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Retrospective Analysis of Dental Implants Placed and Restored by Advanced Prosthodontic Residents

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Abstract

Purpose: The purposes of this retrospective clinical review were to: (1) describe the demographics of implant patients, types of implant treatment and implant-supported prostheses in an Advanced Education in Prosthodontic Program, (2) evaluate the survival rate of dental implants placed by prosthodontic residents from 2006 to 2008, and (3) analyze the relationship between resident year of training and implant survival rate.

Material and Methods: All patients who received dental implants placed by prosthodontic residents from January 2006 to October of 2008 in the Advanced Prosthodontic Program at the University of Illinois at Chicago College of Dentistry were selected for this study. Age, gender, implant diameter, length, implant locations, surgical and restorative detail, and year of prosthodontic residency training were collected and analyzed. Life-table and Kaplan–Meier survival analyses were performed based on implants overall, locations, year of training, and use of a computer-generated surgical guide. A Logrank statistic was performed between implant survival and year of prosthodontic residency training, location, and use of computer-generated surgical guide ($\alpha = 0.05$).

Results: Three hundred and six implants were placed, and of these, seven failed. Life-table and Kaplan–Meier analyses computed a cumulative survival rate (CSR) of 97% for overall implants and implants placed with a computer-generated surgical guide. No statistical difference was found in implant survival rates as a function of year of training ($P = 0.85$).

Conclusion: Dental implants placed by prosthodontic residents had a CSR comparable to previously published studies by other specialties. The year of prosthodontic residency training and implant failure rate did not have any significant relationship.

Dental implant therapy is an integral part of patient care. The predictability and advantages of dental implant therapy have been well documented for partially[1-3] and completely edentulous patients.[4-7] With growing population, public interest, and awareness, the patient demand for dental implants and implant-supported care will continue to increase.[8-9] To accommodate this demand, implant surgical training has become a vital part of dental curricula.[10-20] Although a small number of studies have reported implant placement in predoctoral education programs,[11-12] most implant surgical training occurs at the advanced education level, where studies have demonstrated high survival rates for implants placed by residents from dental surgical specialties.[10,18-20]

Prosthodontists provide a broad spectrum of therapy approaches for patients with dental implants, and some prosthodontists also surgically place dental implants.[21] Prosthodontists receive surgical training through specialty programs, continuing education, and self-training.[21] At the specialty level, prosthodontics embraces its interactive and leadership role as part of a therapy team, while in the comprehensive primary care responsibility, a prosthodontist often acts as a single provider. A recent publication showed that implant therapy,

both placement and restoration, accounted for 37% of the revenue for the average prosthodontic practice.[22] Dental implants placed by prosthodontists accounted for 12% of the revenue.[23] A survey by the Advanced Education in Prosthodontics (AEP) program directors in the United States and Canada reported that implant surgical training has become an essential part of prosthodontic program curricula.[24] The American College of Prosthodontists (ACP) also recognized implant placement as an important component of the Accreditation Standards for Advanced Specialty Education Programs in Prosthodontics.[25] A recent survey addressed prosthodontic residents and their perception of their surgical training. The majority of prosthodontic residents had opportunities to place dental implants in their program, and nearly half the respondents felt their residency training was adequate for future implant placement in practice. Many residents expected to become surgically competent in placing dental implants in the course of their training.[26]

Studies related to implant training in surgical specialties and levels of experience have reported differing conclusions in clinical outcomes.[10,20,27-29] Several studies have advocated that experience level of the surgeon can significantly influence implant survival.[27,28] However, other studies reported that experience level did not play a vital role in implant survival in either university or private practice settings.[10,20,29]

Clinical studies related to implant surgeries performed by prosthodontists and AEP residents are very limited. Therefore, the purposes of this retrospective cohort study were to: (1) describe the demographics of implant patients, types of implant treatment and implant-supported prostheses at the University of Illinois at Chicago College of Dentistry (UIC COD) AEP Program, (2) evaluate the survival rate of dental implants placed by prosthodontic residents from 2006 to 2008, and (3) analyze the relationship between year of prosthodontic residency training and implant survival rate.

Materials and methods

This study was approved by the UIC Institutional Review Board (Research Protocol no. 2008–0866). The cohort for this study was defined as patients receiving implant placements and restorations from the Advanced Prosthodontic Clinic between January 2006 and October 2008. These patients were identified using electronic patient records (axiUm, Exan USA, Las Vegas, NV). The inclusion criteria for this study were: (1) all implants placed by UIC prosthodontic residents from 2006 to 2008, and (2) all patients who received dental implants regardless of age, gender, race, or medical status. Unavailable or incomplete patient records were excluded from this study.

The following information was collected:

1. Patient age and gender.
2. Implant location by arch (maxillary or mandibular), region (anterior or posterior), and site (central incisor, lateral incisor, canine, premolar, or molar).
3. Implant design (straight or tapered).
4. Implant connection (internal or external).
5. Implant length and diameter.

The following information regarding implant placement surgery was collected:

1. Surgical stages (one- or two-stage surgery).
2. Use of 3D planning software and generated surgical guide (yes or no).
3. Bone grafting – any form of osseous augmentation prior to or at the time of implant placement (yes or no).
4. Immediate implant placement at the time of extraction (yes or no).
5. The year of training of the prosthodontic resident when implant surgery was performed (first, second, or third).

A follow-up regimen of 1 week, then 4 to 6 months post second-stage surgery was followed for all patients. After the initial 6-month follow-up, the majority of the patients returned for recall appointments biannually. Modified Albrektsson criteria[30] were used to assess all implants. Clinical and radiographic exams were performed at the recall appointment. The absence of mobility, pain, and radiographic radiolucency confirmed osseointegration. Any complications were noted, and details involving the complications were recorded. Implant failure was defined as any implant that required complete removal for any reason. The duration for implant survival was calculated from the date of surgical placement to the last evaluation appointment.

For implant-supported restorations, the following information was collected:

1. Prosthesis design [implant-supported single-unit crown (ISC), fixed partial denture (FPD), overdenture (OD), or fixed complete denture (FCD)].
2. Prosthesis material (resin-based, metal-ceramic, all-ceramic, or metal).
3. Prosthesis retention [cement, screw-retained, or resilient attachment (Locator^{TM}, Zest Anchors, Escondido, CA).
4. Single abutment design by site [prefabricated, computer-aided design and computer-aided manufacturing (CAD/CAM) or custom cast].
5. Supporting framework design (custom cast, custom cast frame, custom cast-bar, CAD/CAM titanium bar, or CAD/CAM bar).
6. Implant splinting with the definitive restoration (yes or no).

All data were entered into electronic database software (FileMaker Pro Advanced 9.0v3, FileMaker Inc., Santa Clara, CA). Descriptive statistics were used to analyze the patient demographics and implant information. Life-table analysis and Kaplan–Meier survival analysis were completed for the overall implants placed, location, year of training, and use of computer-generated surgical guide using statistical software (Statistical Package for the Social Sciences, version 17.0; SPSS Inc., Chicago, IL). The relationship between implant survival rate and prosthodontic resident's year of training, location, and use of computer-generated surgical guide were assessed using Logrank statistics (MedCalc software, version 12.1.0.0; Mariakerke, Belgium) ($\alpha = 0.05$).

Results

A total of 123 patients were selected for this study, and no patient was excluded. There were 63 men and 60 women, with a mean age of 57.9 years (SD = 13.7). The age ranged from

Table 1 Distribution of implants by arch, region, site, and year of residency training

Arch	N (%)	Region	N (%)	Site	N (%)	Year of training (Year)	N (%)
Maxilla	133 (43.5%)	Anterior	58 (19.0%)	Central	25(8.2%)	First	22(7.2%)
				Lateral	14(4.6%)	Second	19(6.2%)
				Canine	19(6.2%)	Third	17(5.6%)
		Posterior	75 (24.5%)	Premolar	53(17.3%)	First	29(9.5%)
				Molar	22(7.2%)	Second	21(6.9%)
						Third	25(8.2%)
Mandible	173 (56.5%)	Anterior	80 (26.1%)	Central	9(3.0%)	First	29(9.5%)
				Lateral	18(5.9%)	Second	23(7.5%)
				Canine	53(17.3%)	Third	28(9.2%)
		Posterior	93 (30.4%)	Premolar	32(10.5%)	First	34(11.1%)
				Molar	61(19.9%)	Second	26(8.5%)
						Third	33(10.8%)

Table 2 Surgical approach and implant design

Approach/Design	N = 306	
One vs two stage	One	Two
	53 (17.3%)	253(82.7%)
CT-guided vs non-CT guided	CT-Guided	Non-CT Guided
	148 (48.4%)	158 (51.6%)
Immediate placement	No	Yes
	280 (91.5%)	26 (8.5%)
Grafting	No	Yes
	250 (81.7%)	56 (18.3%)
Straight or tapered	Straight	Tapered
	237 (77.5%)	69 (22.5%)
Internal or external connection	Internal	External
	301 (98.4%)	5 (1.6%)

21 to 84 years for men and 27 to 82 years for women. The major brands of implants used were Astra Tech Osseospeed™ (Astra Tech USA, Waltham, MA), which uses a roughened titanium surface with fluoride and Nobel Biocare Replace™ (Nobel Biocare, Yorba Linda, CA), with phosphate-enriched titanium oxide surface.

The total number of implants placed and their distribution are shown in Table 1. A total of 306 implants were placed (179 in men, 127 in women). For both arches, more implants were placed in the posterior region than the anterior. The most prevalent implant location was the mandibular molar region (19.9%), followed by the mandibular canine and maxillary premolar (both 17.3%) (Table 1). Of the total implants placed, 114 implants were placed by first-year residents, 89 implants by second-year residents, and 103 implants during the resident's final year of training.

Table 2 represents implant data arranged by surgical approach and implant design. Most implant surgeries followed a two-stage approach, and almost half the implants were placed using a surgical guide fabricated with the aid of 3D planning software. The cumulative survival rates (CSR) for implants placed by guided and non-guided approach were 97% and 98%, respectively. Twenty-six implants (8.5%) were placed immediately after extraction, and 56 implants (18.3%) required osseous augmentation. Most of the implants placed were straight and had internal connection. The most commonly placed implant dimension was 4 mm × 13 mm (20.3%), followed by 4 mm × 11 mm (15%) (Fig 1).

For the total number of implants placed, the CSR was 97% for the 3-year observation period, as shown in the Life-table and Kaplan–Meier analyses (Table 3, Fig 2). Overall, seven implants placed by prosthodontic residents failed between 2006 and 2008. The details on the failed implants are reported in Table 4. All failures occurred within 6 months of placement. Two implants presented infection within 2 to 4 months of placement, where the implants were removed and grafted. Two implants failed within 2 months of immediate implant placement, followed by immediate provisional restoration. Three implants lost integration at the time of framework try-in, abutment removal, and final impression after 4 to 6 months of healing. There was no statistical difference for survival rate based on location ($p = 0.79$), where the posterior maxilla showed the highest survival rate (98.1%), followed by anterior and posterior mandible (97.4% and 97.6%, respectively) and anterior maxilla (95.9%). Among the residents at different years of training, no statistical difference was found between the implant survival rates ($p = 0.85$). No statistically significant difference was found between the use of computer-generated surgical guide (97% survival rate) and not using one (98% survival rate) ($p = 0.52$).

Implant-supported prosthesis information is described in Table 5 and Figure 3. Within the timeframe of the study, 7 implants were not restored due to failure, and 14 implants had not been restored. The majority of the implants were restored as ISCs (32.4%), followed by FPDs (27.8%) and ODs (22.9%). The majority of the abutments used were prefabricated (47.1%), and mostly used cement-retained (44.8%), metal-ceramic restorations (55.6%). Most of the prosthetic frameworks were custom-cast (60.8%), and the distribution between splinted and non-splinted restoration was fairly even (44.4% and 48.7%, respectively).

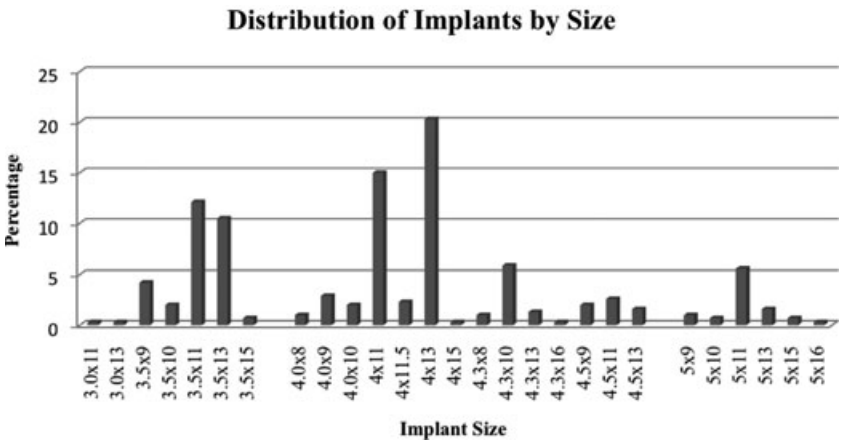

Figure 1 Distribution of implants by size.

Table 3 Life-table analysis for implants placed by advanced prosthodontic residents

Time since implant placement (months)	Total number of implants placed	Number placed during time interval	Number exposed to risk	Number of failed implants	Proportion survival rate (%)	Cumulative survival rate (%)	Hazard rate
0–5	306	76	268	7	97	97	0
6–11	223	87	179.5	0	100	97	0
12–17	136	74	99	0	100	97	0
18–23	62	44	40	0	100	97	0
24–29	18	17	9.5	0	100	97	0
30	1	0	1	0	100	97	0
31	1	1	0.5	0	100	97	0

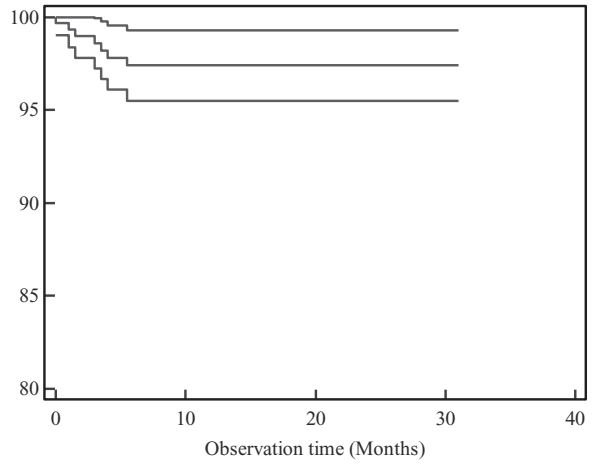

Figure 2 Kaplan–Meier survival function for implants overall with 95% confidence interval.

Discussion

Implant placement in an AEP program can provide successful results. A 2004 survey conducted by the Educational Policy Subcommittee of the ACP examined the implant curricula in AEP programs based on the perceptions of program directors.[24] That study reported that implant dentistry is an integral part of AEP curricula, and noted the incorporation of implant surgical training in the program.

This study examined the survival rate of dental implants placed and restored exclusively by prosthodontic residents. The CSR of 97% for the implants placed by prosthodontic residents from this study was similar to findings from other studies.[10,19,31,32] A 5-year retrospective study by Kucey reported survival rates of 96.2% of implants placed by prosthodontists in private practice.[31] Chung et al showed a 96.3% CSR for implant therapy provided in a graduate prosthodontic program from 1988 to 2000.[32] Starr and Maksoud reported a 96.6% implant survival rate in a 7-year period at an advanced general dentistry residency program.[19] Melo et al showed a 91% survival rate from 175 implants placed in an oral and maxillofacial surgery program,[10] suggesting that residency programs may have predictable results.

With the increasing number of patients requiring replacement of missing teeth, the need for dental implant therapy will increase as well.[8-9] Having surgical experience in the prosthodontic residency program can help prosthodontic residents treatment plan and provide implant therapy in a patient-centered and comprehensive manner, while communicating and using other surgical colleagues when appropriate. With this in mind, using advanced diagnostic tools, such as computed tomography (CT), is critical in making proper diagnoses, patient selection, and communication with other surgical specialists.[33-36] In this study, nearly half the implant surgeries used CT scans, 3D

Table 4 Detailed information on implant failures

Patient information							
Patient	*1*	*2*	*3*	*4*	*5*	*6*	*7*
Age	37	47	47	57	80	68	60
Gender	M	F	M	M	M	F	M
Past medical history	NSF	Multiple sclerosis	NSF	NSF	History of cancer	Arthritis, GERD, HTN	Diabetes
Provider information							
Year of training (years)	2	2	1	1	3	3	3
Implant information							
Arch	Max	Max	Mand	Mand	Max	Mand	Mand
Immediate placement	N	Y	N	N	N	N	N
Grafting	Y	N	N	N	Y	N	N
Diameter	4.0	4.0	4.0	3.5	4.3	4.3	4.0
Length	11	13	13	10	13	10	13
Infection present	N	N	N	N	N	Y	N
Location	13	11	30	26	7	20	27
1 or 2 stages?	2	1	2	1	2	1	2
CT-guided	Y	N	Y	Y	N	Y	N
Survival (months)	5.7	1.1	0.7	3.6	3.1	4.0	1.5

Note: all failed implants reported no fenestrations and were all internal-connection implants
NSF = No significant findings
GERD = Gastrointestinal esophageal reflux disease
HTN = Hypertension
Max = Maxillary
Mand = Mandibular

Table 5 Detailed characteristics of implant-supported prostheses

Abutment type	**Number of implants**
Prefabricated	144 (47.1%)
Custom cast	66 (21.6%)
CAD/CAM	75 (24.5)
Not restored-failed	7 (2.3%)
Not yet restored	14 (4.6%)
Framework design	**Number of implants**
Custom cast	186 (60.8%)
Custom cast – bar	8 (2.6%)
CAD/CAM titanium – bar	28 (9.2%)
None	63 (20.6%)
Not restored-failed	7 (2.3%)
Not yet restored	14 (4.6%)
Prosthesis material	**Number of implants**
All-ceramic	9 (2.9%)
Metal-ceramic	170 (55.6%)
Metal	1 (0.3%)
Resin-based	105 (34.4%)
Not restored-failed	7 (2.3%)
Not yet restored	14 (4.6%)
Retention	**Number of implants**
Cement	137 (44.8%)
Screw	76 (25.8%)
Resilient	72 (23.5%)
Not restored-failed	7 (2.3%)
Not yet restored	14 (4.6%)
Splinted	**Number of implants**
Yes	136 (44.4%)
No	149 (48.7%)
Not restored-failed	7 (2.3%)
Not yet restored	14 (4.6%)

planning software, and software-planned surgical guides. The use of a CT-based software and CAD/CAM-generated surgical guide has been documented to be advantageous for implant surgery due to the ability to plan prior to surgery using anatomical diagnostic information, possibly avoiding additional surgical procedures, and potentially simplified surgical process with simultaneous prosthetic reconstruction.[33,36] A recent literature review documented that implant placements using a CT-generated surgical guide can have survival rates comparable to other placements, where the mean failure rate of implants placed with computer assistance was 3.36%.[36] The accuracy of surgical guide and placement of implants was "reasonably" accurate, having a total mean error of 0.74 mm at the bony entry point and 0.85 mm at the apex.[33-37] Advanced imaging based on anticipated final restorations and thorough diagnostic tools can contribute to a high level of success in implant therapy.

The implant failures and years of residency training did not have any significant correlation in this study. Other studies have suggested that the level of training of the provider may not be a significant reason for causing implant failures.[10-11,29,38] A novice resident may begin surgical training from a site with good bone quality, such as anterior mandible, and progress to the more difficult area in the oral cavity as one gains more experience. Interestingly, the locations of implant placement and level of surgical experience did not have any correlation in this study. In this study, first-year residents had very good survival rates for all implant locations, with the highest number of implants and failure rates comparable to other resident's levels. Some residents may have additional surgical experience before starting the prosthodontic residency program through general practice residency, military, or private practice. There are programs where predoctoral dental students experience implant placements as well.[11] Whether prior experience influences the

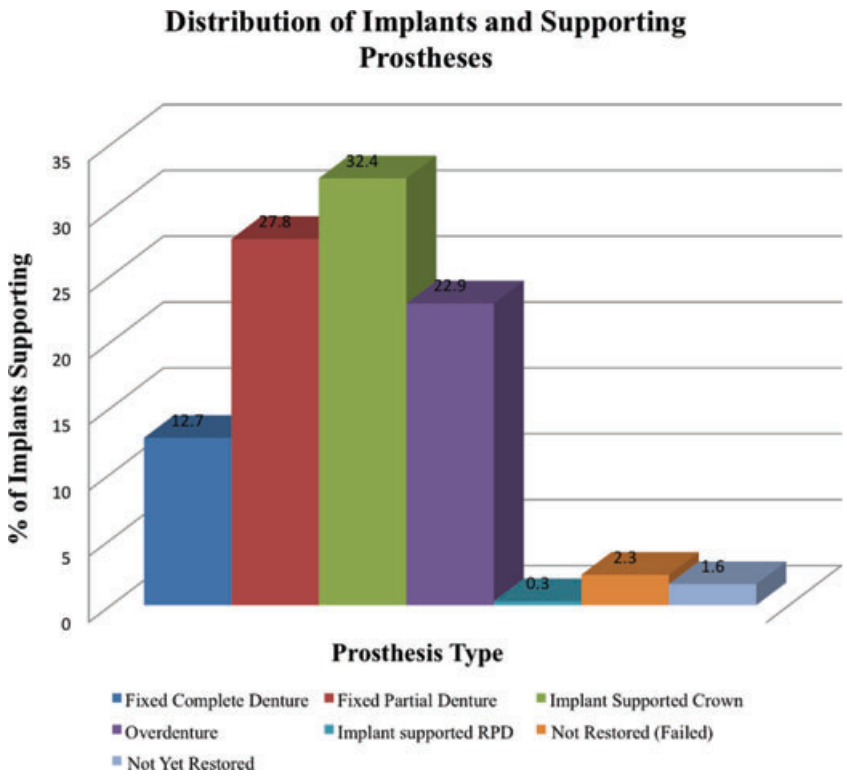

Figure 3 Distribution of implants and supporting prostheses.

survival of dental implants in this prosthodontic program was not addressed in this study.

Data regarding implant therapy was followed through the use of a database generated based on collaborative efforts. In this study, although implant survival was followed, the success of the implant-supported prostheses was not tracked due to the lack of data on patient recall. Afshari et al reported the need for an improved recall system in advanced prosthodontic programs in 2010, where only 64% of programs reported an active recall system.[39] The value of a proper recall system in a prosthodontic program is evident in this study. The follow-up of the patients treated may be inconsistent and challenging due to the discontinuous care provided by the different resident providers, and the patients not returning to the university after treatment. Documenting the success of prosthetic treatments through a recall system could provide valuable data to derive prognostic factors that may assist in better predicting future patient care prognosis. As implant therapy is restoratively driven, adequate follow up for patient treatment and success of the prostheses must be accounted for. Future study in this area is necessary.

Conclusion

The CSR of dental implants placed by UIC Advanced Prosthodontic residents was high (97%) and comparable to previously published studies. During the observed study period, year of prosthodontic residency training did not affect the implant survival rate. Documentation of implant surgical outcomes and associated prognostic factors may lead to greater confidence in diagnosis, planning, prognosis assessment, predictable placement, and restoration of patients at the advanced prosthodontics level and may support effective learning experiences necessary for an advanced program graduate.

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