STOMATOLOGY FOR THE 21ST CENTURY -
The Education and Practice of Tomorrow's Dentists

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ABSTRACT

New developments in science (minimally invasive surgery, tissue engineering and digitalization), society (information technology and connectivity) and education (the cyber university) offer opportunities for dentistry in the 21st century to move beyond the tooth to become stomatology, the orofacial medical specialty. This paper explores the implications of these developments on the definition and delivery of oral health care and delineates some of the challenges to becoming craniofacial physicians. Dentistry must acknowledge and respond to these transitions or risk being increasingly marginalized in the consolidation of health care.

INTRODUCTION

It is tempting at the beginning of any epoch to review the past and plan for the future. I have yielded to a popular temptation at the beginning of this millennium to disclose my own ideas about the future of dental practice and dental education. These projections are based on emerging technologies and demographics as well as the restrictions that the word "dental" consciously or unconsciously places on its practitioners and the public in the United States. These projections may be applicable elsewhere. The future will certainly differ from the present. How it will differ depends on our ability to understand, evaluate and incorporate in our thinking, our life styles and our practice the aspects of emerging technologies that enhance and expand our professional potential to improve oral health. Let me illustrate this by considering the following revolutionary technologies: minimally invasive dentistry; tissue engineering; digitalization and the World Wide Web.

The movement to minimally invasive dentistry began in the 1970s with the development of restorative materials that bind to enamel and dentin. This conserved both tooth structure and strength. Further development of these technologies are likely to lead to esthetic restorative methods that duplicate the strength and wear resistance of the natural dentition. Minimally invasive dentistry has recently spread to its surgical specialties, following the lead of minimally invasive surgery itself, resulting in fewer quadrants of periodontal surgery and more focused maxillofacial surgery as we have increased our understanding of the etiologies of disease, trauma and congenital malformations in the craniofacial region. Tissue engineering is a rapidly expanding technology that utilizes basic principles of biology and engineering. Cells and growth factors are combined with a biocompatible, often biodegradable, matrix to restore missing tissues or organs. This technology is best developed for skin and cartilage and will soon be available for other tissues, including the periodontium. And salivary glands. Thus, both minimally invasive procedures and tissue engineering constitute a variety of novel approaches to the clinical practice of our profession.

The digitalization revolution has impacted dentistry most notably in radiology, where the digital radiograph offers high resolution, easy storage, rapid comparison with previous digital data and instant transmission to consultants or third party payers. Digitalization has expanded to the dental record and even the dental office itself. The challenge here is to incorporate this technology without deprecating the personal attention on which appropriate, personal oral health care depends.

The World Wide Web has brought great changes to both our society and our profession. Access to the Internet is becoming widespread in both homes and offices and communications by
electronic mail are escalating. E-commerce is being used by patients to select dentists and appointments are increasingly being made and confirmed by e-mail. Soon any office without digitalization and electronic capabilities will be left behind both socially and professionally.10

In the 20th century dental education was standardized to follow that of medicine11 and dental practice benefited from technological developments and scientific advances in biology, surgery, infection control and dental materials. In the 21st century the challenges to dental education and practice will be even greater as we discover more about the interdependence of oral and systemic health and disease12,13 and as our profession, forced to look beyond the tooth, seeks closer ties with medicine and health care.14

THE IMPLICATIONS OF STOMATOLOGY

A major challenge to dentistry is whether it will continue its professional development to incorporate oral health into health care.15 Will we become the experts in craniofacial health and help monitor the systemic health of our patients by what can be found in and around their mouths? The mouth is a mirror of numerous systemic conditions (cancers, bone diseases and infections, to name a few). In short, are we willing to move beyond being "tooth doctors" to being "mouth doctors"? If so, then we need to change both our focus (to the oral or craniofacial complex) and our name (to stomatology or a similar broad term) as we expand dental practice and education to become the physicians of the orofacial region. If not, dentists will become essentially technicians, be increasingly marginalized in health care and see their professional prestige eroded.

DIAGNOSIS

In the 21st century molecular technologies will make clinical diagnoses fast and efficient. Combined with the patient history, clinical observations and radiographic surveys currently employed, the new diagnostic armamentarium will support the emerging view that orofacial diseases and congenital anomalies are localized, site-specific events. This will in turn blend with the trends toward digitalization, minimally invasive clinical procedures and expansion of the clinical applications of tissue engineering (see above). Thus, diagnosis will acquire an expanding molecular base that will affect every aspect of clinical dentistry - from site-specific infections of the periodontal diseases and the pulp to specific gene alterations in congenital malformations.

TREATMENT

The local nature of specific dental pathologies implies that treatment in the 21st century will be increasingly targeted to specific sites. Methods for prolonged local drug delivery (fibers and microchips) will make treatment of disease-specific pathologies also site-specific. The strategy will be to modify local biological responses (illustrated but not limited to inflammation) by local delivery of drug combinations.16 Presently, this approach is limited to single antibiotics and single growth factors. Future developments will include combinations of each and sequential delivery of different drugs/growth factors - a virtual local pharmacy. Thus, what is emerging from molecular biology is the ability to target specific factors to specific sites in specific delivery sequences to treat disease and/or accomplish predictable tissue regeneration.

Surgery will also become more selective, site-specific, precise and less invasive.17 The applications of computer and radiographic technologies to surgery are already enhancing the precise, 3-dimensional placement of surgical devices,18,19 reducing time and morbidity. Combined with tissue engineering, surgical procedures will greatly expand therapeutic options for craniofacial problems. The mouth has long been known as a mirror of the body - an observation on which the field of oral medicine is based. Current technology, employs largely visual and radiographic methods. With the development of miniaturized sampling devices, molecular techniques, including PCR, are increasing the number and sensitivity of diagnostic and therapeutic options. Taken together all of the above indicate that the professional expertise of dentistry is shifting beyond the tooth to the oral cavity and adjacent tissues - stomatology.

A recent development in both medical and dental therapy is the use of evidence-based analyses.20 Evidence-based health care21 is an attempt to apply the appropriate results of specific scientific investigations to a particular patient.22 In essence, it
is a study in itself of the available evidence and the individual patient. This includes defining the patient’s problem, determining the information needed to address it, conducting an efficient search of the literature for this information, evaluating the scientific validity of each study and its specific application to this patient, selecting the best of these studies, extracting the clinical message for the patient, discussing this with colleagues and finally treating the patient. By far the most important step is critical evaluation of each study to assess its strengths, weaknesses and applicability to a given patient.23 Given the variables of sex, age, genetic background and drug history of participants in published studies and the paucity of randomized, double-blind clinical trials, currently there are few opportunities in medicine and none in dentistry for evidence-based care.24-25 But, this is the wave of the future for effective, individualized and efficient health care and it will be possible with the appropriate electronic connections at the office (Example: Ovid Technologies-Evidence Based Medicine Reviews on line). It is the best way to ensure that any dental care provides effective interventions at the right time, in the right way, for the right patient to get the best results.26 To use research and information technology effectively dental practitioners in the 21st century must be critical thinkers, users of outcome data, life long learners and must be willing to set and uphold standards. This is not easily accomplished and we have a long way to go professionally.

PREVENTION

The most effective health care emphasizes prevention and most people will continue to see dentists more frequently than physicians. These opportunities, when combined with the trends discussed above, expand the contributions that stomatologists will have to prevent decay, to detect the early oral manifestations of systemic pathologies and to counsel patients about the influences of diet, nicotine and periodontal infections on health itself.14 In the 21st century we can expect an even more important role for the dental profession in promoting general health by being gatekeepers for prevention.

DENTAL EDUCATION

Potential changes in dental education may be a bit easier to predict than much of the foregoing because of three significant evaluations of dental education in the United States in the 1990s. The first, in 1993, was by the Pew Foundation Health Professions Commission27 the second came in 1995 by the Institute of Medicine (IOM) of the national Academy of Sciences28 and the third was published in 1998 by the American Dental Association.29 There were common themes in each. The most comprehensive was the IOM study entitled, Dental Education at the Crossroads: challenges and change.30 It made 22 recommendations in four categories:

1. the need to use more medical information in clinical practice (implying a need for greater integration of dentistry in health care)

2. the need for dental educators to be more desirable role models for both teaching and practice,

3. the need for dental schools themselves to be integrated into health care schools/universities so that dental students can learn to work more closely with other health care students, and

4. the need to improve methods of teaching, testing and practice.

This report challenged most dental schools to be more in touch with their students and with developments in education, health care and clinical practice; in short, to produce stomatologists. Dental schools must make the basic sciences more clinically relevant, their clinical sciences more evidence-based and their staff more experienced in communication technology and pedagogy and in performance-based evaluations.31 Otherwise, the escalating information overload leads to information anxiety32 rather than information management, the mastery of information access and critical thinking.33,34 Most schools still use methods designed to graduate novices or beginners, as described by Chambers and Glassman35, rather than competent practitioners or experts. The result is an underinspired graduate who has few desirable role models for practice and even fewer for an academic career.36 Indeed, the lack of well-trained, full time academic faculty in dental schools is a major problem and will be a crisis within a decade when significant numbers of current staff retire.37,38
center and its scientific and practitioner bases.\textsuperscript{39,28} It will teach and test using a wider variety of methods including on line. Yes, it will be part of a cyber university where learning on line will be the norm.\textsuperscript{40} Interactive three-dimensional imaging technology will be used in most courses to teach technique, diagnosis, treatment and maintenance.\textsuperscript{41} Methods, such as critical thinking and analysis, will replace facts at the curricular center. The new role of the teacher\textsuperscript{42} will be as mentor, teaching and modeling how to test the validity of basic and clinical research data and how to apply this in practice.

CONTINUING EDUCATION

The role of continuing education in dentistry is to help all practitioners keep up to date in new procedures, help them sharpen their evaluative skills and support the commitment to life long learning, which sustain all health care professions. This is the cornerstone of effective evidence-based care. Continuing education will become increasingly on line rather than at a specific site - to reduce costs and to increase interactions. This will be easy with the emergence of the cyber university and an electronically connected society. Stomatologists and other physicians will be connected in focus groups on line during and after formal education to maintain clinical skills and to understand new scientific advances and their applications. Molecular monitoring for both diagnosis and treatment will be commonplace and will be updated more frequently than current software programs for PCs. Continuing education will be not only necessary but enjoyable if dental education graduates the appropriate practitioner.

MOVING AHEAD

If this can be the future,\textsuperscript{43} how do we get there? It will not be easy. First, the most important attitudes for facing the future are an open mind and flexibility. None of us sees the present clearly, not to mention the future. We must be open to the strengths and the weaknesses of the present and seek ways to make our profession stronger in its service as a healing art. What will this take? How can this be best accomplished? What are the current trends in science and society that can be used to improve the future? I have outlined my responses to these and other questions above.

Second, we can expect considerable resistance to any change.\textsuperscript{45} This will come from the students themselves but also from the staff, who have their own inertia and zealotry about maintaining the status quo. Thus, staff must be given the time and the resources to retrain. Because staff will be mentors and role models, it is imperative that the competency and dedication of the staff be the first order of transformation. Life long learners are created by role models and learning institutions who constantly demonstrate that the joy of discovery and learning lead to understanding, not just rote memory and recall. The environment of learning will be changed when students and staff learn together on line, in the classroom, laboratory, clinic and community. No one’s learning habits are more important than the leaders, who must lead by example.\textsuperscript{44}

Third, we must have a vision to provide direction. A shared vision also provides some of the natural energy needed for change. Thus, leadership is needed not only to inspire and support staff but to create and interpret the big picture in consultation.\textsuperscript{46} According to Bethel,\textsuperscript{47} effective leadership has a mission that matters, thinks big, is ethical, is a master of change, is sensitive, a risk taker, a communicator, a team builder and is courageous and committed. Our profession in the 21st century will need these characteristics in abundance if we are to become who we can be. Are you ready to join the quest?

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