Implant Dentistry Curriculum in Undergraduate Education: Part 1—A Literature Review

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Purpose: The aim of this literature review was to evaluate to what extent oral implant dentistry was integrated into undergraduate educational programs worldwide. ***Materials and Methods:*** An online search of PubMed (MEDLINE and additional life science journals) was performed for articles published from 1966 to January 2010 using combinations of select medical subject headings. Additionally, the ISI Web of Knowledge database (MEDLINE: 1950 to present, Web of Science: 1945 to present) was searched using "education" and "implant" as search terms. The online search was supplemented with a manual search of dental journals in the fields of education, prosthodontics, and implant dentistry and of the reference lists of selected full-text articles. Surveys comparing different undergraduate dental implant curricula and articles describing the undergraduate dental implant curriculum of a single university were identified. Postgraduate or continuing education programs for dental practitioners or master and specialist programs were excluded. ***Results:*** Twenty-five articles met the inclusion criteria of this review. The percentage of universities that included implant dentistry in undergraduate education increased from 51% in 1974 to 97% in 2006 for universities in the United States and to 100% for surveyed European universities. All curricula included lectures (mostly 1 to 20 hours) and 30% to 42% included laboratory courses, but the level of clinical experience differed greatly between surveyed universities. ***Conclusion:*** Because oral implant dentistry has become a standard treatment alternative, the undergraduate dental curricula should include its application in treatment planning, observation of placing and restoring implants, and treating patients with implant-retained or -supported restorations. *Int J Prosthodont 2011;24:221–234.*

The impact of implants on the field of dentistry has been profound. The use of oral endosseous implants in the rehabilitation of partially and completely edentulous arches to provide support for fixed and removable prostheses is considered a predictable and successful treatment modality with favorable long-term survival rates.[1–3] In partially edentulous arches, implants are a valuable alternative to tooth-supported fixed partial dentures (FPDs), especially in situations with adjacent healthy or minimally filled teeth. The use of implants has the advantage of preserving healthy tooth structure and avoiding biologic complications (eg, loss of vitality, secondary caries, tooth fracture) because of the preparation of teeth as FPD abutments.[4,5] In free-end situations, implants can serve as a fixed alternative to otherwise fixed-removable tooth-supported prostheses or cantilevered FPDs. This avoids possible overloading of abutment teeth by long extensions.

Edentulous patients in particular may now have multiple treatment options, ranging from conventional complete dentures, implant-supported overdentures (with ball or bar attachments, telescopic crowns), FPDs, or full-arch FPDs supported by implants. With only two implants in edentulous jaws, the oral health–related quality of life of patients can be improved significantly compared to that with complete dentures.[6] Since implant placement is dependent on the amount of available bone width and height, implant treatment is either restricted to sites with appropriate bone dimensions or bone augmentative procedures need to be included in the treatment plan. To give the future

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general dental practitioner the capability of including implant dentistry in treatment plans, many universities in the United States,[7,8] Europe,[9,10] and the United Kingdom and Ireland[11,12] have integrated oral implant dentistry into their undergraduate teaching programs.

The aim of this study was to evaluate to what extent oral implant dentistry has been integrated into undergraduate programs of dental schools worldwide.

Materials and Methods

Surveys comparing different undergraduate dental implant curricula and articles describing the undergraduate dental implant curriculum of a single university were included. Articles describing postgraduate, dental practitioner, continuing education, master, or specialist programs were excluded. Articles about endosseous and osseointegrated implants were included, while articles on subperiosteal implants, "orthodontic" implants, and miniscrews were excluded. Exclusion criteria also included interviews, editorials, letters, articles only reporting on survival and success rates of implants and implant restorations placed in an undergraduate dental implant curriculum, studies of patient satisfaction after undergraduate treatment, and articles reporting redundant data.

Types of Outcome Measures

Outcome measures were as follows.

- Number of sent surveys and geographic area of universities; response rate to questionnaires
- Statement of implementation of dental implant programs in undergraduate education
- Description of teaching format: lecture, symposium, or seminar (eg, problem-based learning); preclinical laboratory component (model, phantom head/mannequin); and level of clinical experience in implant dentistry
- Number of lecturing or teaching hours in implant curriculum
- Year(s) in which dental implant curriculum was implemented in overall dentistry studies
- University departments involved in teaching undergraduate dental implant curriculum
- Type of prosthetic restorations performed by undergraduate students on implants
- Implant systems used in undergraduate implant education
- Type of support by implant companies for undergraduate implant programs

Search Methodology

The PubMed database was searched for terms relating to education in dentistry and implant dentistry using medical subject headings (MeSH). The online search of the PubMed electronic library was performed for studies published between 1966 and January 2010 using the following MeSH terms: "dental implants" AND "education, dental," "dental implants" AND "students, dental," "dental implants" AND "schools, dental," "education, dental" AND "dental implantation," "education, dental" AND "dental implantation, endosseous," "dental implantation" AND "students, dental," "dental implantation" AND "schools, dental," "dental implantation, endosseous" AND "students, dental," and "dental implantation, endosseous" AND "schools, dental." Additionally, the ISI Web of Knowledge database (MEDLINE: 1950 to present, Web of Science: 1945 to present) was searched using "education" and "implant" as search terms.

The database search was supplemented with a manual search of the electronic archives of the following journals: *European Journal of Dental Education, Journal of Dental Education, British Dental Journal, Clinical Oral Implants Research, Implant Dentistry, International Journal of Oral Implantology, International Journal of Oral and Maxillofacial Implants, International Journal of Prosthodontics, Journal of Prosthetic Dentistry, Journal of Prosthodontics, Journal of the American Dental Association, Journal of the California Dental Association, Journal of Dentistry, Journal of Oral Implantology, Journal of Oral and Maxillofacial Surgery, Journal of Oral Rehabilitation, Schweizer Monatsschrift Zahnmedizin,* and *Deutsche Zahnaerztliche Zeitschrift.* In addition, a manual search of the reference lists of the selected full-text articles was conducted.

Study Selection

The titles and abstracts (if available) of all identified articles in the electronic and hand search were screened by the first author. Redundant or duplicate articles and articles not related to the topic, according to the exclusion criteria, were removed. For studies appearing to meet the inclusion criteria or for which there were insufficient data in the title and abstract to make a clear decision, the full-text articles were obtained.

All remaining articles were reviewed and whether the article met the inclusion criteria was assessed. All studies meeting the inclusion criteria underwent data extraction. Articles rejected at this stage were recorded, as well as the reason for exclusion (Table 1).

Table 1 List of Excluded Full-Text Articles

Study	Reason for exclusion
"Curriculum guidelines in implant dentistry . . ."[13]	Not undergraduate education
"Curriculum guidelines for predoctoral implant dentistry"[14]	No information on curriculum structure, only core contents and behavioral objectives
Adeyemo et al[15]	Review
Appleby[16]	Editorial
Bell et al[17]	Redundant data (Bell and Hendricson[62])
Buchanan[18]	Not topic-related
Carrotte et al[19]	Conference abstracts, not topic-related
Cole and Thomas[20]	Not topic-related
Cranin[21]	Not undergraduate education, program description of postgraduate dental implant fellowship
Cranin[22]	Not topic-related
Cummings and Arbree[23]	Implant and prosthetic outcomes
Fein[24]	Letter to editor
Goldhaber[25]	Not topic-related
Goodacre[26]	Not topic-related
Henry and Klineberg[27]	Insufficient data
Hsu[28]	Not topic-related
Huebner[29]	Not topic-related
Ismail[30]	No information on curriculum structure, only core contents and behavioral objectives
Landesman[31]	Opinion, short communication
Maalhagh-Fard et al[32]	Redundant data (Maalhagh-Fard and Nimmo[60])
McCracken et al[33]	Not topic-related
Meijer et al[34]	Not topic-related
Misch[35]	Not topic-related
Misch[36]	Editorial comment
Moore and Dexter[37]	Not topic-related
Ong et al[38]	Not topic-related
Schnitman[39]	Not topic-related
Schuhbeck et al[40]	Not topic-related
Simons and Badr[41]	No information on curriculum structure, only core contents and behavioral objectives
Steflik et al[42]	Review
Steflik et al[43]	Not topic-related, interactive computer program (textbook and simulated patient treatment)
Steflik et al[44]	Not topic-related, interactive computer program (textbook and computer-assisted instruction)
Steflik et al[45]	Not topic-related, interactive computer program (textbook and computer-assisted instruction)
Stoler[46]	Not undergraduate education
Vasak et al[47]	Not undergraduate education

Data Extraction and Synthesis

Data were extracted in data extraction forms if they met the inclusion criteria. Because of the different reporting formats, not all information for each criterion could be obtained from all articles.

Descriptive analysis of the available data was calculated with frequencies. The statistical unit was the number of universities responding to the survey and teaching implant dentistry. Added frequencies may exceed 100% because of multiple-answer options to questions or rounding errors.

Table 2 Surveys Reporting on Undergraduate Dental Implant Curricula (Group A): Teaching Formats and Level of Clinical Experience in Implant Dentistry

Study	Country	Type of Study	No. of sent questionnaires	No. of responding universities	No teaching of implant dentistry	Teaching implant dentistry	Lecture
De Bruyn et al[10]	Europe (18 countries)	Survey	73	49 (67%)	0	43 (100%)	43 (100%)
Addy et al[12]	GB, Ireland	Survey	15	15 (100%)	2 (13%)	13 (87%)	9 (69%)
Blum et al[48]	GB/UK	Survey	13	13 (100%)	0	13 (100%)	13 (100%)
Petropoulos et al[49]	USA, Canada	Survey	56	39 (70%)	1 (3%)	38 (97%)	NR
Afsharzand et al[9]	Europe (23 countries)	Survey	56	40 (71%)	10 (25%)	30 (75%)	30 (100%)
Lim et al[50]	USA	Survey	54	38 (70%)	6 (16%)	32 (84%)	32 (100%)
Young et al[51]	UK, Ireland	Survey	16	16 (100%)	0	16 (100%)	16 (100%)
Seckinger et al[52]	not USA	Survey	51	44 (86%)	20 (45%)	24 (55%)	24 (100%)
Weintraub et al[53]	USA	Survey	54	50 (93%)	7 (14%)	43 (86%)	43 (100%)
Watson[11]	UK, Ireland	Survey	18	17 (94%)	1 (6%)	16 (94%)	12 (75%)
Arbree and Chapman[8]	USA, Canada	Survey	68	52 (77%)	18 (35%)	34 (65%)	35%
Bavitz[7]	USA	Survey	59	44 (75%)	NR	NR	73%
Gowgiel[54]	USA	Survey	59	50 (85%)	19 (38%)	31 (62%)	14 (45%)
Chappell[55]	USA, Canada, Puerto Rico	Survey	61	61 (100%)	30 (49%)	31 (51%)	NR

NR = not reported.

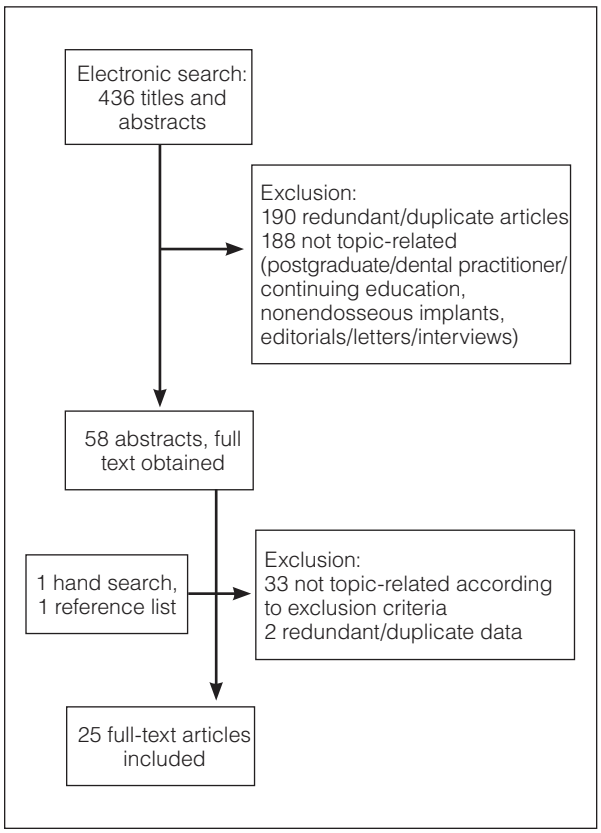

Fig 1 Schematic representation of the literature search and article selection.

Results

The initial electronic search from 1966 to January 2010 identified 436 titles. The screening and evaluation of these titles and abstracts led to 58 included abstracts (190 titles were redundant and 188 titles were excluded because they either focused on postgraduate or dental practitioner education, related to nonendosseous implants, or were identified as editorials or letters) (Fig 1).

The manual search yielded one additional article in the *European Journal of Dental Education,* and one additional article was found in the reference lists of identified full-text articles.

After full-text analyses, 33 articles were excluded according to the exclusion criteria, and two articles were excluded because of redundant data (Table 1). A total of 25 articles remained for data extraction. Relevant articles were grouped into group A (surveys reporting on undergraduate implant education at different universities)[7–12,48–55] and group B (descriptions of undergraduate educational implant dentistry programs at single universities).[56–66] Several authors sent questionnaires to universities for the evaluation of undergraduate dental implant education in the United States and Canada, Europe, Great Britain, and Ireland. The response rates of the universities were between 67% and 100% (Table 2).

Type of teaching/teaching format			Level of clinical experience in implant dentistry					
Symposium/ seminar	Laboratory/ model/ phantom head	Patient treatment	No clinical experience	Treatment planning	Observation of restoring implants	Restoration of implants	Observation of implant surgery	Placement of implants
NR	12 (30%)	15 (35%)	13 (30%)	NR	17 (40%)	15 (35%)	17 (40%)	2 (5%)
5 (38%)	8 (62%)	4 (31%)	NR	7 (54%)	7 (54%)	4 (31%)	5 (38%)	1 (8%)
NR	2 (15%)	9 (69%)	2 (15%)	NR	7 (54%)	4 (31%)	9 (69%)	NR
NR	NR	30 (86%)	NR	NR	NR	30 (86%)	26 (84%)	26 (74%)
NR	11 (37%)	11 (37%)	NR	NR	NR	11 (37%)	19 (63%)	NR
NR	25 (78%)	Yes	NR	NR	NR	28 (88%)	19 (59%)	2 (6%)
NR	NR	4 (25%)	NR	NR	15 (84%)	4 (25%)	15 (94%)	0
NR	9 (38%)	NR	NR	NR	8 (33%)	3 (13%)	9 (38%)	1 (4%)
NR	18 (42%)	Yes	NR	NR	26 (60%)	18 (42%)	24 (56%)	3 (7%)
6 (38%)	NR	6 (38%)	NR	NR	6 (38%)	NR	6 (38%)	NR
8%	NR	7%	NR	NR	16%	9%	6%	NR
NR	NR	11%, 2%	NR	NR	NR	11%	NR	2%
NR	NR	NR	NR	NR	NR	NR	NR	NR
NR	NR	NR	NR	NR	NR	8 (26%)	1 (3%)	2 (6%)

Publications through 1995 showed that a lower percentage of universities had incorporated implant dentistry education in their curricula[8,11,52,53] than surveys that were published between 1999 and 2009.[48,50] Those who implemented an implant dentistry curriculum preferred to use the lecture format for teaching. In the surveys, a relatively high percentage of universities also state that they had laboratory courses with hands-on exercises using models (15%[48] to 78%[50]) and that students perform the restoration of implants (9%[8] to 88%[50]) or even implant surgery (2%[7] to 74%[49]). But in many implant programs, this holds true for only a small percentage of students. The implant curriculum is often split into lectures for all participating students and a selective component for approximately 10 students (Table 3). The selected students receive intense preparation with seminars (eg, problem-based learning, hands-on in the laboratory, clinic rotations with observation of restoring and placing implants) before they perform the restoration and placement of implants themselves.[60,62,63]

The amount of lecture hours devoted to implant dentistry varied by region (Tables 4 and 5). Blum et al[48] reported 1 to 10 lecture hours in 85% of British and Irish universities and 11 to 20 hours in 15% of universities. The surveys from the United States and Canada reported 1 to 10 lecture hours in 74% of the universities and 11 to 20 hours in 21% of the universities in 1991,[8] and in 2005, shifted toward 11 to 20 hours (57% of universities) and 21 to 30 hours (22% of universities).[50] The 2005 European survey[9] found similar distributions: 11 to 20 hours in 30% of universities, 21 to 30 hours in 23% of universities, and 31 to 40 hours in 10% of universities.

Most dental schools offer a predoctoral implant course in the fourth or fifth year.[9,12,48] In universities in the United States, the implant curriculum predominantly occurs in the third and fourth years (Tables 6 and 7).[56,60,61,63]

In most dental schools, teaching the undergraduate implant curriculum is a team effort, consisting of multiple university departments (prosthodontics, oral surgery, and periodontics) (Tables 8 and 9).

When students performed implant restorations, the most common prosthetic implant treatment was a single crown, followed by mandibular overdentures on two implants and small-unit FPDs (Tables 10 and 11).

Universities mostly use implants and components of well-known implant companies (eg, Nobel Biocare, Straumann, Astra, Dentsply Friadent, Sterioss, Biomet 3i, IMZ) (Tables 12 and 13), and many undergraduate implant curricula are supported financially by implant companies who provide the implants and prosthetic components (Tables 14 and 15).

Table 3 University Undergraduate Implant Dentistry Programs at One Institution (Group B): Teaching Formats and Level of Clinical Experience in Implant Dentistry

		Type of teaching/teaching format			
Study	University	Lecture	Symposium/seminar	Laboratory/model/ phantom head	Patient treatment
Kido et al[57]	Fukuoka Dental College, Japan	NR	NR	Yes (2 days)	NR
Jahangiri and Choi[56]	New York University, USA	Yes	NR	Yes	Yes
Kronstrom et al[59]	Dalhousie University, Halifax, Canada	NR	NR	NR	Yes
Maalhagh-Fard and Nimmo[60]	University of Detroit, USA	Yes (100% of students)	Yes (14% of students)	Yes (14% of students)	Yes (14% of students)
Klokkevold[58]	University of California Los Angeles, USA	Yes (30 h)	NR	Yes (4 h)	Yes
Mitchell[61]	University of Oklahoma, USA	NR	NR	Yes (45 h)	Yes
Wilcox et al[64]	Creighton University, USA	Yes (30 h)	NR	Yes (8 h)	Yes
Simons et al[63]	University of Texas, USA	Yes	Yes	Yes	Yes
	Universtiy of Washington, USA	Yes	Yes	Yes	Yes (12 students)
	Ohio State University, USA	Yes	NR	NR	Yes
Bell and Hendricson[62]	University of Texas, USA	Yes (8 h)	Yes (10 students: PBL, 36 h, + 12 h seminars)	Yes (3 h)	Yes (10 students, 90 h)
Richards[65]	Temple University, USA	Yes (13 h)	NR	Yes	NR
James[66]	Loma Linda University, USA	Yes (2 h all students, 8 h 15 students)	NR	Yes (18 h for 15 students)	Yes

NR = not reported.

Table 4 Group A: Lecture Hours

	No. of teaching/lecture hours					
Study	1–10	11–20	21–30	31–40	41–50	> 50
Blum et al[48]	11 (85%)	2 (15%)	0	0	0	0
Afsharzand et al[9]	9 (30%)	9 (30%)	7 (23%)	3 (10%)	1 (3%)	1 (3%)
Lim et al[50]	3 (9%)	18 (57%)	7 (22%)	2 (6%)	1 (3%)	1 (3%)
Watson[11]	12 (75%)					
Arbree and Chapman[8]	74%	21%	3%	NR	NR	NR

NR = not reported.

Discussion

In dental education, the aim has been to prepare young dentists for practice upon graduation. With an increasing range of knowledge and skills over the past decades, this has led to overcrowded undergraduate dental curricula. In different countries, educational guidelines have been developed, such as those of the Association for Dental Education in Europe,[67] the United Kingdom General Dental Council, and the American Association of Dental Schools,[13,14] and they state that students should have the knowledge

Level of clinical experience in implant dentistry					
No clinical experience	Treatment planning	Observation of restoring implants	Restoration of implants	Observation of implant surgery	Placement of implants
NR	NR	Yes (30 days)	No	NR	No
No	100%	NR	91.80%	NR	NR
No	Yes	NR	Yes	Yes	No
62 (86%)	10 (14%)	10 (14%)	10 (14%)	10 (14%)	0 (0%)
No	Yes	NR	Yes	Yes	No
NR	NR	Yes (1 week)	Yes	Yes	No
No	Yes	Yes	Yes	Yes	Yes
Majority of students	20-25 students	NR	20-25 students	NR	10 students
Majority of students	All students	NR	12 students	12 students	No
No	Yes	Yes	10 students	10 students	No
Majority of students	Yes	NR	Yes (10 students)	NR	Yes (10 students)
NR	NR	NR	NR	NR	NR
NR	NR	NR	NR	Yes (15 students)	Yes (selected students)

Table 5 Group B: Lecture Hours

	No. of teaching/lecture hours					
Study	1–10 h	11–20	21–30	31–40	41–50	> 50
Maalhagh-Fard and Nimmo[60]			Seminar			
Klokkevold[58]				Yes		
Wilcox et al[64]			Yes			
Simons et al[63]						
University of Texas, USA		Yes				
Ohio State University, USA	Yes		Yes in elective program			
Richards[65]		Yes				
James[66]	Yes					

Table 6 Group A: Year in Which Implant Curriculum is Taught

	Year taught						
Study	1st	2nd	3rd	4th	5th	6th	Multiple years
Addy et al[12]	No	No	6 (46%)	"Most"	"Most"	NR	NR
Blum et al[48]	NR	1 (8%)	3 (23%)	13 (100%)	13 (100%)	NR	Yes
Afsharzand et al[9]	0	0	2 (6%)	11 (37%)	6 (20%)	1 (3%)	10 (33%)
Seckinger et al[52]	1 (4%)	2 (8%)	7 (33%)	21 (85%)	3 (14%)	NR	Yes
Watson[11]	6 (12%)	15 (30%)	32 (64%)	27 (54%)	NR	NR	NR

NR = not reported.

Table 7 Group B: Year in Which Implant Curriculum is Taught

	Year taught						
Study	1st	2nd	3rd	4th	5th	6th	Multiple years
Kido et al[57]					Yes		
Jahangiri and Choi[56]	Yes (integrated in anatomy, histology)	Yes (28-h simulation course, 6 hs of lectures)	Yes (clinical)	Yes (clinical)			Yes
Maalhagh-Fard and Nimmo[60]	No	No	Yes	Yes			Yes
Mitchell[61]			Yes	Yes			Yes
Wilcox et al[64]		Yes	Yes	Yes			Yes
Simons et al[63]							
University of Texas, USA		Yes	Yes	Yes			Yes
University of Washington, USA			Yes	Yes			Yes
Ohio State University, USA		Yes	Yes	Yes			Yes
Bell and Hendricson[62]				6-week course for 10 students in summer break, no other courses at the same time			
James[66]	Yes		Yes	Yes			Yes

of how missing teeth should be replaced, choosing between the alternatives of no replacement, FPDs, removable dentures, or implants. Since implants have become a more accepted treatment alternative, this review could show an increase in the percentage of universities that included teaching implant dentistry in their undergraduate curricula.[10,49,55] But just as dental curricula differ from one university to another, great diversity among undergraduate implant curricula also can be found. Although almost 100% of the implant curricula of the surveyed universities involved a series of lectures, the overall number of lecturing hours differed, with most surveys reporting 1 to 20 hours of lectures in the majority of curricula[8,9,48,50] and only few teaching more than 20 hours.[8,9,50] This reflects the predominant view that undergraduate students should only receive a basic theoretic overview of implant dentistry, also stated in the curriculum guidelines,[14] and practical experience in the field of implant dentistry, such as "hands-on" courses on models or cadavers, treatment planning, restoration or placement of implants in actual patients, is not recommended.

Despite this lack of a guidelines requirement, this review revealed the effort of many universities to include clinical experience in implant dentistry in their teaching.[64] The implementation of teaching formats such as laboratory hands-on courses on plastic models or phantom heads was found in 30% to 42% of universities[9,10,52,53]; two surveys reported a higher percentage of 62%[12] and 78%.[50] A high percentage of universities also give their students the opportunity to observe implant surgeries and the prosthetic restoration of implants. If students were allowed to treat implant patients, it mostly referred to the restoration of previously placed implants and seldom the actual placement of implants. The analysis of the reports on specific implant programs also revealed that restoring or placing implants is in most curricula only performed by a select group of students from the entire semester.[60,62,63] The majority of students only received lectures or seminars. But some universities have also incorporated more modern teaching concepts such as problem-based learning in the didactic component.[60,62] When analyzing the types of restorations on implants performed by undergraduate students, it becomes obvious that students usually are assigned to treat straightforward noncomplex cases such as mandibular overdentures on two implants and one- to four-unit FPDs.[10,49,50]

In most universities, the implant curriculum is taught over several years of the students' university studies, with an emphasis in the junior and senior years.[11,48,56,63] This coincides with the more complex and interdisciplinary nature of treatment planning and treatment in implant dentistry, which requires at least a basic knowledge of diagnostics, oral pathology, anesthesia, restorative dentistry, prosthodontics, periodontics, and oral surgery.

In the majority of universities, teaching the implant curricula is a multidisciplinary effort involving mainly the prosthodontics, periodontics, and oral surgery departments.[9,49,59–61,64] In the didactic component, the prosthodontic faculty often covers case selection, treatment planning, and restoration of implants; the topics of surgical implant placement and uncovering and bone grafting are presented by the faculty of oral and maxillofacial surgery; the maintenance of implants, soft tissue management, and treatment of ailing implants are covered by faculty from the department of periodontology.[60,64]

Because dental curricula aim to prepare dentists for practice, it can be critically asked what effect the teaching of oral implant dentistry in undergraduate programs has on the application in dental practice. Huebner[29] compared dentists who had graduated from a university with a structured implant educational program with dentists who had no undergraduate implant training. More than twice as many dentists with an undergraduate implant experience restored implants in their general practice (56%) in comparison to the control group (23%). The former also surgically placed more implants (14% vs 3%) and referred a greater number of patients to surgical specialists. Maalhagh-Fard et al[32] found that participation in elective undergraduate implant courses was weakly positively correlated with offering implants and surgically placing implants in private practice. Participants were also more likely to restore implants in professional practice and less likely to refer implant patients to another practitioner.

Dental schools report funding issues (73%), lack of available time within existing teaching curricula (46%), and insufficient numbers of suitably trained staff available for teaching (33%) as their current challenges to developing a teaching program in implant dentistry for undergraduate students.[12] According to Seckinger et al[52] and Weintraub et al,[53] the most frequently cited reasons for not implementing implant dentistry in undergraduate education were: insufficient curriculum time, the belief that implant dentistry did not belong in a predoctoral curriculum, lack of financial resources, lack of qualified faculty, and the belief that implants should be taught at an advanced educational level. Similar findings were stated by Petropoulos et al,[49] who ranked challenges to providing students with clinical implant experience as not enough trained faculty, cost of implants to patients, lack of time, not enough patients with a need for implants, lack of interest/acceptance of implants by faculty, and cost of implants to the school. Many universities state the importance of support by implant companies with free components or other funding to be able to finance undergraduate implant educational programs. Petropoulos et al[49] reported that 85% of universities teaching undergraduate implant curricula in the United States receive free implants, whereas only 33% of British and Irish universities are provided with free implants: 20% receive restorative components and 46% receive simulation models for the implant curricula.[12] In the 1990s, implant systems from Nobel Biocare, Friadent, IMZ, Integral/Calcitec, and ITI/Straumann were used predominantly in education.[7,8,52,53] Surveys from 2005 and 2008[9,12,48,50] revealed that most universities used the Nobel Biocare implant system, followed by ITI/Straumann, Astra, Dentsply Friadent, Steri-Oss, Biomet 3i, and Paragon. Some universities restrict themselves to one implant system because of easier inventory and to facilitate maintenance, limiting diversity of components,[60] while other universities use different systems because different departments and sponsors are involved.

Table 8 Group A: Departments Involved in Teaching Implant Curriculum

	Taught by (department)				
Study	Rest	Prosth	Perio	OS	Prosth + OS
Addy et al[12]	5 (38%)	5 (38%)	NR	NR	1 (8%)
Blum et al[48]	2 (15%)	3 (23%)	0	0	0
Petropoulos et al[49]	4 (11%)	7 (20%) implant surgery, 33 (94%) implant prosth	27 (77%)	25 (71%)	NR
Afsharzand et al[9]	2 (7%)	5 (17%)	1 (3%)	5 (17%)	8 (27%)
Lim et al[50]	12 (38%)	10 (32%)	1 (3%)	1 (3%)	1 (3%)
Young et al[51]	16 (100%)	4 (25%)	4 (25%)	7 (44%)	NR
Seckinger et al[52]	5 (21%)	15 (62%)	8 (33%)	15 (62%)	NR
Weintraub et al[53]	18 (42%)	25 fixed + 23 removable prostth	29 (67%)	30 (70%)	NR
Watson[11]	6 (35%)	17 (100%)	7 (41%)	11 (65%)	NR
Arbree and Chapman[8]	NR	59% removable + 29% fixed prosth	9%	50%	NR
Chappell[55]	NR	28 (90%)	10 (32%)	25 (81%)	NR

NR = not reported; Rest = restorative dentistry; Prosth = prosthodontics; Perio = periodontics; OS = oral surgery.

Table 9 Group B: Departments Involved in Teaching Implant Curriculum

	Taught by (department)				
Study	Rest	Prosth	Perio	OS	Prosth + OS
Kronstrom et al[59]					
Maalhagh-Fard and Nimmo[60]					
Klokke-vold [58]		Primarily			
Mitchell[61]		Yes	Yes	Yes	
Wilcox et al[64]		Yes	Yes	Yes	
Simons et al[63] University of Texas, USA University of Washington, USA	Yes	Yes			
Richards[65]			Yes		
James[66]	Yes			Yes	

Rest = restorative dentistry; Prosth = prosthodontics; Perio = periodontics; OS = oral surgery.

Table 10 Group A: Types of Restorations on Implants Performed by Undergraduate Students

Study	Overdenture two implants: ball, Locator attachment	Overdenture two implants: bar attachment	Overdenture > 2 implants: bar/telescopic crowns
De Bruyn et al[10]	10 (23%)	4 (9%)	NR
Petropoulos et al[49]	25 (83%)	5 (17%)	NR
Lim et al[50]	NR	17 (53%)	7 (22%)
Arbree and Chapman[8]	18%	NR	NR

FPD = fixed partial denture; NR = not reported.

Table 11 Group B: Types of Restorations on Implants Performed by Undergraduate Students

Study	Overdenture two implants: ball, Locator attachment	Overdenture two implants: bar attachment	Overdenture > 2 implants: bar/telescopic crowns
Jahangiri and Choi[56]	Yes	NR	NR
Kronstrom et al[59]	No	Yes (32%)	NR
Maalhagh-Fard and Nimm[60]	Yes	Yes	NR
Klokkevold [58]	NR	Yes	NR
Mitchell[61]	Yes	NR	NR
Wilcox et al[64]	Yes	Yes	NR
Bell and Hendricson[62]	NR	Yes	NR

FPD = fixed partial denture; NR = not reported.

Taught by (department)						
Perio + prosth	Perio + OS	Rest + OS	Perio + prosth + OS	Rest + perio + OS	Rest + prosth + OS	Rest + prosth + perio + OS
4 (31%)	NR	8 (61%)	NR	NR	NR	NR
0	0	3 (23%)	1 (8%)	1 (8%)	1 (8%)	2 (15%)
NR	NR	NR	NR	NR	NR	NR
1 (3%)	1 (3%)	0	6 (20%)	NR	NR	1 (3%)
2 (6%)	0	0	3 (9%)	0	0	1 (3%)
NR	NR	NR	NR	NR	NR	NR
NR	NR	NR	NR	NR	NR	NR
NR	NR	NR	NR	NR	NR	NR
NR	NR	NR	NR	NR	NR	NR
NR	NR	NR	NR	NR	NR	NR
NR	NR	NR	NR	NR	NR	NR

Taught by (department)						
Perio + prosth	Perio + OS	Rest + OS	Perio prosth + OS	Rest + perio + OS	Rest + prosth + OS	Rest + prosth + perio + OS
			Yes			
			Yes			
						Yes
			Yes			

FPD: single crown	FPD: 2- to 4-unit	FPD: full arch
14 (33%)	7 (16%)	0
27 (90%)	10 (33%)	NR
25 (78%)	17 (53%)	NR
15%	NR	NR

FPD: single crown	FPD: 2- to 4-unit	FPD: full arch
Yes	NR	NR
Yes (61%)	Yes (7%)	NR
Yes	Yes	Yes
Yes	Yes	NR
Yes	Yes	NR
Yes	Yes	NR
Yes	NR	NR

Table 12 Group A: Implant Systems Used in Undergraduate Education

	No. of dental schools using implant systems in undergraduate programs			
Study	Nobel Biocare	ITI, Straumann	Astra	Dentsply Friadent, Corevent
Addy et al[12]	7 (54%)	4 (31%)	2 (15%)	2 (15%)
Blum et al[48]	9 (69%)	6 (46%)	5 (38%)	3 (23%)
Afsharzand et al[9]	15%	19%		
Lim et al[50]	11 (34%)	9 (28%)		2 (6%)
Seckinger et al[52]	9 (38%)	4 (17%)	1 (4%)	1 (4%)
Weintraub et al[53]	30 (70%)	12 (28%)		12 (28%)
Watson[11]	12 (75%)	7 (44%)	3 (19%)	3 (19%)
Arbree and Chapman[8]	18%			9%
Bavitz[7]	66%			45%

Table 13 Group B: Implant Systems Used in Undergraduate Education

	Implant companies supporting undergraduate programs			
Study	Nobel Biocare	Life Core, Biomedical	Integral, Calcitec	GC
Kido et al[57]	Yes			Yes
Jahangiri and Choi[56]	Yes			
Kronstrom et al[59]	Yes			
Maalhagh-Fard and Nimmo[60]	Yes			
Wilcox et al[64]		Yes		
Bell and Hendricson[62]			Yes	

Table 14 Group A: Type of Support by Implant Companies

	Type of support by implant companies:				
Study	Provision of simulated models (surgical/restorative)	Provision of implants	Provision of restorative components	Laboratory funding support	Funding for clinical staff
Addy et al[12]	7 (46%)	5 (33%)	3 (20%)	2 (13%)	1 (7%)
Petropoulos et al[49]	NR	29 (85%)	NR	NR	NR

NR = not reported

Table 15 Group B: Type of Support by Implant Companies

	Type of support by implant companies				
Study	Provision of simulated models (surgical/restorative)	Provision of implants	Provision of restorative components	Laboratory funding support	Funding for clinical staff
Jahangiri and Choi[56]	Yes	NR	NR	NR	NR
Maalhagh-Fard and Nimmo[60]	NR	Yes	NR	NR	NR
Bell and Hendricson[62]	NR	Yes	Yes	NR	NR

NR = not reported.

No. of dental schools using implant systems in undergraduate programs						
Steri-Oss	Biomet 3i	Paragon	Life Core, Biomedical	Imtec	Integral, Calcitec	IMZ Interpore
	1 (8%)					
1 (8%)	1 (8%)					
12 (38%)	9 (28%)	8 (25%)	1 (3%)	1 (3%)	1 (3%)	
1 (4%)						2 (8%)
7 (16%)	1 (2%)				15 (35%)	9 (21%)
					2 (13%)	4 (25%)
						3%
					25%	34%

Conclusions

Because oral implant dentistry has become a standard treatment alternative for partially or completely edentulous patients, undergraduate dental curricula should include its application in treatment planning, observation of placing and restoring implants, and treating patients with implant-retained or -supported restorations.

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