled diabetics.56

Two more categories of medical conditions were discussed in the present review: epilepsy and rheumatoid arthritis.^{53,54} Despite the fact that only one study per disease subgroup was available for review, the excellent survival rates (100%) of maxillary implants placed in both studies highlight the predictability of implant treatment in these patient groups.^{53,54}

Limitations and Future Implications

The inclusion criteria utilized in the present review aimed at the inclusion of only reasonably powered observational studies. Therefore, except for the oral cancer subgroup, a low number of studies were identified for the remaining medical conditions. Also, only one study had a case–control study design,⁴⁵ while all remaining studies included only compromised patient cohorts in their observations.

In the present systematic review, most of the included cohort studies did not have internal comparison groups in the form of patients who were not medically compromised receiving maxillary implants. The execution of good-quality individual cohort studies including healthy and compromised patient cohorts with similar exposure characteristics is needed in clinical implant research to allow for outcome comparison between the two groups.

Even when the most stringent quality criteria were imposed, sources of bias could still be identified in all studies. Reporting bias was frequently encountered in the included studies, especially in the diabetes subgroup. For example, glycated hemoglobin levels may currently be the most accepted surrogate for diabetes control in the medical literature but were only utilized in one study.⁴⁵ Also, in a study reporting on the survival of implants placed in patients with epilepsy, the intake of medication, which has been associated with gingival overgrowth, was not explicitly reported, and there was not a clear report of attempts to associate this intake with peri-implant mucosal condition.⁵³

The encouraging results for the survival of maxillary implants in medically compromised patients that were identified in the present literature search may facilitate the overcoming of ethical dilemmas associated with randomized controlled studies in medically compromised patient cohorts, which will provide a higher level of evidence to support implant rehabilitation in the maxilla for this sensitive patient pool.

CONCLUSIONS

Within the limitations of this review, we conclude that although maxillary implants may have less favorable prognosis compared with implants placed in the mandible, the placement of maxillary implants in medically compromised patients seems to yield acceptable survival rates. Implant survival in well-controlled diabetic patients, patients diagnosed with rheumatoid arthritis, and patients treated for severe epilepsy is comparable to that in healthy patients. Implants placed in the maxilla of patients treated for oral cancer may attain osseointegration less predictably than in the mandible. Site-related factors (i.e., posterior sites and resected sites), as well as dosage of radiotherapy exceeding 50 Gy, should be considered as risk indicators of lower implant survival.

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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Figure S1. Quality assessment criteria selected from the Newcastle–Ottawa scale.²⁰

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