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Abstract

Purpose: This retrospective study was conducted at the Marquette University School of Dentistry to (1) characterize the implant patient population in a predoctoral clinic, (2) describe the implants inserted, and (3) provide information on implant failures.

Materials and Methods: The study cohort included 1091 patients who received 1918 dental implants between 2004 and 2012, and had their implants restored by a crown or a fixed dental prosthesis. Data were collected from patient records, entered in a database, and summarized in tables and figures. Contingency tables were prepared and analyzed by a chi-squared test. The cumulative survival probability of implants was described using a Kaplan-Meier survival curve. Univariate and multivariate frailty Cox regression models for clustered observations were computed to identify factors associated with implant failure.

Results: Mean patient age (±1 SD) at implantation was 59.7 ± 15.3 years; 53.9% of patients were females, 73.5% were Caucasians. Noble Biocare was the most frequently used implant brand (65.0%). Most implants had a regular-size diameter (59.3%). More implants were inserted in posterior (79.0%) than in anterior jaw regions. Mandibular posterior was the most frequently restored site (43%); 87.8% of implants were restored using single implant crowns. The overall implant-based cumulative survival rate was 96.4%. The patient-based implant survival rate was 94.6%. Implant failure risk was greater among patients than within patients ($p < 0.05$). Age (>65 years; hazard ratio [HR] = 3.2, $p = 0.02$), implant staging (two-stage; HR = 4.0, $p < 0.001$), and implant diameter (wide; HR = 0.4, $p = 0.04$) were statistically associated with implant failure.

Conclusions: Treatment with dental implants in a supervised predoctoral clinic environment resulted in survival rates similar to published results obtained in private practice or research clinics. Older age and implant staging

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increased failure risk, while the selection of a wide implant diameter was associated with a lower failure risk.

For the replacement of missing teeth, dental implants are a popular, generally accepted alternative to conventional fixed and removable partial dentures.[1-6] Treatment planning and restoring with implant-supported fixed dental prostheses (FDPs) have improved both function and patient acceptability.[7-11] Favorable long-term survival rates of implants and implant-based restorations have been well documented and have established implant procedures as safe and affordable.[12-33]

With the improvement of dental implants, the demand for implant treatment has increased exponentially.[18-21] To accommodate this increasing demand and to prepare future dentists with necessary skills, several dental schools in the United States and abroad incorporated implant training in the curriculum.[34-40] A strong correlation was found between implant training and use of implant restoration in practice after graduation. Dental students who received training in implant restoration in their predoctoral education were more likely to use dental implants in their practice after graduation.[41, 42] In an effort to respond to the rising demand for implants, in 2010 the Commission on Dental Accreditation mandated graduates of predoctoral programs to be competent in replacing teeth by using fixed, removable, and dental implant prosthodontics.[43]

Quality of implant treatment and clinician experience has been known to impact the survival rate of dental implants.[44] In addition to such provider-related differences, patients seeking treatment in dental schools may exhibit a lower level of oral health literacy, compliance with dental hygiene, and different expectations than their peers treated in private practice, which could also affect the long-term treatment outcome. Therefore, implant survival rates achieved in a predoctoral clinic may differ from the survival rates observed in an experienced clinician's practice; however, to the best of our knowledge, reports about success and failure of implants placed in the context of a predoctoral teaching program are very few in number and limited to small patient cohorts.[24,45-50]

Therefore, the purpose of this retrospective cohort study is to report on implant survival in patients treated at the Marquette University School of Dentistry (MUSoD) predoctoral clinic between the years 2004 and 2012. In Aim 1, the study population will be briefly characterized. In Aim 2, implant-related variables, restoration type, and anatomic location of implant placement will be described. In Aim 3, patient-, implant-, and restoration-related factors that might be associated with implant failure will be investigated. Based on the assumption that risk of implant failure will cluster within patients and be more heterogeneous among patients, the study employed frailty Cox regression models to investigate associations between variables of interest and risk of implant failure.[51] In the context of said assumption, the null hypothesis that the implant failure risk is homogeneous among predoctoral clinic patients was tested.

Materials and methods

Implant treatment in the predoctoral program at MUSoD

Dental students participated in diagnosis and treatment planning, assisted in the surgical procedures, and executed all prosthodontic procedures. In particular, they reviewed the patient health history, performed intraoral examinations, and took radiographs as required by the case. Then, a diagnostic tooth set-up of the missing dentition was performed, and after initial consent from the patient, an implant board was scheduled with the student, patient, restorative faculty, and surgeon. All parties involved reviewed the case, and the consent for the treatment was signed. Faculty from the Department of Surgical Science placed all implants according to the manufacturer's guidelines. All potential implant sites were included. Bone grafting and sinus lift were performed when necessary to prepare the implant site prior to implant placement. The implant was placed using the immediate or delayed protocol, as dictated by the individual case. Implant system and size were selected primarily by the surgeon rather than the restorative dentist and were based on the surgeon's preference and patient's bone availability. Immediate and delayed loading protocols were used for implant loading. After osseointegration, the implants were restored by the predoctoral

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students under faculty supervision. Screw- and cement-retained prostheses were used to restore implants. A radiograph was taken on the day of abutment/crown delivery as a baseline for future follow-ups.

Study design

MUSoD's Institutional Review Board (HR-2261) approved the research protocol. The study investigated records of predoctoral clinic patients who had received at least one dental implant between January 1, 2004 and December 31, 2012. Inclusion was limited to patients who had their implants restored by single implant crown (SIC) or FDP. Patients who had received implant-supported removable prostheses were excluded. Eligible patients were identified through MUSoD's electronic patient record system (axiUm; Exan, Coquitlam, BC) by corresponding procedure codes associated with the surgical and prosthodontic phases (D6010, D6056, D6057, D6059, D6061, D6065) of implant therapy. When necessary, missing or additional data were obtained from patient charts. The data collection was limited to information about the patient (demographics, medical history, medications), implant (number, brand, diameter), anatomy (placement site, proximity), surgery (date of implantation, type of implantation, staging), and prosthesis (SIC/FDP, retention). Implant failure was the primary outcome variable. Failure was defined as implant loss for any reason.[52] Survival time was defined as the period from implant placement to loss or the most recent follow-up for surviving implants.

Statistical methods

Data were summarized using frequency distributions for categorical data and mean values and measure of variability for continuous data. Contingency tables were prepared and analyzed by a chi-squared test or a log-linear analysis for three-way tables. The cumulative survival probability of implants was estimated using Kaplan and Meier's method (1958).[53] The implant survival probability against time was plotted based on patient's first implant failure.

Univariate and multivariate frailty Cox proportional hazards models for clustered observations were computed to identify factors

associated with implant failure.[51] Briefly, a frailty model is a mixed-effects model where the frailty variable ("patients") affects the hazard function. In the present study, it considered that failures cluster within patients (i.e., that the implant failure rate within patients was different than among patients). Hougaard[54] and Chuang et al[51] explained the method in detail.

The R subroutine *coxme* (R version 3.2.1) was used for all statistical procedures related to Cox proportional hazard models. The subroutine *coxme* was directly installed from the R package. It was built to fit a general mixed-effect Cox model of which the frailty model considered here is a special case.[55] To avoid overfitting the data, the significances of the covariates based on univariate analyses were tested. Covariates with a p-value >0.15 were excluded from further analysis in the multivariate frailty model if they were also deemed biologically irrelevant. The frailty model with between-subject heterogeneity was tested statistically against no between-subject variability. Once the frailty Cox proportion hazard model was fit with all relevant covariates, hazard ratios (HRs) and associated large sample confidence intervals (95% confidence interval; CI) were computed. Finally, a parsimonious multivariate Cox frailty regression model was developed to further assess the effect on implant failure by selecting covariates from the Cox regression model with p-value ≤0.05 using a step-wise process.

Results

Patients

The cohort included 1091 patients. Figure 1 is a histogram of the patient age at implant placement. Mean age (±1 SD) was 59.7 (±15.3) years; 588 patients (53.9%) were females; 503 (46.1%) were males; 802 patients (73.5%) were Caucasians; 41 (3.7%) were African Americans; 29 patients (2.6%) were Hispanics; 26 (2.4%) were Asians; 2 (0.2%) were Native Americans; and 32 (3.0%) were from other races or ethnicities. For 159 patients (14.6%), neither race nor ethnicity was known.

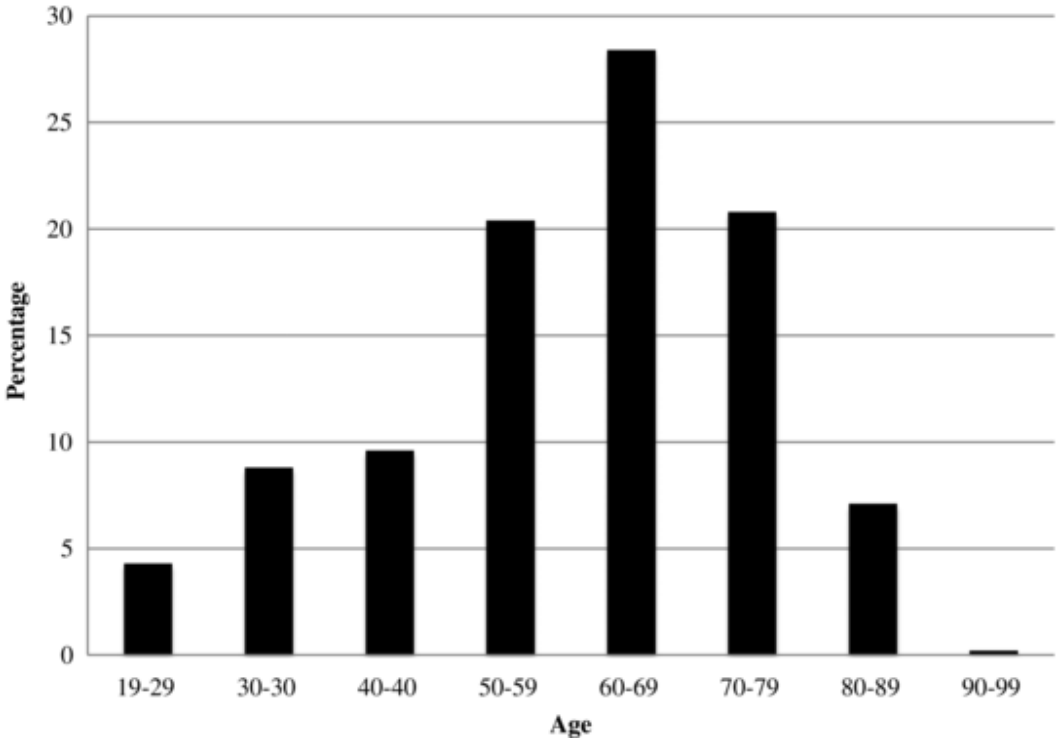

Figure 1. Age distribution of study cohort (N = 1091).

Six hundred seventy-nine patients (62.2%) had a significant medical condition or were using prescription medicine. Fifty-five patients (5.5%) were diabetic, 14 (1.3%) experienced some degree of osteoporosis, 177 (16.2%) had a diagnosis of arthritis, and 67 (6.1%) had a thyroid disorder. Thirty patients (2.8%) had a history of cancer or radiation therapy at some point of their life, and 29 (2.7%) were treated with bisphosphonates.

Implants, brands, and diameters

A total of 1918 implants were placed with an average of 1.76 (range: 1 to 10) implants per patient; 650 patients (59.6%) had one implant inserted, 250 (22.9%) had two implants, 93 (8.5%) had three implants, and 98 (9.0%) had four or more implants. Several implant brands (Table 1) were used in the predoctoral clinic. The most frequently used brands included Nobel Biocare (NB; Nobel Biocare USA, Yorba Linda, CA), Astra Tech (AT; Astra Tech USA, Waltham, MA), and Straumann (ST; Straumann USA, Andover, MA).

Table 1. Frequently used implant brands (N = 1918)

Implant brand	N	(%)
Astra Tech	471	24.5
Nobel Biocare	1246	65.0
Straumann	190	10.0
Other brands	11	0.5

Table 2 presents the relationship between implant diameter (narrow, regular, wide) and implant brand. The information on the diameters of 25 implants was missing. There was a statistically significant association between implant diameter and brand ($p < 0.0001$).

Table 2. Number (%) of implants by implant diameter and implant brand (N = 1893)

	Narrow	Regular	Wide	Total
1. Information on 25 implants was missing.				
Astra Tech	29 (1.5)	246 (13.0)	190 (10.0)	465
Straumann	14 (0.7)	174 (9.2)	1 (0.05)	189
Nobel Biocare	104 (5.5)	702 (37.1)	433 (22.9)	1239
Total	147 (7.8)	1122 (59.3)	624 (33.0)	

Anatomic location and proximity

Table 3 shows the relationship between anatomic location of implant placement and implant brand; 928 (48.4%) and 990 (51.6%) implants were inserted in the mandible and maxilla, respectively; 403 (21%) and 1515 (79%) implants were placed in anterior and posterior jaw regions, respectively. The association between jaw location and implant brand was statistically significant ($p < 0.001$).

Table 3. Number of implants by anatomic location and implant brand

	Mandible			Maxilla			
Brand	Ante	Post	Total (Man)	Ante	Post	Total (Max)	Total
1. Ante: anterior; Post: posterior. Man: mandible; Max: maxilla							
Astra Tech	26	186	212	90	169	259	471
Nobel Biocare	68	509	577	200	469	669	1246
Straumann	9	127	136	9	45	54	190
Other brands	0	3	3	1	7	8	11
Total	103	825	928	300	690	990	1918

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The distribution of anatomic location by implant diameter is presented in Table 4. A statistically significant ($p < 0.001$) relationship was found between the jaw region and implant diameter. Posterior implants had a regular or wide diameter more frequently, while narrow or regular diameter implants were inserted more frequently in anterior jaw regions; 1324 implants were placed between two adjacent natural teeth, 443 implants had one adjacent natural tooth and one implant, 58 implants had two adjacent implants, 52 implants had one adjacent tooth, and 41 implants had one adjacent implant.

Table 4. Number of implants by anatomic location and implant diameter (N = 1918)

	Mandible			Maxilla			
Diameter	**Ante**	**Post**	**Total (Man)**	**Ante**	**Post**	**Total (Max)**	**Total**
Narrow	26	186	212	90	169	259	471
Regular	68	509	577	200	469	669	1246
Wide	9	127	136	9	45	54	190
Total	103	825	928	300	690	990	1918

1. Ante: anterior; Post: posterior. Man: mandible; Max: maxilla

Surgery

Delayed and immediate implantation procedures were selected for 1507 (78.6%) and 358 (18.7%) of the implants, respectively. Information on implant procedure for 53 (2.7%) implants was not available. There was a statistically significant association between implantation procedure and anatomic location ($p < 0.001$); immediate placement was more frequently used in the anterior maxilla. Delayed implantation was the preferred procedure when implants were inserted in posterior sites. There was a statistically significant ($p < 0.01$) relationship between implantation type and implant brand; delayed implantation was most frequently selected for ST implants. Immediate implantation was the preferred surgical procedure for AT implants.

Most implants (N = 1122, 58.5%) were placed using one-stage surgical procedures. Two-stage procedures were used for 687 (35.8%) implants. The staging of 109 (5.7%) implants was unknown. There was a statistically significant relationship ($p < 0.001$) between anatomic locations and staging; one-stage procedures were more frequently applied for implants inserted in mandibular posterior sites.

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In contrast, two-stage procedures were more frequently used for implants inserted in anterior sites of the maxilla. There was also a statistically significant ($p < 0.001$) relationship between staging and brand. ST and NB implants were mostly placed using a one-stage procedure, whereas the majority of AT implants were inserted using a two-stage procedure.

Implant restoration

Of the implants, 1684 (87.8%) and 182 (9.5%) were restored with SIC and FDP, respectively. The restoration type of 52 (2.7%) implants was unknown. There was a statistically significant ($p < 0.001$) association between restoration type (SIC or FDP) and anatomic location. FDPs were more frequently used to restore implants placed in the anterior region of the mandible, while SICs were more frequently placed in posterior regions. Cement- and screw-retained restorations comprised 1661 (86.6%) and 113 (5.9%) implant restorations, respectively. Six (0.3%) implants were not restored. The information on restoration retention was missing for 138 (7.2%) of the implants. There was a statistically significant association between restoration retention and anatomic location of the implant ($p < 0.001$); screw-retained restorations were preferred when implants were placed in the maxilla. Cement retention was most frequently used for restorations on implants located in the posterior mandible. Any implants that were not restored were placed in the maxilla.

Implant survival and failure

Figure 2 shows a Kaplan-Meier survival curve based on patients at the time of their first implant loss. Fifty-nine of 1091 patients lost at least one implant. Fifty-two patients had one failing implant; 5 had 2 failing implants. One patient had three failing implants and one patient had five failing implants. The cumulative probability of no implant loss was 0.946 at a mean observation period of 68.4 months (95% CI: 67.5, 69.3).

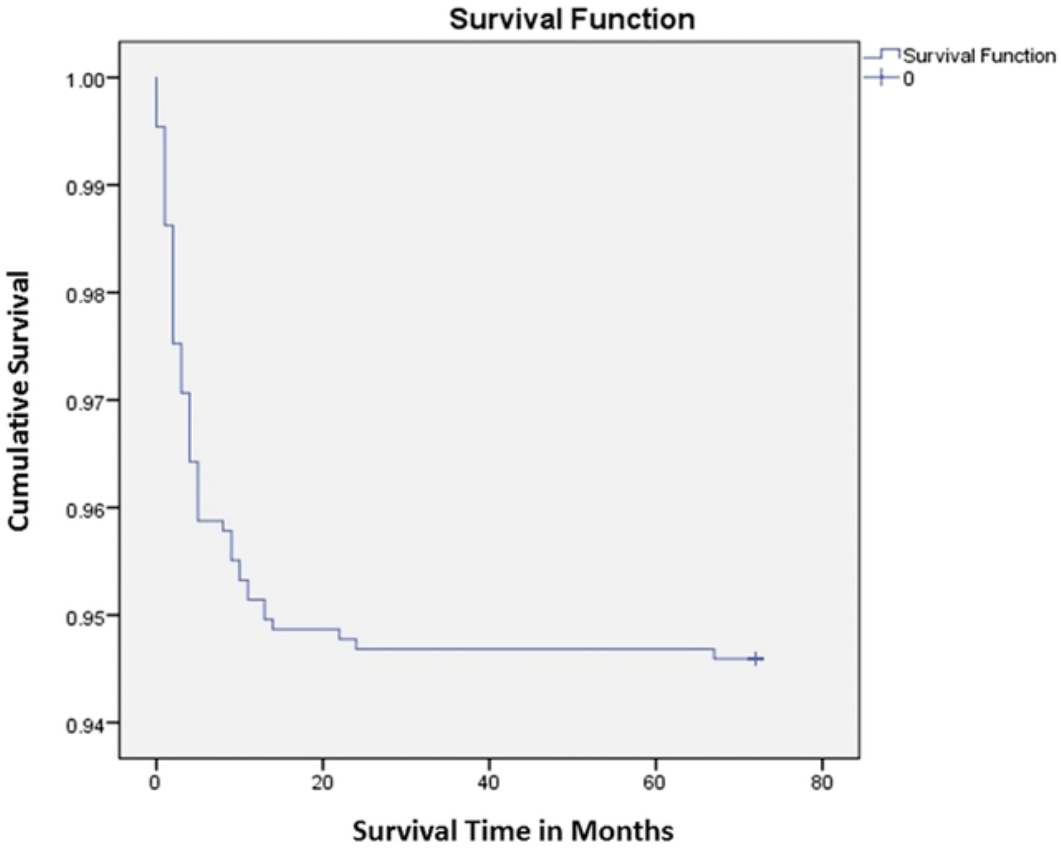

Figure 2. Kaplan-Meier survival curve based on patients' first implant failure.

Of 1918 implants inserted, 1848 (96.4%) survived. Altogether, the patients lost 70 implants (3.6%). Fifty-three implants were lost within 6 months of insertion. Nine implants failed after 7 to 12 months, 7 implants failed after 13 to 24 months, and one implant loss occurred after 67 months. Thirty-three (47.1%) implants failed in females and 37 (52.9%) implants failed in males. Of the lost implants, a majority were lost before they could be restored; however, all implants (17, 24.3%) that were restored prior to failing were cement-retained.

Univariate and multivariate analyses of risk indicators

Table 5 shows a summary of study variables associated with implant failure. Results are expressed as HRs and associated 95% CI. Of all univariate analyses, five variables met the statistical requirement for further analysis. They were arthritis, anatomic location, implant diameter, implant brand, and staging. In addition, patient age and gender were selected because they were deemed

biologically relevant. The seven variables were then used to construct the multivariate frailty Cox regression model (Table 6). Variables gender, arthritis, anatomic location, and implant brand failed to meet the minimum target for inclusion in the parsimonious multivariate frailty Cox regression model and were no longer considered. Table 7 shows the results obtained from modeling the reduced number of risk variables. Variables age >65 years, wide implant diameter, and staging prevailed. The frailty term (SD = 1.1540) due to patients' variability was statistically significantly different from zero ($p < 0.05$). It provided statistical evidence that the relative risk of implant failure was heterogeneous among patients, and that for some patients the risk could be 3.2 times greater than the risk within the patients.

Table 5. Univariate analyses of factors associated with implant failure (1091 patients, 1918 implants with nonmissing cases varied from model to model)

	HR	95% CI	Frailty robust *p*-value
Demographic variables			
Age >65	2.1	(0.4, 9.8)	0.4
Age 50-65	1	(0.2, 5.4)	1
Age <50	1		
Gender (Male)	1.8	(0.8, 4.0)	0.2
Health status factors and medications			
Diabetes	1.3	(0.4, 4.1)	0.7
Osteoporosis	0 +	(0-∞)	1
Cancer	0.5	(0.06, 4.5)	0.6
Thyroid	0.6	(0.1, 2.8)	0.5
Arthritis	1.8	(0.9, 4.0)	0.1 *
Fosamax	1.5	(0.3, 7.1)	0.6
Anatomic variables			
Location: Mandible posterior	0.3	(0.1, 1.0)	0.06 *
Location: Maxilla anterior	0.7	(0.2, 2.3)	0.6
Location: Maxilla posterior	0.5	(0.1, 1.4)	0.2
Location: Mandible anterior	1		
Proximity of implants (1 adjacent implant)	0 +	(0-∞)	1
Proximity of implants (1 adjacent tooth and 1 implant)	0.4	(0.6, 10.3)	0.2

1. HR = hazard ratio, CI = confidence interval, * = significant at $p \leq 0.15$.
2. +HR = 0 is not reliable as length of the CI is infinitely large.
3. ++Cox regression did not calculate *p*-value. Based on chi-square test, no significant difference was observed between failure and nonfailure groups.
4. ST: Straumann; NB: Nobel Biocare; AT: Astra Tech.

	HR	95% CI	Frailty robust *p*-value
Proximity of implants (2 adjacent natural teeth)	0.6	(0.2, 2.3)	0.5
Proximity of implants (2 adjacent implants)	1		
Implant specific variables			
Implant diameter: Regular	0.5	(0.2, 1.0)	0.05 *
Implant diameter: Wide	0.4	(0.2, 1.0)	0.04 *
Implant diameter: Narrow	1		
Implant Brand: ST	0.2	(0.03, 1.1)	0.06 *
Implant Brand: NB	0.3	(0.1, 0.8)	0.01 *
Implant Brand: AT	1		
Implant staging: 2-stage	5.7	(2.4, 14.0)	<0.01 *
Implant staging: 1-stage	1		
Immediate placement	1.6	(0.7, 3.7)	0.3
Prosthesis variables			
Fixed bridge	24.5++	(0-∞)	
SIC	1		
Screw-retained	0 +	(0-∞)	1
Cement-retained	1		

Table 6. Multivariate frailty Cox regression model (637 patients, 1188 implants)

	HR	95% CI	Frailty robust *p*-value

1. HR = hazard ratio, CI = confidence interval.
2. +HR = 0 is not reliable as length of the CI is infinitely large.
3. ST: Straumann; NB: Nobel Biocare; AT: Astra Tech.

Age >65	2.7 (0.7, 10.6)	0.1
Age 50-65	1.1 (0.3, 5.0)	1
Age <50	1	
Gender (Male)	1.5 (0.7, 3.2)	1.0
Arthritis	1.7 (0.8, 4.0)	0.2
Location: Mandible posterior	0.7 (0.1, 4.0)	0.7
Location: Maxilla anterior	0.6 (0.1, 3.4)	0.6
Location: Maxilla posterior	0.5 (0.09, 2.8)	0.5
Location: Mandible anterior	1	
Implant diameter: Regular	0.4 (0.1, 1.3)	0.1
Implant diameter: Wide	0.3 (0.09, 1.2)	0.1
Implant diameter: Narrow	1	
Implant Brand: ST	0+ (0-∞)	1
Implant Brand: NB	0.7 (0.3, 1.6)	0.4
Implant Brand: AT	1	
Implant staging: 2-stage	4.5 (1.9, 10.4)	<0.01

Table 7. Parsimonious multivariate frailty mixed-effects Cox regression model (1059 patients, 1844 implants)

	HR	95% CI	Frailty robust P-value
1. HR = hazard ratio, CI = confidence interval.			
Age >65	3.2	(1.2, 8.7)	0.0190
Age 50–65	1.3	(0.4, 3.9)	0.6500
Implant diameter: Regular	0.4	(0.2, 1.0)	0.0520
Implant diameter: Wide	0.4	(0.2, 1.0)	0.0400
Implant staging: 2-stage	4.0	(2.1, 7.5)	0.0002
Frailty term (1.15647)			$p < 0.05$

Discussion

This study presents data-supported evidence that implant treatment delivered in a faculty-supervised predoctoral clinic can be successful. The cumulative implant survival rate of 96.4% (94.6% at the patient level), observed over an 8-year period, was similar to the survival rates achieved under more sophisticated conditions or by experienced dentists in specialized clinics.[16,17,22-24] To the best of our knowledge, this might be the first report to identify advanced age as an important risk indicator for implant failure. In fact, patients older than 65 years had a three times greater risk of experiencing implant failures than their younger peers.[28,29,56] Last but not the least, the study also corroborated reports that the risk of dental implant failure clusters within patients.[51,56] However, implementation of a proportional hazard frailty model has an important consequence for the proper interpretation of the resulting HR. In contrast to the standard Cox proportional hazard model that produces results at the population level, the frailty model estimates the HR at the patient level.[51]

The average age of the present study cohort was 59.7 years, which was higher than the average age reported in many other studies.[56-60] However, recently, Reese et al presented demographic information that shed light on the decision process of dental school patients, who received implants or root canals.[61] The average age (±1 SD) of their implant patients was 60.2 ± 18.3 years, that is, similar to the patients of this study. In contrast, patients who received root canal treatment were 15 years younger on average. The authors concluded that patients of younger age favored root canals because they had a better chance to preserve tooth substance and periodontal support. Patients of advanced age, however, were facing more severely

compromised teeth, and therefore more likely to prefer replacement with an implant.

The present study included a diverse patient cohort. Nonetheless, despite the substantial degree of diversity, the make-up of the cohort was primarily Caucasian and not representative of the population of Milwaukee or the U.S. The discrepancy, in particular the underrepresentation of the African American population among recipients of dental implants, can be attributed primarily to their precarious socioeconomic situation, widespread dental illiteracy, and lack of dental insurance coverage.

The average number of implants placed per patient was 1.76. This is much lower than in other reported studies, where the average number of implants per patient ranged from 4 to 10.4.[59,62-65] The difference could be the result of case selection, which was targeted in favor of less-complicated clinical situations, possibly typical for an educational environment. Comparable numbers of implants were placed in the maxilla and mandible (Table 3). Other studies showed different distributions. For example, in a study by van Steenberghe et al all implants were placed in the maxilla,[62] and Malo et al reported placement of 72 implants in the maxilla and 20 in the mandible.[63] Most likely, in prospective studies, anatomic location and proximity to teeth or implants are dictated by the study protocol. In retrospective database studies such variables are most likely dictated by chance.

In a systematic review evaluating clinical performance of implant restorations, a greater number of SICs were observed compared to FDP restorations (1720 SIC, 1040 FDP).[66] A total of 25 studies reported on cement-retained and 9 studies reported on screw-retained SIC. The authors reported that among the 1720 SIC restorations analyzed, a majority of SICs were cement-retained (1316, 76.5%), and a few were screw-retained restorations (404, 23.5%).[66] The same review found 19 studies that reported on implant-supported FDP. Seven hundred thirty-one (70.3%) FDP restorations were screw-retained and 309 (29.7%) were cement-retained.[66] The finding of the present study was similar to that presented in the systematic review, with a greater percentage of restorations being SIC (87.8%) and cement-retained (86.6%), respectively; however, unlike the

systematic review, the present study reported a majority of FDPs to be cement-retained restorations.

Altogether, 70 implant failures in 59 patients were registered. Fifty-three implants (75.7%) were lost during the first 6 months following placement (Fig 2). Early implant failures are usually observed before prosthetic connection and loading.[18] They are due mainly to failure in achieving osseointegration and are frequently associated with fibrous scar tissue formation at the bone/implant interface.[18,25] Late implant failure is observed after prosthetic connection and loading. Failure to maintain osseointegration has been listed as the most likely reason.[18,26,27] Several factors may contribute to late failures, including presence and composition of local biofilms and type of prosthetic rehabilitation.[18,26,27]

A recent long-term study reported high implant survival rates in a small cohort of medically healthy elderly patients.[67] The cumulative implant-based survival rate of 94.6% was similar to the rate reported herein. Other studies that investigated the role of age on implant survival found no relationship between increasing age and implant survival or failure.[29,51,68-71] In contrast, this study concluded that patients older than 65 years might experience a three times greater risk of implant loss relative to patients of younger age. Although older age by itself does not affect wound healing, many age-related changes can interfere with the proper staging of wound healing. Factors subject to age-related changes may include, among many others, decline of sex hormones, malnutrition due to impaired chewing ability, medication, and medical conditions like diabetes.[72]

This study identified implant diameter as an important risk indicator for failure. Placing a wide-diameter implant decreased the risk of implant failure more than twofold in comparison to a narrow-diameter implant, always assuming sufficient bone is available. Regular-diameter implants achieved a similar result, but statistical support for this was less convincing. The finding of the present study is in agreement with previous reports.[30,31] A recent systematic review and meta-analysis of retrospective and prospective studies concluded that implants with wide-diameter implants had promising 5-year survival rates (92.7%, 97.8%, respectively).

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Two-stage implant placement had a four times greater failure risk than one-stage implant placement. The observation is in contrast to Tallarico et al and Chuang et al's studies.[32,51] They found that one-stage protocols had a higher risk to fail than two-stage protocols. In another study comparing one-stage versus two-stage implant placement with maxillary sinus lift procedures 4 months after loading, no staging difference was found. The authors reported no failure in the one-stage groups and only a single failure in the two-stage groups.[33] The high relative risk of failure seen with the two-stage placement protocol could be attributed to questionable case selection. In several situations implant placement was performed in conjunction with bone grafting. Perhaps grafting the site and waiting for complete healing prior to implant placement would have been a better approach to minimize failure.

In a thorough review of available scientific evidence, Diz et al concluded that there were very few absolute contraindications to dental implant therapy, and the degree of systemic disease control was more important than the nature of the disorder itself.[15] The present study corroborated the bold conclusion. It failed to reliably identify any variables of medical history and medication that could have affected implant failure rates; however, the result must be interpreted cautiously, as the sample size available for investigating effect of medical history or medications on failure rates was too small. In addition, implant failures and serious morbidities were observed in small numbers. Hence, much larger cohorts would have to be studied to achieve results that would be statistically reliable.

Limitations of the present study included those that are typical for all retrospective cohort studies. For example, there was only very limited control over the approach to sampling the cohort. As a result, racial/ethnic minorities were underrepresented in the cohort. Also, quality, completeness, and accuracy of the original data collection were not known. For example, complete medical histories were found in 679 of 1918 patient records only. It is not known whether patients with missing medical information were in fact healthy or not. Also, smoking status of patients was not recorded.

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Conclusion

Within the limitation of the study, implant placement in the predoctoral clinics was predictable and successful as confirmed by a cumulative implant survival rate of 96.4%.

1. Age (>65 years), implant diameter, and two-stage placement were associated with the risk of implant failure.
2. The risk of implant failure between subjects was heterogeneous.

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