PROSTHETIC RECONSTRUCTIONS AND REFERRING IMPLANT SURVIVAL IN A POSTGRADUATE PROGRAM: A RETROSPECTIVE STUDY

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ABSTRACT

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Aims: To analyze frequency distribution of prosthetic reconstructions and therapeutic modalities with implant-supported reconstructions (ISRs) applied in a university graduate program.
Methodology: Data of implant placement and related ISR were obtained from treatment plans, surgical protocols and patients' charts, covering the 2005 to 2010 time period. Loading time, implant survival and type of ISR, i.e. fixed (single crown (SC), short-span fixed dental prosthesis (FDP), full-arch FDP (IB)) and removable ISR (denture with ball attachments (RDP), bar-supported overdenture (Bar-IOD)) were determined and analyzed with descriptive statistical methods.
Results: Data of 819 patients with a mean age of 62.3 ± 11.6 years were available. Graduate students placed 2337 implants and 1133 related ISRs were fabricated. The observation time ranged from 1 to 8 years (mean 4.7 ± 1.8). The number of implants supporting fixed and removable ISRs was 1053 (45.1%) and 1284 (54.9%), respectively. The percentage distribution of implants per ISRs exhibited 337/337 SCs (14.4%), 422/190 FDPs (18.1%), 294/54 IBs (12.6%), 374/198 RDPs (16.0%) and 910/354 Bar-IODs (38.9%). Thirty-one implants were lost (12 before and 19 after loading) resulting in an 8-year cumulative survival rate of 98.6% without difference between implants of different groups (fixed vs. removable ISRs, splinted vs. non-splinted ISRs, no GBR/SFE vs. GBR/SFE, upper vs. lower jaw).
Conclusions: A broad variety of fixed and removable implant supported prostheses for partially and completely edentulous patients was identified. Although these data represent learning curves for graduate students working under supervision, implant survival was successful in a short-term range.
Keywords: implant-dentistry, graduate training, implant survival, prosthetic reconstructions, CAD/CAM.

1. Introduction

Implant dentistry has become an integral part of clinical practice. Already in the early nineties when basic research in osseointegration and clinical application of implants grew rapidly, clinicians and university educators discussed the teaching of implantology for undergraduate students and for postgraduate trainings[1]. At this time the lack of trained and qualified teachers appeared to be a limitation when implantology should be introduced in university curricula[2]. However, gradually implant restorations were included into general and specialist dental practice[3]. Nevertheless, the topic of undergraduate training was taken up again only after the year 2000 and is currently being discussed worldwide.

Surveys and reviews that gathered data from dental schools in Northern America and less frequently in Europe revealed that implant dentistry has been incorporated to a high percentage into the undergraduate training[4-11]. Teaching implant dentistry often focused on the surgical aspects

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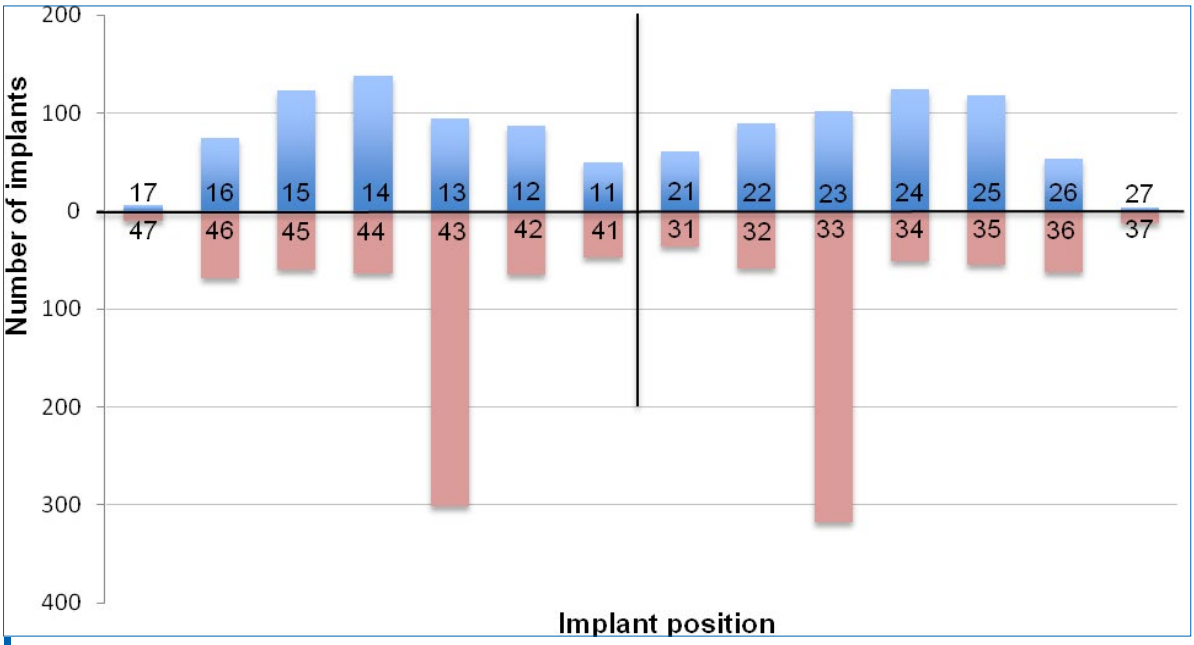

Figure 1. Distribution of implants placed in the maxilla and the mandible

and was performed by specialists in oral surgery, maxillofacial surgery and by periodontists[12] while prosthdodontists took an active role if patients were to be prosthetically restored with implants[13]. Such publications demonstrate the clear trend toward teaching implantology at universities and dental schools, otherwise they illustrate that there remain great variations how education in implant dentistry is provided for undergraduate students. In some schools teaching consists either exclusively in lecture-based theory or they include Typodont model and laboratory training while clinical interaction with patients and delivering implant supported restorations is not yet the standard. Implant placement by students is rarely reported and electively performed[6], however the students attend the surgical procedures as clinical observers[4]. Today, local and international courses for general practitioners and specialists, master programs offered by dental schools and dental associations or by private organizers are announced worldwide and various specialty degrees and diplomas can be obtained. Furthermore, courses are often sponsored by the industry[14]. Global standards for quality criteria or competency levels of such education and training programs are not available. The International Team for Implantology (ITI) published a grading system that classifies the surgical and prosthodontic procedures into straightforward, advanced, complex (SAC)[15]. Consensus conferences were also held and attempts made to establish teaching goals and to look at further needs and development in implant training. They summarize to what extent knowledge should be provided, and the level of skills that should be reached by undergraduate and postgraduate students[10,16-18]. Guidelines were proposed by various dental associations such as the American Academy of Implant Dentistry[1]. In this context, the aim of this retrospective study was to analyze frequency distribution of implant-supported prosthetic reconstructions and referred implant survival of implants placed from graduate students in a university training program.

2. Methodology

2.1. Admission to the program

A structured postgraduate program in prosthodontics and implant dentistry was established at the former Department of Prosthodontics, University of Bern, Bern, Switzerland. This comprehensive curriculum comprises prosthetic therapy and implant-surgery in one University clinic during a minimum of 3 years. The admission criteria for the program are that the graduate students have completed firstly a two yaer-clinical training in general dentistry, which includes training in oral surgery and secondly a doctoral thesis as general dentist (Dr. med. dent.). The focus was on problem based teaching and evidence-based, patient-centered comprehensive treatment. Furthermore, a scientific article had to be published by the graduate student or the university must have accepted another thesis. During the entire curriculum period the graduate students also took also an active role in theoretical teaching, planning sessions and clinical training of the undergraduate students in Prosthodontics, which comprised straightforward implant reconstructions such as mandibular overdentures, single crowns and short span fixed dental prosthesis. Such teaching assignment broadened their experience and helped to develop skills in social behavior and attitudes toward students, patients and teachers.

2.2. Study material

Prosthetic patients were consecutively admitted for treatment in the course of this postgraduate curriculum. They signed an informed consent willing to be treated by graduate students. This

Table 1. Number of implants according to the gender and the dental status

		Implants in maxilla	Implants in mandible	Total implants
Gender	Male	556	575	1131 (48.4%)
	Female	569	637	1206 (51.6%)
Dental status	Partially dentate	527	421	948 (40.6%)
	Edentulous	598	791	1389 (59.4%)
Total		1125 (48.1%)	1212 (51.9%)	2337 (100%)

Table 2. Number of implants according to the type of ISR performed

Type of ISR		Maxilla Implants / ISRs	Mandible Implants / ISRs	Total Implants / ISRs	Lost implants preload; loaded
Fixed	SC*	180* / 180	157* / 157	337 (14.4%)* / 337	1; 6
	FDP	207 / 92	215 / 98	422 (18.1%) / 190	1; 3
	IB	228 / 39	66 / 15	294 (12.8%) / 54	1; 2
Removable	RDP*	236* / 121	138* / 77	374 (16.0%)* / 198	1; 3
	Bar-IOD	274 / 66	636 / 288	910 (38.9%) / 354	8; 5
Total		1125 / 498	1212 / 635	2337 (100%) / 1133	12; 19

* non-splinted implants from SCs and RDP (total 711, 30.4%)
ISR: Implant supported reconstruction
SC: Single crown
FDP: short-span fixed dental prosthesis
IB: Full-arch FDP (Implant bridge)
RDP: Removable dental prosthesis
IOD: Implant-Overdenture

survey was part of a quality control assessment of the dental consultation. The data were based on an abstraction of the oral examinations and were collected strictly anonymously. The study respected the regulations of the Helsinki Declaration from 1975 and was performed in accordance with the STROBE statements. The study protocol was reviewed and approved by the University of Bern School of Dental Medicine Institutional Ethical Committee. The progress of the patients' treatment was regularly supervised and documented in case presentations either live chairside or with adequate digital presentations.

The case presentations followed the PICO structure[19,20], meaning that decision making and implant therapy should be based on the best evidence available and meet the patients' needs. The students performed the implant surgery and prosthetic rehabilitation under the guidance and supervision of the director and staff specialists of the Department.

Detailed records and photographs were obtained from all patients during the entire treatment period. When the treatment was completed all patients were included in a well-organized maintenance program.

The goal of the 3-year training curriculum was to reach a competency level of grade A (advanced) for surgical and prosthodontic procedures according to the ITI treatment guide. Complex treatments and invasive approaches that were not frequently encountered were performed by the supervisors and assisted by the students.

2.3. Patient management

The patients involved in the graduate curriculum were partially dentate or edentulous in one or both jaws. They often presented failures of old reconstructions and teeth not worth being maintained. They had a different background (recall, prevention, etc.) and the reasons for tooth loss were long in the past. The patient management followed a strict protocol as described below:

- The patient's chief complaint and demands were assessed.
- The records of the patient's history comprised social aspects, general health, special habits (smoking, bruxism, alcohol and drug abuse) and dental history. Records on medications were kept and the family physician was contacted, if necessary.
- Clinical examination and dental/oral diagnosis: It included the periodontal status, caries, tooth wear and in single case a dietary protocol by the patient, occlusal analysis and assessment of the vertical dimension, functional analysis of temporomandibular joints (TMJ), single radiographs, status of endodontically treated teeth, pathologies of oral mucosa or pathological findings on the panoramic radiography, atrophic jaw (areas), evaluation of old reconstructions, aesthetic analysis (facial morphology, smile line, gummy smile, gingival border and papillae, tooth axis, lip closure and biotype of gingiva).

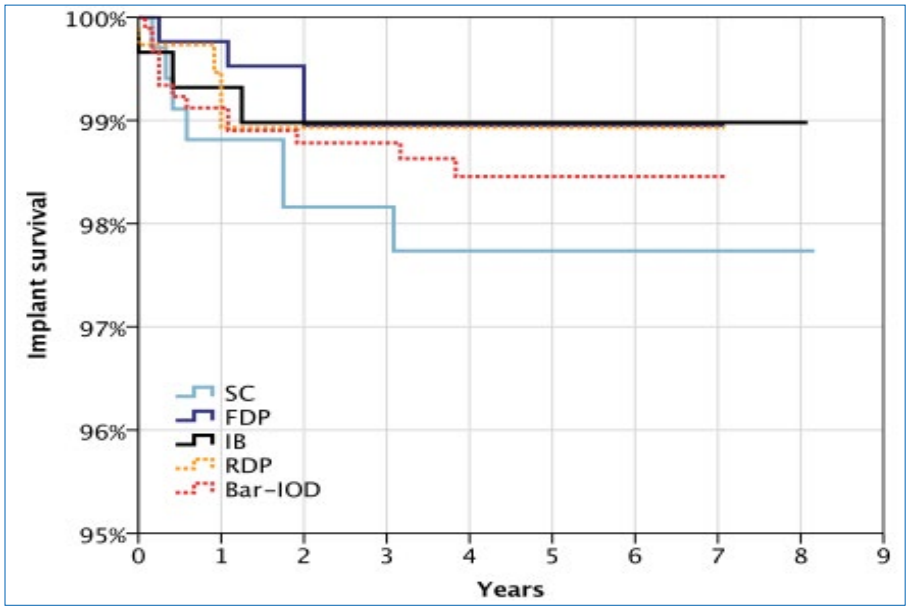

Figure 2. The implant survival was not significantly different for the implants supporting the different prosthetic reconstructions

- Planning: It was based on the clinical examination and comprised analysis of casts mounted with a face-bow, a prosthetic tooth setup simulating the prospective treatment outcome, evaluation of the best treatment plan based on objective criteria and possible modification of the plan which reflect the patients' benefit and demands, cost estimate, case presentation and establishing of the final procedures, and a virtual three-dimensional implant planning with specific software program.
- Pretreatment phase: It consisted in a smoking cessation protocol, periodontal treatment, fillings, endodontic treatment, tooth extraction and tooth setup, mockup, provisional prostheses including splints, reevaluation of the pretreatment, fabrication of radiographic splints and virtual implant placement with special computer software, fabrication of surgical splints. Based on proper treatment planning and case presentation the permission by the director of the department was obtained to perform implant surgery.
- Implant surgery: In the beginning the graduate students assisted implant surgery taking the role of the nurse and eventually performed all types of surgery themselves under guidance. According to the SAC criteria this included standard implant placement and eventually more complex surgery, such as staged or simultaneous local guided bone regeneration (GBR), sinus floor elevation (SFE) with transcrestal access or with lateral fenestration, submerged healing, in selected cases immediate implants or immediate loading, small connective tissue grafts, reevaluation of surgery and case presentation. The Nobel Replace implant system (Nobel Biocare, Gothenburg, Sweden) was used.
- Prosthetic phase: This phase consisted in the reevaluation of the provisional prostheses and modifications needed for the final prostheses, impression taking with individual trays, bite registration, final setup with orientation index and try-in session, case presentation, delivery of finale prosthesis and case presentation. The implant-supported reconstructions (ISRs) consisted of fixed (single crown (SC), short-span fixed dental prosthesis (FDP), full-arch FDP (IB)) and removable ISR (denture with ball attachments (RDP), bar-supported overdenture (Bar-IOD)). The fixed ISRs were either cement retained on an abutment or screw retained directly to the implant.
- Maintenance: The maintenance care program comprised at least one scheduled visit per year and monitoring of the oral hygiene by the dental hygienist. It was carried out by the graduate students during their training period. Handling of complications was equally part of the educational program since patients of the maintenance care program who exhibited any kind of problem were attributed to the trainees during their curriculum period.

2.4. Prosthesis design and materials

At the beginning of the time period covered by the present study standard technologies i.e. porcelain fused to metal were applied for fabricating of SCs and FDPs. Removable prostheses were connected to soldered rigid gold bars, using prefabricated elements as provided by the manufacturer, less

Table 3. Number of implants supporting CAD/CAM fabricated ISRs made from zirconium dioxide (ZrO_2) and titanium

Type of ISR	Implants in 2005	Implants in 2006	Implants in 2007	Implants in 2008	Implants in 2009	Implants in 2010	Total implants
Total fixed ISR	145	233	205	158	113	199	1053
CAD/CAM ISR ZrO_2	54 (37%)	34 (15%)	60 (29%)	34 (22%)	65 (58%)	68 (34%)	315 (30%)
Total removable ISR	208	247	225	207	213	184	1284
CAD/CAM bar titanium	15 (7%)	26 (11%)	87 (39%)	95 (46%)	123 (58%)	117 (64%)	462 (36%)

CAD/CAM: computer-aided-design/computer-assisted-manufacturing
ZrO_2: zirconium dioxide
ISR: implant supported reconstruction

Table 4. Life table analysis reporting on the totally 31 implant failures

Observation period (year)	Implants at risk (N)	Implant drop-outs (N)	Implant failures (N)	Interval survival (%)	Cumulative survival (%)
Preload	2337	0	12	99.49	99.49
0-1	2325	0	9	99.61	99.10
1-2	2316	294	7	99.70	98.80
2-3	2015	343	1	99.95	98.75
3-4	1671	354	2	99.88	98.63
4-5	1315	410	0	100.00	98.63
5-6	905	464	0	100.00	98.63
6-7	441	379	0	100.00	98.63
7-8	62	59	0	100.00	98.63
8-9	3	3	0	100.00	98.63

frequently to ball anchors and locators. Gradually the computer-aided-design/computer-assisted-manufacturing (CAD/CAM) fabrication for prosthesis frameworks and bars was introduced and recently became the prevalent technology[21]. Most frequently the Procera system (Nobel Biocare, Gothenburg, Sweden) was used for titanium and zirconium dioxide (ZrO2) reconstructions, followed by Zeno and Lava technology. Subsequently, all bars were milled from homogenous block of titanium grade IV. Milled titanium was also an option for large frameworks of full-arch IBs. In parallel, ZrO2 became the preferred material for all types of fixed prostheses. A close cooperation with laboratory technicians, who were trained and willing to apply modern CAD/CAM techniques, was established. All reconstructions were intended to be screw retained, directly from the implant shoulder without the interposition of an abutment. Thus, optimum implant planning and surgery was required, with proper alignment of the implant axis.

2.5. Data Collection

The present study material covers the data collection of these patients and related treatment, performed during the time period from January 2005 to December 2010. All necessary information was available from the patients' documentation that had to be kept by the graduate students. Additionally all data on implants, surgery procedures and prostheses were registered in a separate excel file. The data collection of the present study was based on the treatment plans, surgical protocols and daily records in the patients' charts during the treatment phase and the maintenance care period. The patients' age and gender, date of implant placement, implant location and loading time, implant survival, and type of ISR were determined.

2.6. Statistical analysis

The primary outcome was implant survival. The secondary outcome was the type of ISR performed and in particular the specific design and type of material used for the prosthetic reconstruction. Descriptive statistics included mean values, standard deviation (SD) and proportional analysis. A life table analysis was performed and the cumulative implant survival rate was calculated. The significance level was 5%. The SPSS software (SPSS 18.0, Chicago, IL, USA) was used for analysis and graphical illustrations.

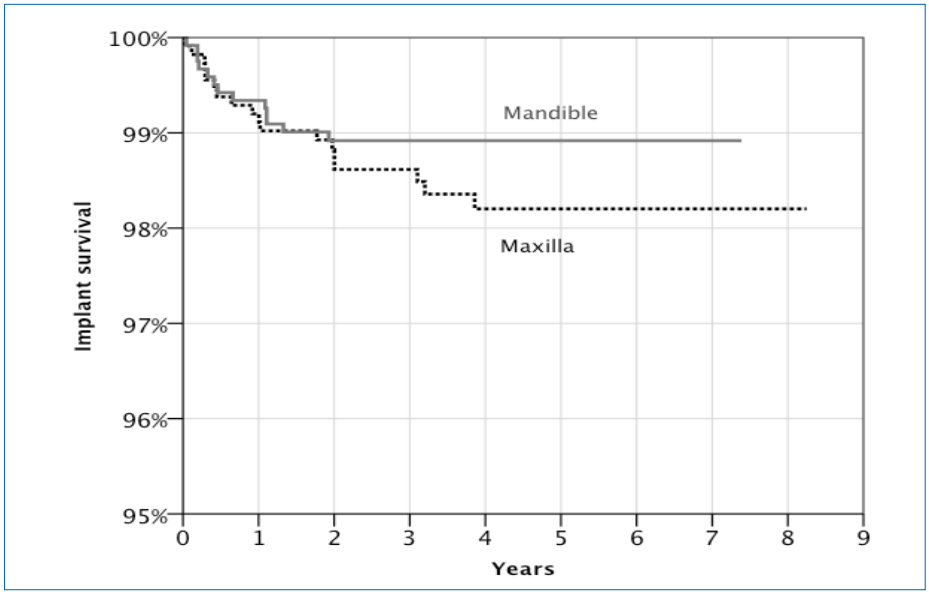

Figure 3. The implant survival was not significantly different between the upper and lower jaw

3. Results

3.1. Number of patients

Data of 819 patients, 420 women and 399 men were available. The mean age at the time of implant placement was 62.3 ± 11.6 years. 507 patients (62%) were > 60 years old. The observation time ranged from 1 to 8 years (mean 4.7 ± 1.8 years). Altogether 2337 implants were placed and 1133 related ISRs fabricated during the 6 years of implant placement. The average number of implants per patient was 2.9.

3.2. Number of implants

The distribution of the implants within the jaws was equal in the maxilla and mandible with exception of the canine FDI-positions 43 and 33 which was 6 times higher (Fig. 1).

Partially dentate patients received totally 948 implants (40.6%) compared to 1389 (59.4%) in the edentulous ones (Table 1).

The graduate students themselves placed 80% of the implants under guidance and supervision in the context of their education program. 10% of these implants were inserted in patients that were selected for the training in the undergraduate student course.

The remaining 20% of the implants were placed by the program director and instructors while the graduate-students took the role of the assistant nurse.

3.3. Number of reconstructions

The number of implants supporting fixed and removable ISR was 1053 (45.1%) and 1284 (54.9%), respectively.

The percentage distribution of implants per ISR exhibited 337/337 SCs (14.4%), 422/190 FDPs (18.1%), 294/54 IBs (12.6%), 374/198 RDPs (16.0%) and 910/354 Bar-IODs (38.9%) (Table 2). While the absolute and relative number of CAD/CAM fabricated removable ISR increased from 7% to 64%, the proportion of ZrO2-based fixed ISR varied between 15% and 55% without a clear trend during the observation time (Table 3).

3.4. Implant survival

Thirty-one implants were lost resulting in a cumulative survival rate (CSR) of 98.6% after 8 years. Twelve implants failed before loading while 19 implants were lost 1 to 4 years after loading (Table 4). Totally 12 implants in 8 patients were lost before functional loading. These patients were between 51 and 79 years old, all non-smokers and without significant general health problems. Eight (of 12) implants were located in the mandible (7 interforaminally, one at FDI position 36). One woman suffered from chronic osteoporosis that was treated with an oral bisphosphonate (Fosamax 10mg/day, MSD Merck Sharp & Dohme AG, Luzern, Switzerland) and showed no problems after replacement of the failed implant. Another female lost the first three interforaminally positioned implant and the second two implants, as well. She had no risk factors and was finally treated with a complete lower denture without implants.

Out of a total of 19 implants lost after functional loading 15 implants were located in the maxilla. Detailed information about the restorations and the patients are shown in Table 5. No statistically significant difference was observed for the survival rates between the prosthetic reconstructions (Table 2, Fig. 2). Further analysis revealed no difference comparing fixed vs. removable ISRs, implants with

Table 4. 19 late implants failures occurred in 16 patients after a loading time of 3 to 46 months. Implant removal (explantation) was performed in local anesthesia and a local disinfection was performed for 2 weeks

Patient	Gender	Age (Years)	General health status (Medication)	Implant type, diameter / length (mm)	Implant position (FDA)	GBA	SFE	Immediate implant placement	Immediate load	ISR	Months in situ
1	Male	64	Pneumonia 3 weeks after implant surgery	NRG, 10 / 4.3	12	Yes	No	No	No	Bar-IOD	3
			Complication: Periimplantitis (8 mm crestal bone loss distal and mesial, pus palatal), mild pain; Etiology: Periimplantitis, general risk factors? / Therapy: explantation, relining of IOD.								
2	Female	49	Smoker (25 pack years)	NRG, 13 / 3.5	34	Yes	No	No	Yes	SC	4
			Complication: slightly mobile cement-retained SC, no bone loss, no mucosal inflammation, no pus, no pain / Etiology: Overload while implant was loaded immediately? / Therapy: explantation and new implant after 5 months incl. GBR, new SC.								
3	Male	84	Nephritis, obstructive sleep apnea syndrome, tuberculosis (1944 – 1947), daily alcohol consumption, angina pectoris (2008)	NRG, 10 / 4.3	16	Yes	Yes	No	No	SC	5
			Complication: Periimplantitis (7 mm crestal bone loss distal and mesial, distal pus), no pain; Etiology: Periimplantitis, general risk factors? / Therapy: explantation.								
4	Female	58	Healthy	NRG, 13 / 4.3	36	Yes	No	Yes	No	SC	7
				NRG, 13 / 3.5	14	No	No	Yes	No	SC	21
			36: Complication: mobile SC / implant fracture 2mm apically of shoulder, no crestal bone loss, slight mucosal inflammation, no pus, no pain / Etiology: screw loosening, patient missed recal, i.e. was abroad > 1 year / Therapy: explantation and new implant immediately, new SC after osseointegration. 14: Complication: Periimplantitis (10 mm crestal bone loss distal, pus), occasional pain; Etiology: Periimplantitis / Therapy: explantation and new restoration 15-x.								
5	Female	50	Smoker (25 pack years), weekly cannabis consumption, status after tx of colon and uterus carcinoma, rheumatism, hepatitis C	NRG, 10 / 4.3	25	Yes	Yes	No	No	Bar-IOD	7
			Complication: Periimplantitis (8 mm crestal bone loss mesial and distal, pus), occasional pain; Etiology: Periimplantitis, general risk factors? / Therapy: explantation and bar shortened, relining of IOD								
6	Female	60	Smoker (40 pack years), chronic depression, osteoporosis	NRG, 13 / 4.3	15	Yes	Yes	No	No	SC	10
			Complication: Periimplantitis (7 mm crestal bone loss distal and mesial, pus), occasional pain; Etiology: Periimplantitis, general risk factors? / Therapy: explantation.								
7	Male	60	Smoker (25 pack years - stopped smoking before implant surgery)	NRG, 13 / 3.5	24	Yes	No	No	No	Ball abutment / IOD	11

			Complication: slightly mobile implant, circumferential 0.5mm bone loss, slight mucosal inflammation, no pus, no pain / Etiology: Overload? general risk factor? / Therapy: explantation and relining of RDP.								
8	Male	65	Hypertension	NRG, 13 / 3.5	23	Yes (autogenous bone)	No	No	No	Locator abutment / IOD	12
				NRG, 13 / 3.5	13	Yes (autogenous bone)	No	No	No	Locator abutment / IOD	12
			13: Complication: mobile locator / implant fracture 7mm apical to shoulder, no crestal bone loss, slight mucosal inflammation, no pus, no pain / Etiology: overload, bruxism? / Therapy: explantation, relining of IOD. 23: Complication: slightly mobile locator, circumferential 0.5mm bone loss, slight mucosal inflammation, no pus, no pain / Etiology: Overload, bruxism? / Therapy: explantation, relining of IOD.								
9	Male	65	Status after heart surgery	NRG, 13 / 4.3	46	Yes	No	No	No	FDP	13
			Complication: Periimplantitis (9 mm crestal bone loss distal and mesial, pus), no pain; Etiology: Periimplantitis / Therapy: explantation and shortening of cement-retained FDP 44-x .								
10	Male	42	Smoker 5 cigarettes/ day Chronic periodontitis	NRG, 13 / 4.3	35	No	No	No	No	SC	15
			Complication: Periimplantitis (6 mm crestal bone loss distal and mesial, pus), no pain; Etiology: Periimplantitis, local risk factors? / Therapy: explantation and new implant after 5 months incl. GBR, new SC.								
11	Male	53	Meliodisis, Diabetes type II, heart operation	NRG, 10 / 4.3	25	Yes	No	No	No	Bar-IOD	23
			Complication: IOD tooth fracture region 23, radiographic 5mm crestal bone loss mesial and distal, no inflammation, no pus, no pain / Etiology: Overload? / Therapy: explantation and new implant 3 months after removal, bar and IOD adaptation.								
12	Male	77	Chronic depression, Hypertension, Smoker (daily pipe smoker - stopped before implant surgery)	NRG, 10 / 4.3	16	Yes	Yes	No	No	FDP	24
				NRG, 13 / 3.5	14	Yes	No	No	No	FDP	24
			Complication: slightly mobile FDP 16x14, circumferential 0.5mm bone loss, no mucosal inflammation, no pus, no pain / Etiology: Overload? (depression and bruxism after colon-carcinoma surgery in 2010 / Therapy: explantation.								
13	Male	66	Healthy	NRG, 13 / 3.5	14	No	No	No	No	SC	32
			Complication: Periimplantitis (7 mm crestal bone loss distal and mesial, pus), occasional pain; Etiology: Periimplantitis / Therapy: explantation.								
14	Male	56	Chronic periodontitis, Smoker (30 pack years)	NRG, 10 / 4.3	14	No	Yes	No	No	SC	37
			Complication: Periimplantitis (6 mm crestal bone loss distal and mesial, pus), occasional pain; Etiology: Periimplantitis, local risk factor? / Therapy: explantation.								

15	Male	54	Smoker (40 pack years), daily alcohol consumption (one beer), angina pectoris, hypertension, reflux disease	NRG, 10 / 4.3	24	No	No	No	Yes	Bar-IOD	38
			Complication: at 1.5 year recall mild periimplantitis, at 3 years additional circumferential 0.5mm bone loss, mild mucosal inflammation, no pus, no pain / Etiology: Overload and periimplantitis / Therapy: explantation.								
16	Male	55	Smoker (36 pack years)	NRG, 13 / 3.5	24	Yes	No	No	No	Bar-IOD	46
			Complication: Periimplantitis (8 mm crestal bone loss distal and mesial, pus), occasional pain; Etiology: Periimplantitis, local risk factor? / Therapy: : explantation and bar shortened, relining of IOD.								

GBA: Guided Bone Augmentation, i.e. simultaneous buccal augmentation with Bio-Oss / particulated autogenous bone and Bio-Gide membrane (Geistlich, Wolhusen, Switzerland)
SFE: Sinus Floor Elevation
NRG: NobelReplace Tapered Groovy Implant (Nobel Biocare, Gothenburg, Sweden)
ISR: Implant supported reconstruction
SC: Single crown
FDP: short-span fixed dental prosthesis
IB: Full-arch FDP (Implant bridge)
RDP: Removable dental prosthesis
IOD: Implant-Overdenture

vs. without GBR or SFE, splinted vs. non-splinted ISRs and ISRs in the upper vs. lower jaw (Fig. 3).

4. Discussion

The aim of this retrospective study was to analyze frequency distribution of implant-supported prosthetic reconstructions and referred implant survival of implants placed from graduate students in a university training program. A broad variety of fixed and removable ISRs for partially and completely edentulous patients was identified. Although these data represent learning curves for graduate students working under supervision, implant survival was successful in a short-term range. The overall implant CSR of 98.6% after 8 years is comparable to other studies where implants where placed by novice operators that were supervised by experts during implant placement. In a recent study[22] the survival rate of 49 implants and referring SC that were placed and fabricated by undergraduate students was 94% after 10 years of loading. The authors concluded that it is acceptable to include implant therapy in the clinical undergraduate dental curriculum, provided the focus remains on straightforward cases with substantial supervision by trained dentists and oral and maxillofacial surgeons. This teaching situation is comparable to the setting in the present study.

However, the 5-year cumulative survival rate of the implants was considerably higher with 98.6%. A learning curve has to be considered but cannot be specified for the single students. Maxillary implants were slightly less successful, as it is often reported from clinical studies. Some specific treatment outcomes are also represented by various clinical studies performed during the same time period, based on the same study material[23-29]. Since the present data were collected within a prosthodontic department the number of edentulous jaws that were included in the data collection is relatively high. This is in contrast to a study performed in a department for oral surgery where the most frequent reconstruction performed was an implant supported SC[30]. This difference is also represented by the average number of implants per patient of 1.5 vs. 2.9 in the present study.

Another study investigated the 12-months clinical outcome of immediate implants placed by novice operators showing that the success rate was high and predictable provided there were routine school procedures and supervision from experienced surgeons[31]. The clinical studies available in the literature reporting on success rate of implants placed by graduate students include only a small number of implants. At the Prosthodontic Department of the University of Washington a number of 273 implants was observed during at least 5 years and showed a comparable survival rate of 96.3%[32].

At the University of Kentucky College of Dentistry a total of 415 patients with 963 implants were interviewed. The implant survival rate was 97%, and 88% of the implants were considered successful as determined by patient-centred criteria[33]. These results suggest that work standardization (in the form of specific treatment protocols) and the use of a formal, incremental learning system can result in positive patient outcomes. Clinical outcomes should be monitored in academic dental settings as part of the clinical process improvement, and these outcomes can provide a means of assessing the effectiveness of the training program.

So far little information was provided in the literature on the treatment outcomes of implant-placed prosthodontic graduate training curricula. As mentioned in the introduction many articles show clear trends that implant dentistry becomes integrated worldwide in the undergraduate training of dental students. Implant dentistry knowledge, however, is mostly a basic theoretical overview on implants. It appears that if the undergraduate students get in touch with implant dentistry they are more likely to incorporate implant treatment in their practice[34]. A small survey restricted to a local area revealed that particularly male general practitioners felt the need to obtain training in implant dentistry[35]. Today young dentists will meet patients who will ask for implant treatment[7] and who have already all kind of information on implants. In this respect, it seems important that in-depth knowledge is provided and the graduate students must achieve a good level of skills in well structured implant programs.

A recent survey conducted in the States revealed that today many postgraduate prosthodontic curricula allow students to perform implant surgery in their advanced education program[36]. The answers indicate that up to 50% of students judged their implant-surgery skills on a level of good competence while others felt the need of more training to reach a better level of competence. One study showed that even a short but intense and closely supervised training of 4 sessions 3 days each may significantly improve surgical skills and as a result also implant survival[37]. Postgraduate implant programs in University settings often underscore the multidisciplinary aspect of implant dentistry, as there are oral or maxillofacial surgery, prosthodontics and periodontology. With regard to implants, the specialty training programs subsequently focused on their own, specific knowledge and skills, and several specialists perform the implant treatment. Therefore, the comprehensive character of implant dentistry does not become sufficiently visible.

In general, the intent of oral surgery is the removal of a pathological process and treatment of dental or oral diseases. Although implant placement is a surgical procedure, as well, its result is not the pathology but the prosthetic rehabilitation after tooth loss. The implant itself is a tool used to enable, improve and perform prosthetic treatment. Thus, implant dentistry must be prosthetically centered and driven, with regard to analysis, planning and the final outcome. Already in the nineties some authors emphasized the importance of prosthodontics training with regard to implant therapy[1,2]. The chewing function, phonetics and esthetics are the crucial aspects oft implant treatment. The term „backward planning" was created and this should become the standard in any implant treatment, particularly for full mouth rehabilitation. Accordingly, a comprehensive prosthetic training including implant placement and implant restoration appears to be the most effective approach to a broad understanding of the potential and limitations in implant rehabilitation.

The data of the present study show that the students were involved in the whole broad, therapeutic spectrum of implant dentistry, including the surgical and prosthodontic part as well as maintenance care. Thus, they reached full competence level of grade A (advanced) for surgery and prosthetics, while level C (complex) can be practiced under close supervision, particularly with regard to the surgical techniques. At the end of the training curriculum it is expected that the students are able to properly judge their own knowledge and skills and to adhere to strict patient selection criteria. Furthermore, the use of CAD/CAM technology for implant supported fixed and removable reconstructions helped to standardize the fabrication workflow and minimize inaccuracies due to manual errors. As reported in another investigation, the specific analysis revealed a predictable outcome of the implant reconstructions with improvements for the digital workflow[38].

In the current competitive and fast developing market of implantology, which is often business driven, it becomes essential that high quality education and treatment is guaranteed. Therefore, theoretical knowledge and training of clinical skills must be an integral part of well-structured educational programs in comprehensive implant dentistry to reach the required competence and to maintain a high standard of care[39]. The majority of articles on implant curricula deal with undergraduate education while information on specialty training for young dentists and general practitioners is somehow confusing and less clear. If implant teaching in University curricula is described, a variety of terms are applied, such as: undergraduate, predoctoral, graduate, postgraduate or residency and specialty training, advanced education or master program. It appears that there is no consensus and common use of these terms - except with regard to undergraduate education, which would clearly address the degree of training and specify the level competence.

Furthermore, two universities recently reported on a predoctoral implant program where selected students placed a series of implants themselves. While the students highly benefited from this experience by improving their understanding of the connection between surgical implant placement and definitive prosthodontics reconstruction, their interest for a postgraduate implant program to improve theoretical and clinical skills became more intense[40].

The placement of implants by undergraduate students as part of an implant program would require significant efforts in theoretical education, pre-clinical laboratory training and clinical treatment. However, it has been demonstrated that this approach may result in acceptable clinical outcomes, patient satisfaction and positive student perception[41].

5. Conclusions

Within the limits of this retrospective study we conclude that a broad variety of fixed and removable implant supported prostheses for partially and completely edentulous patients was identified. Although these data represent learning curves for young graduate students working under supervision, implant survival was successful in a short-term range. Well-structured educational programs in comprehensive implant dentistry providing theoretical knowledge and clinical skills may enhance a high standard of maintenance care and a high treatment outcome quality in the current competitive market of implantology.

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CV

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Questions

The mean age of the patient seeking implants was

❑a. 30 years;
❑b. 40 years;
❑c. 60 years;
❑d. 80 years.

The cumulative survival rate (CSR) after 8 years of observation time was

❑a. 95.4 %;
❑b. 97.1 %;
❑c. 98.6 %;
❑d. 100 %.

Did the different prosthetic reconstructions have an influence on the implant failure rates ?

❑a. Yes, because an implant bridge had a significantly lower survival rate than single crowns (SC);
❑b. Yes, because removable suprastructues had a significantly lower failure rate than fixed suprastructures;
❑c. Yes, because SC had a significant higher failure rate than the other suprastructures;
❑d. No, there was no significant difference.

The implants inserted were positioned mainly

❑a. In the anterior maxilla;
❑b. In the anterior mandible;
❑c. In the posterior maxilla;
❑d. In the posterior mandible.