Neuroanatomy for the Dentist in the Twenty-First Century

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Abstract: Both the anatomy and physiology parts of national boards have questions on neuroscience. Currently, there are course guidelines established for dental neuroanatomy but not for dental neuroscience. As a result, there is great variability in what and how neurosciences are taught to dental students. At first glance, it is difficult to determine where neurosciences fit in the dental curriculum. One area where there is a close tie between basic science and clinical care is the realm of pain control. Since the Institute of Medicine study recommended that basic and clinical sciences curricula provide clinically relevant education, a neuroscience curriculum can integrate basic understanding of how the nervous system works in the care and management of dental pain. This paper describes the integrated approach to teaching neuroanatomy as a component of the head and neck gross anatomy course at the University of Louisville. This integrated strategy provides dental students with the basic concepts of neuroscience, pain pathways, autonomic nervous system, and detailed information on the cranial nerves.

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Foundation knowledge is that part of the dental curriculum that serves as the steppingstone on which other basic science and preclinical courses are based.[1] It is rather easy to see where gross anatomy and oral histology fit as foundation knowledge. However, for students it might not be easy to understand the role of neuroanatomy (Figure 1). The purpose of this paper is to describe the role of neuroscience in dental education and discuss an approach to the neuroanatomy curriculum at the University of Louisville that might serve as a curriculum model for neuroscience education for the dentist in the twenty-first century.

Sessle et al.[2] addressed the place of neuroscience in dentistry. Based on a research background, they proposed that dental neuroscience research focus on oral-facial neural mechanisms including dental pain, taste, mastication, and speech. Practicing dentists are concerned with pain control, proper structure and function of mastication, and proprioceptive input from muscles, joints, and the periodontal ligament. Thus, Sessle et al. extrapolated that dentists should have an understanding of these mechanisms.

In 1981, the American Association of Dental Schools Anatomical Science Section published guidelines for teaching neuroanatomy, which looked like the index to a current neuroanatomy text.[3] These guidelines addressed all areas of neuroanatomy that would be covered in a typical medical neuroscience course. In 1992, the list was revised and drastically cut in length, but this time it included a number of guidelines.[4] The 1992 guidelines recommended that dental neuroanatomy courses should focus on helping students gain an understanding of the nervous system's control of the muscles of the head and neck and the regulation of the perception of pain. A course should cover one or two systems in detail as examples rather than cover all systems. The 1992 report proposed four outcomes for such a course:

1) The students should be able to: Characterize the structure and function of neuronal and glial cells and the coverings of the nervous system;
2) Describe the structure and function of the peripheral nervous system, the major pathways that convey information in the central nervous system, and the primary nuclei or cortical regions that modify passage of the signal or that alter the behavior of the organism;
3) Define in detail sensory, motor, and autonomic innervation of the head and neck and the CNS structures and pathways that relate to this innervation; and finally,
4) Apply neurobiological understanding to the practice of dental medicine.[4]

In 2000, Robertson[5] published a survey of neuroscience courses offered by seventeen dental schools across the country. The results of this survey indicated that there was great variation in course content, contact hours, and audiovisual use, as well as problem solving. Neuroscience was taught an aver-

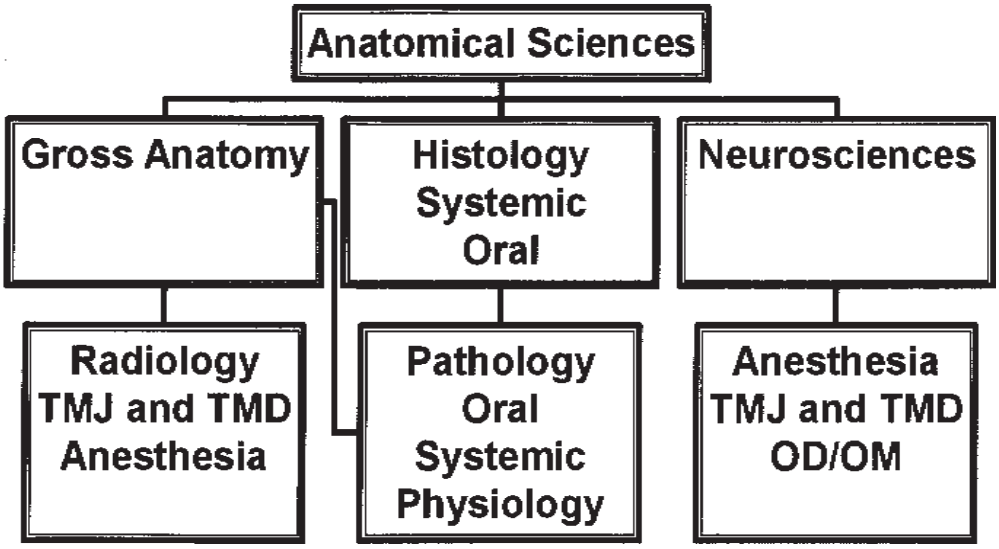

Figure 1. The interrelationships of anatomical science courses with other basic and preclinical sciences

age of 51.4 hours (range: 11 to 110 hours contact time). At a few schools, the dental students took the medical neuroscience course, although they were either graded differently or took only selected parts of the course. Course content of the medical courses was determined without consideration of its clinical relevance to dentistry. Thus, Robertson called for the establishment of goals and objectives for a neuroscience curriculum applicable to dental clinicians.

In the last decade, a number of documents have been published on the future of dental education. The Institute of Medicine report *Dental Education at the Crossroads: Challenges and Change*,[6] the Future of Dentistry Report by the American Dental Association,[7] and the new Accreditation Standards for Predoctoral Education[8] have influenced dental education. Changes in the accreditation standards removed the guidelines and replaced them with descriptions of the competencies that entry-level general dental practitioners should possess, which is the cornerstone of a competency-based curriculum.

The Institute of Medicine report presented an analysis of the oral health profession, examining many aspects of oral health delivery and education.[6] Of the report's twenty-two recommendations, number 4 is of particular interest to basic science educators. In essence, this recommendation states that predoctoral curriculum reform should work toward an integration of basic and clinical sciences that results in "clinically relevant education in the basic sciences and scientifically based education in clinical care."[6]

The Commission on Dental Accreditation adopted the following standards for the biomedical sciences in section 2, which deals with the predoctoral curriculum:

2-12 Biomedical science instruction in dental education *must* ensure an in-depth understanding of basic biological principles, consisting of a core of information on the fundamental structures, functions and interrelationships of the body systems.

2-13 The biomedical knowledge base *must* emphasize the oro-facial complex as an important anatomical area existing in a complex biological interrelationship with the entire body.[8]

To address these standards, each dental school is expected to develop its own competencies that define the knowledge, skills, and judgment that new graduates must attain by the time of graduation and prior to beginning independent general practice. These competencies are listed in five general categories, which include scientific and behavioral science foundations as well as the clinically related foundations of patient assessment, disease control and treatment, and practice administration. It is within the realm of the scientific knowledge foundation that the basic sciences fit.

Because of the shift in dental education to assessment of the student's competence to enter unsupervised general practice, it is expected that basic science foundation knowledge will be clinically relevant and related to preclinical courses and clinical practice. The neuroanatomy curriculum at the University of Louisville demonstrates how this relationship can be accomplished.

In the late 1980s, Neuroanatomy was a three-credit course that encompassed the entire Medical Neuroscience course. Later it was reduced to a one-credit course offered concurrently with Gross Anatomy. Also later, the Dental Neuroscience course (one credit) was changed to a block of neuroanatomy lectures for two weeks following gross anatomy at the end of the fall semester. For the past six years, the one credit for neuroanatomy has been incorporated into the gross anatomy curriculum representing a total of seventeen lecture hours plus a two-hour lab. This approach has helped students understand the relationship of neuroanatomy to gross anatomy and their future dental practice. However, no formal outcomes measures are available except for anecdotal remarks from other preclinical course directors.

Today, neuroanatomy has been integrated into the head and neck portion of gross anatomy as outlined in Table 1. The neuroanatomy component focuses on cranial nerve structure and function plus clinically significant correlations presented by the appropriate dental or medical clinician. As a specific region of the head and neck is dissected, the study of the peripheral nervous system of that area is integrated with the central pathways and processes so that the student has a total picture of the cranial nerve(s) being examined.

Table 1. Integration of neuroanatomy with head and neck anatomy

Gross anatomy topic	Neuroanatomy topic
Osteology	Gross morphology of brain
	Dura and CSF
	Gross anatomy of the brain lab
Neck	Blood supply to the brain
Face	Corticobulbar pathway
	Vestibulocochlear system (CN VIII)
Infratemporal fossa	Sensory pathways: CN V
	Clinical Correlation:
	Bell's Palsy and Tic Douloureux
	CN VIII
	Clinical Correlation:
	TMJ and myofascial pain
Orbit	Vision (CN II),
	CN III, IV, and VI
	Autonomic nervous system:
	Eye and lacrimal gland
Larynx and Pharynx	CN IX, X, and XI
Nasal Cavity	Olfaction (CN I)
Pterygopalatine fossa	Pain pathways
	Clinical Correlation:
	Dental Anesthesia
Oral Cavity	Taste and CN XII
	Autonomic Nervous system:
	Salivary glands
	Clinical correlation:
	Cranial nerve exam

The introduction to the nervous system occurs with the study of osteology. As the students learn the skull, a two-hour lab is used to examine the gross morphology of the brain and brain stem. The relationship of the brain to the skull with its coverings, dural sinuses, and the production of CSF is incorporated. When the neck is dissected, blood supply to the brain is examined, and the venous return is used to review the dural sinuses.

As the face is dissected and branches of CN VII are found, the concept of efferent pathways is studied with special emphasis on the corticobulbar tract and its innervation of motor cranial nerves. Comparison with the corticospinal tract is emphasized. Since dental students focus on learning the details of innervation and control of the muscles of the head and neck, the neuroanatomy component of the course places special emphasis on the corticobulbar pathway. The concept of upper and lower motor neurons is easily illustrated by motor innervation of CN VII and the clinical correlation on Bell's palsy.

When the infratemporal fossa is dissected, the peripheral branches of CN V3 are revealed. Not only can the efferent pathway be reviewed, but sensory processing is examined. The basis of pain and anxiety control is an understanding of the sensory pathways of CN V. Each sensory modality is transmitted and processed through branches of CN V. Special emphasis is placed on discussion of the spinal nucleus of the nerve. Comparisons can be made with the somatosensory systems. However, localization of spinal cord lesions is not necessary for foundation knowledge in oral diagnosis or oral medicine as it is for medical students' understanding of the signs and symptoms in neurological diagnosis. Clinical examples focused on sensory abnormalities in reference to head and neck. A detailed discussion of the inferior alveolar nerve block is presented. The first clinical correlation by a neurologist is presented on Bell's palsy and Tic Douloureux. Both of these neurological problems may be seen in the dental office. There is another clinical correlation related to this area: TMJ function and myofascial pain of the head and neck. At this clinical

correlation, a dentist introduces the concept of the cranial nerve exam and why students should understand the fundamental principles of normal and abnormal cranial nerve function.

Study of special senses begins with an examination of CN VIII. The basic concepts of hearing and equilibrium are introduced by examining how sound is received, processed along its pathway, and finally interpreted at the cortical level. Only limited information on the vestibular system is provided.

During instruction on the visual system, each cranial nerve within the orbit is dissected. The neuroanatomy component for each cranial nerve involves examination of its pathway. The visual pathway and an overview of the visual system are studied, including examples of lesions along the pathway and their effects in the visual fields. The control of eye movement, as well as autonomic control of the smooth muscles of the eye and tearing, is examined.

When the pharynx and larynx are dissected, the neuroanatomy of CNs IX, X, and XI are studied. This is an opportunity to review the corticobulbar pathway and the parasympathetic functions of CN X. Olfaction and the olfactory pathway are studied as the nasal cavity is dissected. With the examination of branches of CN V2 from the pterygopalatine fossa, a lecture on the neuroanatomy of pain and its central processing is given in conjunction with the clinical correlation on dental anesthesia.

Finally, as students work on the dissection of the oral cavity, the pathways for taste and CN XII are discussed. The autonomic control of salivation is investigated as the submandibular and sublingual glands are dissected. To highlight the important role that neuroanatomy is likely to play in future dental practice, a clinical correlation on how to do a cranial nerve exam is presented by a faculty member in the Oral Diagnosis and Oral Medicine course.

The combined approach to neuroanatomy in conjunction with head and neck anatomy is not standard in medical schools, but it is my impression that the dental students are more interested and retain more neuroanatomy if they see the course content in relationship to their future dental practice. The integrated curriculum fulfills the recommendations of the IOM study, the Future of Dentistry report, and accreditation standards. The University of Cincinnati medical school has recently adopted a similar approach to the integration of neuroscience with head and neck anatomy.[9] The investigators found that medical students understood neuroanatomy principles and spinal cord pathways better than with the traditional curricular approach and they also demonstrated more comprehension of how neurological defects related to changed cranial nerve function.

The integrated approach to teaching neuroanatomy as a component of the Head and Neck Gross Anatomy course at the University of Louisville provides dental students with the basic concepts of neuroscience, pain pathways, autonomic nervous system, and detailed information on the cranial nerves. The use of clinical correlations relevant to dentistry enhances the application of the basic science in future preclinical and clinical courses.

REFERENCES

1. Curriculum Committee. Competencies for the new dentist. University of Louisville School of Dentistry, 1998.
2. Sessle BJ, Bradley RM, Dubner R, Matthews B, Moller E. Dental neuroscience. New Dentist 1979;10(4):32-8.
3. Section on Anatomical Sciences of the American Association of Dental Schools. Curricular guidelines for neuroanatomy. J Dent Educ 1981;45:88-96.
4. Section on Anatomical Sciences of the American Association of Dental Schools. Curriculum guidelines for neuroanatomy. J Dent Educ 1992;56:762-5.
5. Robertson LT. A survey of neuroscience courses for predoctoral dental students. J Dent Educ 2000;64:416-21.
6. Institute of Medicine. Dental education at the crossroads. Field MJ, ed. Washington, DC: National Academy Press, 1995.
7. American Dental Association. Future of dentistry. Chicago: American Dental Association, Health Policy Resources Center, 2001.
8. Commission on Dental Accreditation. Accreditation standards for dental education programs. Chicago: American Dental Association, 1998.
9. Griffin BF, Drake RL. Gross anatomy of the head and neck and neuroscience in an integrated first-year medical school curriculum. Anat Rec 2000;261:89-93.