ACP AMERICAN COLLEGE OF PROSTHODONTISTS
Your smile. Our specialty.℠

Assessment of Occlusion Curriculum in Predoctoral Dental Education: Report from ACP Task Force on Occlusion Education

Damian J. Lee, DDS, MS,[1] Jonathan P. Wiens, DDS, MSD,[2] John Ference, DDS, MS, MPH,[3] David Donatelli, DDS,[4] Rick M. Smith, DDS, MS,[5] Bryan D. Dye, DDS, MS,[6] Ales Obrez, DMD, PhD,[7] & Lisa A. Lang, DDS, MS[8]

[1]Assistant Professor, Department of Restorative Dentistry, University of Illinois at Chicago College of Dentistry, Chicago, IL
[2]Clinical Professor, University of Detroit-Mercy School of Dentistry, Detroit, MI
[3]Assistant Professor and Clinical Director of Undergraduate Prosthodontics, Department of Prosthodontics, University of Pittsburgh School of Dental Medicine, Pittsburgh, PA
[4]Assistant Professor, Undergraduate Removable Prosthodontics, Department of Restorative Dentistry, Temple University Kornberg School of Dentistry, Philadelphia, PA
[5]Associate Professor of Prosthodontics, Department of Prosthodontics, Arizona School of Dentistry & Oral Health, Mesa, AZ
[6]Assistant Professor and Interim Chair, Department of Restorative Dentistry, West Virginia University School of Dentistry, Morgantown, WV
[7]Associate Professor, Department of Restorative Dentistry, University of Illinois at Chicago College of Dentistry, Chicago, IL
[8]Associate Professor and Chair, Department of Comprehensive Care, Case Western Reserve University School of Dental Medicine, Cleveland, OH

Keywords
Predoctoral prosthodontics curriculum; dental education assessment; competency.

Correspondence
Jonathan P. Wiens, 6177 Orchard Lake Rd., West Bloomfield, MI 48322. E-mail: jonatwiens@comcast.net

The authors deny any conflicts of interest.

This report was supported by the American College of Prosthodontists (ACP).

Previously presented at the ACP Joint Educator's Conference, Rosemont, IL, in 2010 and at the ACP's 40th Annual Session, Orlando, FL, in 2010.

Accepted January 22, 2012

doi: 10.1111/j.1532-849X.2012.00876.x

Abstract

Purpose: The purposes of this report were to (1) assess the current occlusion curriculum in the predoctoral prosthodontic education of US dental institutions and (2) to examine the opinions of faculty, course directors, and program directors on the contents of occlusion curriculum.

Materials and Methods: The Task Force on Occlusion Education from the American College of Prosthodontists (ACP) conducted two surveys using a web-based survey engine: one to assess the current status of occlusion education in predoctoral dental education and another to examine the opinions of faculty and course directors on the content of occlusion curriculum. The sections in the surveys included demographic information, general curriculum information, occlusion curriculum for dentate patients, occlusion curriculum for removable prosthodontics, occlusion curriculum for implant prosthodontics, temporomandibular disorder (TMD) curriculum, teaching philosophy, concepts taught, and methods of assessment. The results from the surveys were compiled and analyzed using descriptive statistics. The results from the two surveys on general concepts taught in occlusion curriculum were sorted and compared for discrepancies.

Results: According to the predoctoral occlusion curriculum surveys, canine guidance was preferred for dentate patients, fixed prosthodontics, and fixed implant prosthodontics. Bilateral balanced occlusion was preferred for removable prosthodontics and removable implant prosthodontics. There were minor differences between the two surveys regarding the occlusion concepts being taught and the opinions of faculty members teaching occlusion.

Conclusion: Two surveys were conducted regarding the current concepts being taught in occlusion curriculum and the opinions of educators on what should be taught in occlusion curriculum. An updated and clearly defined curriculum guideline addressing occlusion in fixed prosthodontics, removable prosthodontics, implant prosthodontics, and TMD is needed.

Throughout the years, the methods of teaching occlusion have evolved. In addition to a single standalone course,[1] many schools are teaching occlusion as a concept that encompasses several courses, such as dental anatomy, fixed prosthodontics, removable prosthodontics, and temporomandibular disorders (TMD). Occlusal concepts related to dental implants are also emerging with the introduction of dental implants into the predoctoral curriculum. Literature reviews have

addressed the concept of occlusion taught in the dental school curriculum.[1-17] Several surveys that examined the prosthodontic curriculum in dental institutions addressed concepts related to occlusion;[3-5,8-13,15] however, available resources on the details of occlusion curriculum are limited.

The Commission on Dental Accreditation (CODA) establishes, maintains, and applies the standards for all dental education programs.[18] Within the goals of CODA standards, several areas address students' ability to diagnose, treatment plan, and provide care for dentate patients and partially and completely edentulous patients.[18] As a part of achieving occlusal harmony of the patients, students must be able to diagnose, analyze, and manage occlusion of these patients accordingly; however, there is a shortage of available information on the description of the occlusion curriculum or how the students are assessed. The American College of Prosthodontists (ACP) is the organization that represents the specialty of prosthodontics and has been involved in the development of guidelines for dental curricula throughout the years. Recently, a task force was established to assess the current status of predoctoral occlusion curriculum and address the guidelines established by CODA.

The purpose of this report from the ACP Task Force on Predoctoral Occlusion Education was to (1) assess the current occlusion curriculum in the predoctoral prosthodontic education of United States dental institutions and (2) examine the opinions of faculty, course directors, and program directors on the contents of occlusion curriculum.

Materials and methods

Two electronic surveys were conducted to assess the current occlusion curriculum in predoctoral prosthodontic education. The ACP central office facilitated data collection and analysis. Participation in the surveys was voluntary and anonymous. All surveys were conducted electronically using a web-based survey engine (Survey Monkey, Palo Alto, CA), and the links to the survey were only available for a specific time period to ensure security.

An e-mail requesting distribution of the survey to faculty, course directors, and program directors responsible for teaching fixed prosthodontics, removable prosthodontics, dental implants, and TMD and related occlusion was sent to the deans of all dental institutions in the US. The Glossary of Prosthodontic Terms (GPT) was referenced for occlusal terminology,[19] accompanied by the International Statistical Classification of Diseases and Related Health Problems (ICD-9), which was used for TMD diagnostic indices. No identifiers were used in the survey other than designation of survey respondent by general or specialty dental status and institution.

The first survey, which assessed the current undergraduate occlusion curriculum, consisted of questions in the following areas:

1. Demographic information: Demographic information included the name of the affiliated institution of the respondents.
2. General curriculum information: This section included questions regarding curricular hours, teaching methods, and names of textbooks or manuals used to teach occlusion. Curricular hours were categorized as 1-2, 3-4, 5-6, 7-8, and >8 hours. Teaching method was categorized as solely lectures, textbook, manual, or textbook and manual.
3. Occlusion curriculum for dentate patients: This question was categorized as: (1) taught during dental anatomy course, (2) taught as a single standalone course, (3) taught in a series of courses on occlusion, (4) incorporated into the various restorative, dental implant, fixed, and removable partial denture (RPD) courses, and (5) other.
4. Teaching philosophy for occlusion for dentate patients: This question was categorized as: (1) didactic course only, (2) didactic and laboratory course combination, (3) laboratory course using a waxing technique, (4) laboratory course using a restorative materials technique rather than a waxing technique, and (5) laboratory course using equilibration of cast as a means to understand occlusion.
5. Mounting diagnostic casts for dentate patients: This question was categorized as: (1) no facebow, (2) arbitrary facebow, (3) hand articulated casts, (4) occlusal registration using a maxillomandibular registration medium in maximal intercuspation, and (5) occlusal registration using a maxillomandibular registration medium in centric relation.
6. Occlusion curriculum for removable prosthodontics: This question was categorized by the type of balanced articulation, such as: (1) nonbalanced anatomical occlusal scheme, (2) balanced anatomical occlusal scheme, (3) nonbalanced monoplane occlusal scheme, (4) balanced monoplane occlusal scheme, (5) nonbalanced lingualized occlusal scheme, (6) balanced lingualized occlusal scheme, (7) working occlusal scheme, and (8) canine or anterior disocclusion.
7. Occlusion curriculum for implant prosthodontics: This question was categorized as: (1) nonbalanced anatomical occlusal scheme, (2) balanced anatomical occlusal scheme, (3) nonbalanced monoplane occlusal scheme, (4) balanced monoplane occlusal scheme, (5) nonbalanced lingualized occlusal scheme, (6) balanced lingualized occlusal scheme, (7) working occlusal scheme, and (8) canine or anterior disocclusion. No distinction between fixed and removable implant prosthodontics was made for this section.
8. TMD curriculum: This question was categorized as: (1) taught as a single standalone course, (2) taught in a series of courses, (3) incorporated into the various restorative, dental implant, fixed partial denture (FPD) and RPD courses, and (4) other.
9. Concepts in occlusion curriculum: The inclusion of various occlusal concepts in the curriculum were queried, and the categories were: usually, occasionally, or never.
10. Assessment: The methods of student assessment were discussed and categorized as: (1) written examination, (2) daily assessments, (3) clinical competency examinations, and (4) other.

The second survey, which assessed faculty opinions on the undergraduate occlusion curriculum, was divided into four main curricular areas of dentate/fixed prosthodontic occlusion, removable prosthodontic occlusion, implant prosthodontic occlusion, and TMD. The categories used for this survey were based on Nimmo et al,[15] and a consensus survey instrument

developed by the ACP Task Force on Occlusion Education. Each survey consisted of 19 questions and addressed the opinion of educators regarding occlusion curriculum.

1. Respondent demographics: Occupation of the respondents was categorized as general dentist, prosthodontist, periodontist, orthodontist, or oral and maxillofacial surgeon.
2. Details of the occlusion curriculum: This section addressed which department or section taught the courses in occlusion, method of instruction, and the term in which it is taught. The departments and sections were identified as clinical sciences, general dentistry, adult restorative, prosthodontics, preventive and restorative dentistry, implant dentistry, or comprehensive care. The methods of instruction of the occlusion curriculum were categorized as a single didactic course, coordinated series of didactic courses, includes laboratory courses, not a specific course but included within other courses, or not taught. Instructional methods were further categorized as informal clinical instruction on a student-by-student basis, formalized clinical instruction, or clinical component involving patient care. The years in school were identified as first, second, third, or fourth year.
3. Clinical assessment and management: This section addressed questions regarding how patients are assessed and treated in the comprehensive care clinic.
4. Concepts in occlusion curriculum: Educators who participated in the survey were asked what concepts should be taught in undergraduate dental education, in the areas of fixed prosthodontics, removable prosthodontics, implants, and TMD. The concepts were categorized as: familiarity, understanding, exposure, competency, or should not be in undergraduate curriculum. A focused review was made relative to the establishment of maximal intercuspation at centric occlusion versus maximal intercuspation at the patient's acquired or "habitual" position. In addition, the nature of tooth contacts relative to eccentric maxillomandibular jaw positions based upon the perceived needs for type of treatment being provided was surveyed.
5. Student assessment: This section addressed how student learning was assessed. Questions regarding competency exams, standardized examinations, case- or problem-based studies, computer-based simulations, or portfolios were asked. Also, the opinion on the hours devoted to occlusion curriculum and the effectiveness of the assessment methods were addressed.

Results

Assessment of current undergraduate occlusion curriculum: Survey #1

Demographics

There were 83 total respondents in the initial survey, representing 48 dental institutions in the US. Geographically, 27.0% of the corresponding institutions were from the East Coast, 31.0% from the Midwest, 19.0% from the Southeast, 8.0% from the Southwest, and 15.0% from the West Coast.

General curriculum information

A majority of the correspondents stated that more than eight curricular hours are devoted to dental occlusion during the 4-year curriculum (60.5%). Others (11.1%) reported that occlusion is taught as a laboratory course with more than 60 hours, along with 17 hours of lectures, mostly starting in the spring semester of the first year and extending throughout the curriculum. Generally, occlusion was taught using a combination of textbook and manual (61.7%), where the most commonly used textbook was the *Management of Temporomandibular Disorders & Occlusion* (Jeffrey P. Okeson, 6th edition, 2008, Mosby, Inc., St. Louis, MO, USA), followed by *Functional Occlusion: From TMJ to Smile Design* (Peter E. Dawson, 2007, Mosby, Inc.).

Occlusion curriculum for dentate patients

Occlusion for dentate or partially dentate patients was incorporated into various restorative, dental implant, FPD and RPD courses for most institutions (60.5%). Twenty-five respondents (30.9%) stated that occlusion is taught as a single standalone course. Nearly all respondents stated that teaching philosophy for occlusion included a combination of didactic and laboratory courses (95.0%). Within the laboratory course, 49.0% of institutions used waxing techniques and 39.0% used mounted casts to understand occlusion. When mounting diagnostic casts for dentate patients, the majority of the respondents stated that using arbitrary facebow is taught (73.0%) along with making occlusal registrations in centric relation (72.0%).

Occlusion curriculum for removable and implant prosthodontics

The three most common types of occlusal schemes for removable denture occlusion were balanced articulation: anatomical (58.0%), lingualized (54.0%), and monoplane (51.0%). Nonbalanced articulation anatomical occlusal scheme was the least common (4.0%). Interestingly, 54 respondents (69.2%) selected teaching more than one occlusal scheme, 35 respondents (44.9%) selected using three or more, and 9 respondents (11.5%) reported teaching four or more occlusal schemes. For implants, the preferred occlusal scheme taught was canine guidance/anterior disocclusion (73.0%). Similar distribution was observed for working occlusal, balanced lingualized, balanced anatomical, and nonbalanced anatomical occlusal schemes.

TMD curriculum

TMD was taught either as a single standalone course (35.8%), in a series of courses (27.2%), or incorporated into restorative, implant, fixed prosthodontic, or removable prosthodontic courses (30.9%). Others expressed that TMD curriculum is taught later in the third or fourth year of the student's training and may involve other departments such as oral medicine or oral surgery.

General concepts in occlusion curriculum

Table 1 categorizes the general occlusal concepts into whether they were usually, occasionally, or never included in the undergraduate dental education. Most of the concepts were part

Table 1 General occlusion concepts included in undergraduate dental education

Usually included in undergraduate occlusion curriculum	
Centric relation	Myospasm
Centric occlusion	Arthritis
Maximal intercuspation	Articulating ribbon
Protrusive disocclusion	Articulating paper
Canine disocclusion	Shimstock
Group function	Fremitus
Bilateral balanced articulation	Arbitrary facebow
Horizontal condylar inclination	Fixed value articulator
Bennett angle	Posselt's envelope of motion
Bennett's side-shift	Curve of Wilson
Tooth-to-tooth contact	Curve of Spee
Tooth-to-two-teeth contact	Monson occlusal curve
Cusp-to-fossa tripodal contact	Compensating curve
Deflective tooth contacts	Hanau's quint
Occlusal adjustment/"equilibration"	Occlusal vertical dimension
Acquired maximal intercuspation	Physiologic rest position
Intercondylar dimension	Closest speaking space
Anteriorly displaced disc	Transverse horizontal axis
Closed lock	Sagittal axis
Bruxism	Arcon versus nonarcon
Frankfort mandibular angle	Frankfort plane
Angle occlusion classification	Occlusal plane
Occasionally/never included in undergraduate occlusion curriculum	
Cross-tooth versus cross-arch articulation	Occlusal spray
Reverse articulation	T-scan
Fischer's angle	Kinematic facebow
ABC tooth contact	Cephalometric analysis
Freedom from centric	Fully adjustable articulator
Functionally generated path	Virtual articulator
Neuromuscular release	Triple tray impression technique
Muscle splinting	Myomonitor
Alterable occlusal vertical dimension	Thielmann's formula
Incisal coupling	

of undergraduate dental curriculum to some degree; however, concepts such as reverse articulation, ABC tooth contact, functionally generated path, T-scan (Tekscan, Inc. Boston, MA), kinematic facebow, fully adjustable and virtual articulator, myomonitor (Myotronics, Kent, WA), and triple-tray impression technique were never included.

Assessment

Methods of instruction for occlusion in predoctoral occlusion curriculum are shown on Table 2. For student assessment, half of the respondents (50.0%) used various combinations of written examination, daily assessments, and clinical competency examinations. Nine respondents (19.6%) stated that all three were used in their institutions. Written examinations were the most common assessment method (52.2%). Others reported that occlusion assessment is a component of other preclinical/clinical competency exams, simulated examinations, or Objective-Structured Clinical Examination (OSCE).

Table 2 Preclinical methods of instruction on occlusion by topic

Topic	Instruction methods
Fixed prosthodontics	■ Occlusal device/adjustment, equilibration on casts ■ Laboratory occlusal wax-up ■ Adjustment of interim prostheses ■ Custom incisal guide table ■ Jaw relation records ■ Diagnostic mounting ■ Facebow transfer
Removable prosthodontics	■ Diagnostic mounting ■ Lab occlusal wax-up ■ Intraoral gothic arch tracing ■ Preclinical lab CD and RPD tooth arrangement, design, and fabrication ■ Setting denture teeth: anatomic, balanced, lingualized, monoplane
Implants	■ Diagnostic mounting ■ Diagnostic wax-up ■ Occlusal device adjustment on casts ■ Only lectures ■ Laboratory exercises ■ None
TMD	■ Bite splint wax-up and fabrication ■ D1 (first sem.): morphology; D1 (second sem.): general dental occlusion; D3 (second sem.): management of TMD ■ Diagnostic mounting and adjusting casts ■ Equilibrations on casts, occlusal device fabrication

Assessment of faculty opinions on the undergraduate occlusion curriculum: Survey #2

Demographics

For the second survey, which assessed the opinions of faculty regarding the occlusion curriculum, 76 faculty members participated. These faculty members were involved in teaching fixed prosthodontics, removable prosthodontics, dental implants, and TMD. The respondents consisted of prosthodontists (90.8%), general dentists (7.9%), and orthodontists (1.3%).

General curriculum information

According to the responses given by the faculty members, the concept of occlusion was generally covered in the department of prosthodontics (51.4%), followed by the department of adult restorative dentistry (27.0%). Other departments included preventative and restorative dentistry, general dentistry, clinical sciences, and implant dentistry.

In regards to the curricular organization, 60.5% of the respondents stated that the occlusion curriculum involved a laboratory course, and 55.3% stated that occlusion is presented as a series of didactic courses. Others reported occlusion being taught as

a single didactic course (34.2%) or having no specific course (28.9%).

According to the results, occlusion was typically offered in the second and third year of the dental curriculum (66.9%) with the greatest frequency noted in the second year (36.1%). By topic, fixed and removable prosthodontic occlusion education was scheduled during the second year, whereas occlusion for dental implants and TMD-related topics were subsequently taught in the third year. Table 2 represents the preclinical methods of instruction related to occlusion by topics.

Occlusion for dentate patients

In fixed prosthodontics, the type of occlusion most frequently taught was canine guidance/anterior disocclusion with maximal intercuspation established at centric occlusion. Nearly all respondents (91.6%) stated that informal clinical instructions are given on a student-by-student basis regarding fixed prosthodontic occlusion. Seventy-five percent of respondents included a formalized clinical instruction, and 92.3% reported having a clinical component involving patient care as a part of occlusion education. During new patient screening, most of the institutions accepted patients with fixed prosthodontic needs in the predoctoral or undergraduate clinic (92.3%). A majority of the respondents (80.8%) indicated that occlusal assessment is always or usually completed as a part of the examination during new patient screening in the undergraduate clinic. Specific parameters or limitations for undergraduate clinical treatments included: the number of units treatment-planned per patient, alteration of the occlusal vertical dimension (OVD), collapsed posterior support, full-mouth reconstruction, number of opposing units, number of missing teeth and existing crowns, and the FPD length or span.

Occlusion for removable prosthodontics

For patients with opposing complete dentures, the most preferred occlusal schemes were balanced anatomical, balanced monoplane, and balanced lingualized occlusion with maximal intercuspation established at centric occlusion. In instances where a complete denture opposed an RPD, a balanced articulation anatomical occlusal scheme with maximal intercuspation established at centric occlusion was preferred. When an RPD opposed natural dentition, canine guidance/anterior disocclusion was the most-preferred occlusal scheme, followed by nonbalanced anatomical occlusion, both with maximal intercuspation established at centric occlusion. In removable prosthodontics, 77.8% of the respondents stated that informal clinical instructions are given on a student-by-student basis, and 89.5% had a formalized clinical instruction as a part of occlusion education at their institutions. Nearly all respondents (94.4%) reported having a clinical component involving patient care in the curriculum. All respondents (100.0%) stated that patients needing removable prosthodontic therapy are accepted in the predoctoral or undergraduate clinic, and a majority (89.5%) reported that occlusal assessment was always or usually completed during the new patient screening in the undergraduate clinic.

Occlusion for implant prosthodontics

For removable implant prosthodontics, balanced articulation using a lingualized occlusal scheme was most preferred; however, for fixed implant prosthodontics, when the canine was present and not an implant, the occlusion of choice was canine/anterior disocclusion. If the implant is the opposing arch with a removable prosthesis, canine/anterior disocclusion will be selected as well, as long as the prosthesis does not require stabilization. In both removable and fixed implant prosthodontics, maximal intercuspation is established at centric occlusion. Of the respondents, 87.5% reported providing informal clinical instructions given on a student-by-student basis. Formal clinical instructions regarding dental implant occlusion were given by 75% of the respondent's dental institutions. Nearly all respondents (93.8%) reported having a clinical component involving patient care as a part of the dental implant occlusion curriculum. Few respondents (11.8%) stated that patients needing dental implants are generally referred to the postdoctoral clinic for care. Respondents (88.2%) reported that occlusal assessment is always completed during screening examinations for new patients needing dental implants.

TMD curriculum

Most of the respondents (81.8%) expressed that informal clinical instructions are given on a student-by-student basis regarding TMD; however, unlike the other topics, 58.3% of respondents stated there are no formalized clinical instructions or clinical components involving patients (54.5%) for the TMD curriculum. Although the occlusal assessment was always or usually performed during new patient screening in the predoctoral or undergraduate clinic (66.7%), patients with TMD-related concerns were generally referred (66.7%), especially to the postdoctoral clinic (41.7%).

General concepts in occlusion curriculum

The general concepts that are components of occlusion curriculum were grouped and categorized (Table 3).

Assessment

In the areas of student assessment, clinical and laboratory competency exams were a routine part of fixed and removable prosthodontic curriculum addressing occlusion; however, in the implant and TMD curriculum, only one form of competency exam was reported, which was directed toward treatment-planning competency. Other forms of assessment tools used were oral examinations, standardized examinations (i.e., OSCE), case- or problem-based studies, computer-based simulations, and portfolios.

Predoctoral educators reported that barriers to occlusion education were related to the lack of available curriculum hours, lack of faculty, and the lack of adequate expertise. Other lesser barriers noted were the lack of ADA guidelines and patients fitting the four modules described.

Table 3 Frequency distribution of the occlusal concepts/terms used in the current occlusion curricula and the expert opinion about their level of educational importance.

	Occlusion survey 1 (being taught)							Occlusion survey 2 (expert opinion)										
	Usually	% of total	Occasionally	% of total	Never	% of total	Total responses	Exposure total	% of total	Understanding total	% of total	Competency total	% of total	Shouldn't be in UG total	% of total	Total responses	Agreement	Less than 50%
Static occlusal terms																		
Angle occlusion classification	***74***	***92.50***	6	7.5	0	0	80	7	13.21	12	22.64	34	64.15	0	0.00	53	y	
Centric relation	***78***	***96.30***	3	3.70	0	0.00	81	2	3.57	5	8.93	49	87.50	0	0.00	56	y	
Centric occlusion	***70***	***87.50***	8	**10.00**	2	2.50	80	2	3.57	7	12.50	45	80.36	2	3.57	56	y	
Maximal intercuspation	***79***	***97.53***	2	2.47	0	0.00	81	5	9.62	3	5.77	42	80.77	2	3.85	52	y	
Acquired maximal intercuspation	***39***	***60.00***	20	30.77	6	9.23	65	6	10.71	7	12.50	38	67.86	5	8.93	56	y	
Freedom from centric	21	***33.87***	***26***	**30.84**	15	24.19	62	14	28.57	17	34.69	11	22.45	7	14.29	49	y	y
Tooth-to-tooth contact	***60***	***81.08***	12	16.22	2	2.70	74	3	5.56	10	18.52	38	70.37	3	5.56	54	y	
Tooth-to-two teeth contact	***52***	***72.22***	17	23.61	3	4.17	72	12	22.22	15	27.78	23	42.59	4	7.41	54	y	y
Cusp-to-fossa tripodal contact	***47***	***63.51***	22	29.73	5	6.76	74	14	25.45	11	20.00	15	27.27	15	27.27	55	n (split)	y
ABC tooth contact	17	***29.31***	12	20.69	***29***	50.00	58	7	14.00	17	34.00	9	18.00	17	34.00	50	y (split)	
Cross-tooth versus cross-arch articulation	***28***	***41.79***	17	25.37	22	32.84	67	12	23.53	10	19.61	18	35.29	11	21.57	51	y	y
Deflective tooth contacts	***48***	***68.57***	17	24.29	5	7.14	70	6	11.32	7	13.21	40	75.47	0	0.00	53	y	
Occlusal vertical dimension	***76***	***93.83***	5	6.17	0	0.00	81	6	10.91	1	1.82	48	87.27	0	0.00	55	y	
Closest speaking space	***66***	***86.84***	11	14.47	0	0.00	76	4	7.41	7	12.96	43	79.63	0	0.00	54	y	
Physiologic rest position	***75***	***94.94***	4	5.06	0	0.00	79	5	9.09	5	9.09	44	80.00	1	1.82	55	y	
Dynamic occlusal terms																		
Posselt's envelope of motion	***73***	***90.12***	7	8.64	1	1.23	81	5	9.26	16	29.63	27	50.00	6	11.11	54	y	
Occlusal adjustment/ "equilibration"	***59***	***76.62***	14	18.18	4	5.19	77	15	27.27	6	10.91	26	47.27	8	14.55	55	y	
Neuromuscular release	21	***33.33***	***27***	42.86	15	23.81	63	11	20.00	14	25.45	7	12.73	23	41.82	55	n	y
Protrusive disocclusion	***70***	***89.74***	8	10.26	0	0.00	78	7	12.73	4	7.27	36	65.45	8	14.55	55	y	
Canine disocclusion	***79***	***97.53***	2	2.47	0	0.00	81	7	12.96	4	7.41	35	64.81	8	14.81	54	y	
Incisal coupling	***22***	***36.07***	***22***	36.07	17	27.87	61	11	20.75	6	11.32	23	43.40	13	24.53	53	y	y
Group function	***68***	***86.08***	10	12.66	1	1.27	79	13	24.53	8	15.09	28	52.83	4	7.55	53	y	
Bilateral balanced articulation	***61***	***78.21***	12	15.38	5	6.41	78	3	5.88	7	13.73	33	64.71	8	15.69	51	y	
Reverse articulation	7	***12.28***	10	17.54	**40**	70.18	57	22	38.60	12	21.05	22	38.60	1	1.75	57	n (split)	y
General occlusal terms																		
Curve of Wilson	***73***	***90.12***	7	8.64	1	1.23	81	8	14.81	7	12.96	37	68.52	2	3.70	54	y	
Curve of Spee	***76***	***93.83***	4	4.94	1	1.23	81	10	18.52	7	12.96	36	66.67	1	1.85	54	y	
Monson occlusal curve	***40***	***59.70***	17	25.37	11	16.42	67	11	23.91	12	26.09	17	36.96	6	13.04	46	y	y
Hanau's quint	***50***	***70.42***	10	14.08	11	15.49	71	15	29.41	6	11.76	14	27.45	16	31.37	51	n (split)	y
Thielmann's formula	***26***	***41.94***	16	25.81	21	33.87	62	15	29.41	6	11.76	14	27.45	16	31.37	51	n (split)	y
Frankfort plane	***65***	***84.42***	11	14.29	1	1.30	77	8	15.69	8	15.69	34	66.67	1	1.96	51	y	
Frankfort mandibular angle	***43***	***60.56***	18	25.35	10	14.08	71	14	28.00	20	40.00	6	12.00	10	20.00	50	n	

Continued

Table 3 *Continued*

	Occlusion survey 1 (being taught)							Occlusion survey 2 (expert opinion)								
	Usually	% of total	Occasionally	% of total	Never	% of total	Total responses	Exposure total	% of total	Understanding total	% of total	Competency total	% of total	Shouldn't be in UG total	% of total	Total responses	Agreement	Less than 50%
Articulator-related terms																		
Horizontal condylar inclination	***62***	***82.67***	12	16.00	1	1.33	75	8	15.69	4	7.84	39	76.47	0	0.00	51	y	
Bennett angle	***54***	***70.13***	23	29.87	1	1.30	77	14	25.00	10	17.86	27	48.21	5	8.93	56	y	
Bennett side-shift	***54***	***70.13***	16	20.78	7	9.09	77	14	25.00	13	23.21	21	37.50	8	14.29	56	y	y
Fischer angle	15	***25.00***	**23**	38.33	22	36.67	60	9	15.52	18	31.03	6	10.34	25	43.10	58	n	
Alterable occlusal vertical dimension	***31***	***46.27***	28	41.79	9	13.43	67	15	28.85	11	21.15	16	30.77	10	19.23	52	y	y
Intercondylar dimension	***41***	***58.57***	21	30.00	9	12.86	70	15	29.41	11	21.57	12	23.53	13	25.49	51	n	y
Kinematic facebow	5	***8.47***	21	35.59	**33**	55.93	59	4	8.16	6	12.24	5	10.20	34	69.39	49	y	
Arbitrary facebow	***68***	***87.18***	8	10.26	3	3.85	78	8	14.55	5	9.09	41	74.55	1	1.82	55	y	
Fixed value articulator	***38***	***54.29***	24	34.29	8	11.43	70	10	18.52	7	12.96	26	48.15	11	20.37	54	y	y
Fully adjustable articulator	19	**29.23**	16	24.62	**30**	46.15	65	3	6.67	6	13.33	1	2.22	35	77.78	45	y	
Myomonitor	2	***3.636364***	11	20.00	**42**	76.36	55	1	1.92	1	1.92	1	1.92	49	94.23	52	y	

Comparison between survey #1 and survey #2

To compare the differences between what is being currently taught (survey 1) and the expert opinion on what should be taught in predoctoral occlusion curriculum (survey 2), the same occlusion concepts and terms were analyzed and compared between the two surveys. The occlusal concept/terms (independent variable) were grouped into four domains (static, dynamic, and general occlusal terms, and articulator-related occlusal terms). Those occlusal concepts/terms not included in both surveys were eliminated, whereas the remaining data were pooled by the individual occlusal term across the individual prosthodontic disciplines (dentate/fixed, removable, implants). The frequency of responses of the occlusal terms was entered into an Excel spreadsheet (Microsoft Excel 2003, Seattle, WA, USA) by the dependent variables that varied between the two surveys (Table 3).

As mentioned earlier, whereas the focus of survey 1 was an assessment of the frequency of the current use of occlusal concepts/terms (usually, occasionally, never), the focus of survey 2 was the expert opinion of the level of their importance in the curriculum (competency, exposure, understanding, should not be included in the curriculum). The frequency data for each occlusal term were transformed into the percentage of the total responses by each dependent variable and compared between the surveys. Because the dependent variables differed between the two surveys, it was decided by the consensus of the authors that the "usually in predoctoral curriculum" (first survey) corresponded to the level of "competency" variable in the second survey. Similarly, the variable "occasionally" (survey 1) corresponded to the level of "exposure" and "understanding" variables in the survey 2. Finally, the variable "never" in the first survey corresponded to the level of "should not be in predoctoral curriculum" variable in the second survey. Agreement/disagreement between the levels of the current and proposed use of each occlusal concept/term in the occlusion curriculum was noted by comparing percentages of responses by the individual dependent variable. Those occlusal concepts/terms not in agreement with regard to their use in the occlusion curriculum were summarized in a separate spreadsheet (Table 4).

Discussion

In this study, the concepts currently taught in occlusion curriculum and what faculty perceive should be taught were reported. In general, the results were similar to each other; especially the concepts on preferred occlusal schemes in fixed and removable prosthodontics (Table 5). Defining curricular guidelines in the past has been limited in the literature. In 1993, curricular guidelines were defined for fixed and removable prosthodontics and implant dentistry for General Practice Residency and Advanced Education in General Dentistry Programs.[2,16-17] Guidelines for dental curricula may be defined by the specifications of each dental institution, in accordance with the parameters of accreditation standards.[18] A curriculum guideline was identified for TMD curriculum;[20] however, since then, no other forms of curricular guideline have been available in the dental literature, other than suggestions from experts in this area.[7,21]

Table 4 Frequency distribution of those occlusal concepts/terms that were not in an agreement between their current level of use in occlusion curriculum and the corresponding opinion of the experts

Summary: Differences between current curriculum and expert opinion

	Current curriculum							Expert opinion								
	Usually	% of total	Occasionally	% of total	Never	% of total	Total responses	Exposure total	% of total	Understanding total	% of total	Competency total	% of total	Shouldn't be in UG total	% of total	Total responses	Agreement	Less than 50%
Occlusal terms																		
Cusp-to-fossa tripodal contact	***47***	***63.51***	22	29.73	5	6.76	74	14	25.45	11	20.00	15	27.27	15	27.27	55	n (split)	y
ABC tooth contact	17	***29.31***	12	20.69	***29***	50.00	58	7	14.00	17	34.00	9	18.00	17	34.00	50	y (split)	y
Neuromuscular release	21	***33.33***	***27***	42.86	15	23.81	63	11	20.00	14	25.45	7	12.73	23	41.82	55	n	y
Reverse articulation	7	***12.28***	10	17.54	***40***	70.18	57	22	38.60	12	21.05	22	38.60	1	1.75	57	n (split)	y
Incisal coupling	***22***	***36.07***	***22***	36.07	17	27.87	61	11	20.75	6	11.32	23	43.40	13	24.53	53	y (split)	y
Articulator																		
Hanau's quint	***50***	***70.42***	10	14.08	11	15.49	71	15	29.41	6	11.76	14	27.45	16	31.37	51	n	y
Thielmann's formula	***26***	***41.94***	16	25.81	21	33.87	62	15	29.41	6	11.76	14	27.45	16	31.37	51	n	y
Fischer angle	15	***25.00***	***23***	38.33	22	36.67	60	9	15.52	18	31.03	6	10.34	25	43.10	58	n	y
Intercondylar dimension	***41***	***58.57***	21	30.00	9	12.86	70	15	29.41	11	21.57	12	23.53	13	25.49	51	n	y
Frankfort mandibular angle	***43***	***60.56***	18	25.35	10	14.08	71	14	28.00	20	40.00	6	12.00	10	20.00	50	n	y

Table 5 Occlusal concepts for prosthodontic treatment

Parameter	Fixed prosthodontics	Removable prosthodontics	Implant prosthodontics	TMD
MI at CO	√	√	√	N/A
MI acquired				
Canine/anterior guidance	√		√	
Group function guidance	*		*	
BA-anatomical		√		
BA-lingualized		√		
BA-monoplane				
NBA-anatomical				
NBA-lingualized				
NBA-monoplane				

MI = maximal intercuspation; CO = centric occlusion; MI acquired = maximal intercuspation at patient's acquired position; BA = balanced articulation; NBA = nonbalanced articulation; TMD = temporomandibular disorders. Inadequate number of TMD survey respondents limited meaningful data.
*While canine/anterior guidance was the preferred disocclusion scheme for fixed prosthodontic occlusion when the canine(s) were missing or if the tooth wear predominated group function may be considered.

The greatest survey response relative to the four predoctoral occlusion modules was fixed prosthodontics, then removable prosthodontics, with implant prosthodontics a trailing third. The survey responses to the TMD module were half that of fixed prosthodontics, which may challenge the value of the TMD survey information.

There is need for a "standardization" of the concepts within the curriculum for occlusion due to its multifactorial nature and significant influence of expert opinions accompanied by repetitive teaching cycles, rather than evidence-based dentistry. There is limited literature available in the area of occlusion and a lack of best evidence to direct education.[7,21] Occlusion is a broad subject that encompasses many disciplines in dentistry. The incorporation of occlusion into various restorative, fixed, and removable prosthodontic courses that included dental implants accounts for the majority of didactic and clinical curricular hours devoted to occlusion. This is most likely the result of the multidisciplinary nature of the topic and the trend in many dental schools to reorganize their departmental structure; however, despite the challenges, occlusion remains a major component of dentistry and dental education, where well-defined guidelines and assessment methods need to be used for the future of the profession. The development of consensus statements relative to occlusion education by current educators is therefore of value in dental education. The incorporation of dental implants in the curriculum has been a positive influence in all phases of dental education. Implant education is now implemented as early as the second year in the dental curriculum, as reported in this study. Although the levels of incorporation vary for each institution,[8,22] the accreditation standards revised in 2010 address the need to show competency in replacing missing teeth by the use of dental implants for all graduates.[18] The competencies in implant therapy will also need to incorporate an occlusal assessment component, because occlusion for implants is thought to be different than with natural teeth. Further work in defining curricular guidelines for implant therapy in dental institutions will be needed.

It should be noted that a large majority of TMD patients first evaluated in the predoctoral clinics were referred to postdoctoral or orofacial pain/TMD departments. Etiology for TMD can be complex in nature and may need treatment in a more advanced clinical setting, with proper diagnoses and clinical expertise. CODA guidelines state that graduates must have knowledge in the etiology, epidemiology, differential diagnosis, pathogenesis, prevention, treatment, and prognosis of oral-related disorders.[18] In turn, this may reduce the opportunity for predoctoral students to get clinical education experiences in this domain.

When reviewing the differences between the current curriculum and the expert opinion (Table 4), many of the discrepancies are related to variations in whether a concept should never be taught in relation to the degree in which it should be taught. For example, the cusp-to-fossa tripodal contact relationship is currently "usually taught" (competency level) 63.5%. Only 27.3% of the experts believe it should be taught to the competency level, whereas 72.7% of the experts believe it should be taught at some level, and 27.3% believe it should not be taught at all.

Another example of discrepancies noted was related to the topic of reverse articulation. Whereas 70.2% of the schools currently do not teach the concept of reverse articulation, 38.6% of the experts believe that it should be taught at least at the exposure level, while another 38.6% believe it should reach the level of competency. With this large discrepancy, it makes one wonder that if the faculty believe it should be taught, why it is not taught. Table 4 highlights the need for consensus statements relative to the competency standards for occlusion and curricular guidelines.

Methods of assessing dental students have been studied widely in the dental literature, and using different methods of assessment has been well documented.[23-29] Albino et al reported the methodology of current assessment practices in US dental schools in 2008, and the most common assessment strategies included context-free multiple choice questions (MCQ), case-based MCQ, laboratory exercises, daily evaluation, student self-assessment, and clinical competency examinations. The least-used assessment strategies were critically appraised topics (CAT), chart-stimulated evaluation, triple jump exercise, and portfolio-driven assessments. CAT uses students investigating an assigned topic or question and prepares an evidence-based report or presentation formatted to answer a research question and review the available literature, along with the critical appraisal of the evidence presented. Chart-stimulated evaluation is a review of patient care using the medical or dental record as a resource for exploring the student's ability to rationalize the treatment decisions and display comprehension of key concepts and stimulate self-assessment and reflection. Triple jump exercises consist of three jumps, where in the first jump, the students are observed as they gather information from the patient through interview and examination; the second jump consists of writing an assessment of the patient and formulating a treatment plan with rationalization for the planned treatments; and the third jump involves the student explaining the assessment and treatment plan to faculty and responding to sets of questions. In a portfolio-driven assessment, students document and present their work over time using various methods, such as photographs, reports, projects, abstracts, peer or faculty evaluations, and self-evaluation; portfolios are periodically reviewed to assess the progress toward competency.[26] Albino et al also recommended newer assessment methods based on educational fundamentals: OSCE, portfolios, CAT, case-based MCQ, and competency-based learning.[26] During an OSCE, students rotate from one station to another performing specific tasks in a given amount of time, and certain skills or abilities are assessed. Case-based MCQ uses MCQs linked to scenarios describing the patient's general oral health or medical concerns or specific patient care situations. Implementing some of these assessment methods in the occlusion curriculum can be challenging due to the wide range occlusion encompasses in dentistry.

A cumulative type of assessment method could potentially be used in evaluating competence in occlusion by assessing the student in different domains such as biomedical knowledge, problem assessment, patient examination skills, patient interviewing and communication skills, and performing technical procedures.[26] For biomedical knowledge assessment, using MCQ was recommended, whereas for problem assessment, using essays, oral exam, or chart-stimulated reviews were recommended. Standardized examinations such as OSCE and single encounter direct observation by faculty were recommended for assessing patient examination, interviewing, communication skills, and technical procedures performance. Longitudinal assessment by faculty was also considered good for these domains, but there may be limitations for the overall comprehensive evaluation of a student's competence.[26]

There were some limitations to the surveys. The respondents were small in number for certain aspects and may not represent all US dental institutions. Some institutions were represented more than once in some instances, which may influence the results. Because some survey respondents did not answer all questions, the corresponding number of respondents was less than the total possible comments.

Questions arise as to why the surveys were incomplete. The directions listed on the survey asked the recipient to forward the survey to the proper course directors for each discipline, but it was difficult to ensure this happened, because the surveys were anonymous. Were the questions unanswered because the survey was not forwarded to the individual who could best answer this question, was there confusion on the part of the person answering the survey as to the meaning of the question, or were they unfamiliar with some of the terminology used? Although the survey directions referenced GPT for terminology, some of the nonprosthodontist educators are not familiar with this publication and the most-current terminology. These questions are not easily answered; however, future surveys may need to include categories such as "cannot evaluate—not my area of the curriculum," or "unfamiliar with the terminology." These two categories would enlighten future authors as to why questions are being left unanswered. An alternative to this would be to divide the survey into sections sent separately to individuals who teach in the specific area: fixed prosthodontics, removable prosthodontics, implant prosthodontics, and TMD.

Future areas of study should compare US dental school occlusion curriculum to other dental institutions such as those in Canada and the United Kingdom. In addition, the predoctoral

program could be deferred to postdoctoral occlusion education parameters.

Conclusion

Two surveys were conducted regarding the current concepts being taught in occlusion curriculum and the opinions of educators on what should be taught in occlusion curriculum. An updated and clearly defined curriculum guideline addressing occlusion in fixed prosthodontics, removable prosthodontics, implant prosthodontics, and TMD is needed. The results of these surveys will be used to create an ACP Occlusion Primer for predoctoral dental education.

References

1. Weisgold AS: Teaching a core course in occlusion. J Prosthet Dent 1975;33:89-95
2. American Association of Dental Schools Section on Fixed Prosthodontics: Curriculum guidelines for fixed prosthodontics. J Dent Educ 1993;57:49-55
3. Taylor TD, Aquilino SA, Jordan RD: Prosthodontic laboratory and curriculum survey. Part IV: Fixed prosthodontic curriculum survey. J Prosthet Dent 1985;53:267-270
4. Taylor TD, Aquilino SA, Matthews AC, et al: Prosthodontic survey. Part II: Removable prosthodontic curriculum survey. J Prosthet Dent 1984;52:747-749
5. Taylor TD, Matthews AC, Aquilino SA, et al: Prosthodontic survey. Part I: Removable prosthodontic laboratory survey. J Prosthet Dent 1984;52:598-601
6. Weisgold AS: Occlusion: review of various concepts. Probe (Lond) 1975;16:373-380
7. Ash MM, Jr: Occlusion, TMDs, and dental education. Head Face Med 2007;3:1
8. Petropoulos VC, Arbree NS, Tarnow D, et al: Teaching implant dentistry in the predoctoral curriculum: a report from the ADEA Implant Workshop's survey of deans. J Dent Educ 2006;70:580-588
9. Petropoulos VC, Rashedi B: Complete denture education in U.S. dental schools. J Prosthodont 2005;14:191-197
10. Petropoulos VC, Rashedi B: Removable partial denture education in U.S. dental schools. J Prosthodont 2006;15:62-68
11. Petropoulos VC, Weintraub A, Weintraub GS: Predoctoral fixed prosthodontics curriculum survey. J Prosthodont 1998;7:183-191
12. Goodacre CJ: Predoctoral fixed prosthodontics education. J Prosthet Dent 1990;64:319-325
13. Graser GN: Predoctoral removable prosthodontics education. J Prosthet Dent 1990;64:326-333
14. Jasinevicius TR, Yellowitz JA, Vaughan GG, et al: Centric relation definitions taught in 7 dental schools: results of faculty and student surveys. J Prosthodont 2000;9:87-94
15. Nimmo A, Woolsey GD, Arbree NS, et al: Defining predoctoral prosthodontic curriculum: a workshop sponsored by the American College of Prosthodontists and the prosthodontic forum. J Prosthodont 1998;7:30-34
16. American Association of Dental Schools Section on Removable Prosthodontics: Curriculum guidelines for removable prosthodontics. J Dent Educ 1993;57:45-48
17. American Association of Dental Schools: Curriculum guidelines in implant dentistry for general practice residency and advanced education in general dentistry programs. J Dent Educ 1993;57:56-58
18. Accreditation CoD: Accreditation Standards for Dental Education Programs. Chicago, American Dental Association, 2010
19. Shah RV, Albert TJ, Bruegel-Sanchez V, et al: Industry support and correlation to study outcome for papers published in spine. Spine 2005;30:1099-1104
20. Greene CS: Teaching undergraduate dental students about TMJ disorders: survey and proposal. J Dent Educ 1973;37: 16-19
21. Leib A: Whatever happened to occlusion? J Periodontol 2007;78:1182-1184
22. Afsharzand Z, Lim MV, Rashedi B, et al: Predoctoral implant dentistry curriculum survey: European dental schools. Eur J Dent Educ 2005;9:37-45
23. Schoonheim-Klein M, Walmsley AD, Habets L, et al: An implementation strategy for introducing an OSCE into a dental school. Eur J Dent Educ 2005;9:143-149
24. Mossey PA, Newton JP: The Structured Clinical Operative Test (SCOT) in dental competency assessment. Br Dent J 2001;190:387-390
25. Scott BJ, Evans DJ, Drummond JR, et al: An investigation into the use of a structured clinical operative test for the assessment of a clinical skill. Eur J Dent Educ 2001;5:31-37
26. Albino JE, Young SK, Neumann LM, et al: Assessing dental students' competence: best practice recommendations in the performance assessment literature and investigation of current practices in predoctoral dental education. J Dent Educ 2008;72:1405-1435
27. Curtis DA, Lind SL, Brear S, et al: The correlation of student performance in preclinical and clinical prosthodontic assessments. J Dent Educ 2007;71:365-372
28. Jahangiri L, Mucciolo TW, Choi M, et al: Assessment of teaching effectiveness in U.S. Dental schools and the value of triangulation. J Dent Educ 2008;72:707-718
29. Licari FW, Knight GW: Developing a group practice comprehensive care education curriculum. J Dent Educ 2003;67:1312-1315