Evidence-based Medicine Applied to Fixed Prosthodontics

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One of several definitions of prosthodontics is: "The discipline of dentistry concerned with the consequences of congenital absence or acquired loss of oral tissues for appearance, stomatognathic function, comfort, and local and general health of the patient, and with the assessment of whether more good than harm is done by inserting artificial devices made from alloplastic materials to change these conditions."[1] Advances in prosthodontics rely on research from multiple sciences. Basic and applied research in chemistry, physics and biomaterials testing are core subjects, since treatment decisions made to achieve esthetic and functional goals have to follow the possibilities and limitations of available dental biomaterials.

The next level is clinical research, which includes animal studies, epidemiology and clinical studies on human subjects. The practice of prosthodontics, however, lies in the interfaces between health, illness and disease and therefore needs to also draw on theories from the humanities (psychology, philosophy and ethics), the social sciences (sociology and anthropology) and the organizational sciences. Hence, to provide optimal patient management, knowledge is needed about patient help-seeking behavior, doctor-patient interaction and clinical decision-making, as well as about the process of quality development, and adaptation and implementation of new skills and technologies. Proficiency in prosthodontic care can also be further improved by training in key theoretical and practical concepts of communication theory, health beliefs, coping, stress, somatization, empowerment, health technology assessment, quality development, health economy and an understanding of patient priority setting.

Characteristics of the Practice of Prosthodontics

Regardless of whether the dentist is conscious or not of these multifacetted dimensions associated with best clinical practice, three key procedures are essential when managing the individual patient:

1. Identifying the individual patient's problems and needs, priorities and preferences and expectations of prosthodontic treatment
2. Conducting a thorough examination and undertaking appropriate diagnostic tests to arrive at correct diagnoses
3. Presenting and discussing alternative prosthodontic interventions with a clear focus on the possibilities and limitations in order to reach the intended treatment outcome, as well as prognosis, including predictability, risks and potential side-effects.

If we imagined ourselves as a patient we would probably be in agreement that our preference would be to be treated according to the best available scientific evidence as regards accuracy and precision of diagnostic tests, as well as receiving efficacious and safe therapeutic, rehabilitative and preventive interventions leading to predictable and long-lasting positive outcomes. We would probably also favor a doctor who would integrate these concepts with undertaking thoughtful identification and compassionate consideration of our predicament, rights and preferences and who would be open to discussing with us the possible therapeutic alternatives. Although conscientious clinicians have always attempted to apply such principles, their feasibility in practice is hampered by several difficulties.

One fundamental problem is that most dentists are not taught how to carry out a critical appraisal of the scientific literature. This skill is required to prepare for life-long learning. Society expects that health professionals maintain a standard of care by adopting only new procedures and biomaterials that have been scientifically validated.[2] Especially in the current climate of health information overload, the dentist needs continuously to digest new information that may or may not be scientific. Otherwise potentially ineffective and even damaging techniques and materials are offered to patients, who have little or no background to doubt the health provider's recommendations.

Several examples from the field of fixed prosthodontics can be identified where undocumented procedures and technologies have been adopted and advanced by dentists. While some novelties appear and

vanish rapidly from the market others persist, unfortunately to the detriment and/or unnecessary expense of patients (Table 1).

Why do we have a questionable track record of implementing undocumented and/or inappropriate therapies in dentistry? An alternative explanation to lack of the training in critical skills appraisal of new

TECHNOLOGY	INTRO	COMMENT
Posts placed consistently in all endodontically treated abutments.	~1920	Any post, metallic or polymeric will weaken an abutment tooth.
Routine use of a pantograph to record maxilla-mandible relations.	~1930	Time consuming, low reliability and no documented benefits to patient.
"Inlay-bridge" as opposed to extra-coronal tooth preparations.	~1950	Likelihood of iatrogenic damage high if partial de-cementation.
Palladium-Silver alloy for metal-ceramics.	~1974	Ag^+ ions leakage into ceramic resulted in green discoloration.
Vertical Dimension of Occlusion determined by use of EMG.	~1975	"Neuromuscular dentistry". Usually component part of 32-tooth rehabilitation.*
Resin bonded/etch bridge offered as a permanent solution.	~1975	Debond rate inferior to conventional FDP. Technique sensitive, cement is critical.
Sintered ceramic FDP (e.g. Cerestore, Dicor, Hi-Ceram).	~1983	Failed the test of time. No long term clinical data available.
Ceramic posts (e.g. Bioceram).	~1975	Failed the test of time. No long term clinical data available.
Glass-ionomer core build-up (e.g. Miracle-Mix).	~1981	Failed the test of time. No long term clinical data available.
Light-cured resin veneering of Type-3 gold alloy prostheses.	~1980	More discoloration over time than the former heat-cured products.
Repositioning splint → occlusal change (e.g. "Farrar splint").	~1980	Extensive occlusal rehabilitation. Likelihood of TMD improvement small.
1st generation ceramics veneered to titanium substructure.	~1985	Has improved with subsequent formulae. Many formulations.
Silicoup instead of retention pins in cast frameworks.	~1990	Acrylic teeth pop off cast framework over time, especially implant-retained.
1st generation Zirconia posts.	~1995	No data available. Many formulations today.
Fiber-composite as a permanent solution (e.g. Targis-Vectris).	~1995	Rapid deterioration after ~7 year intra-oral function. Product withdrawn.
1st generation Zirconia implant abutments.	~2000	Some manufacturers had to pull their product completely off the market. Many formulations today.
CAM-milled All-ceramic 3-unit FDP (e.g. CEREC 3).	~2000	Promotion stopped after 2 years due to failures.
Pressed ceramic FDP (Lithium Disilicate).	~2001	Clear inferior clinical performance of 3-unit FDPs compared to metal-ceramic FDPs.
Zirconia FDP.	~2006	Longevity unknown. Veneer-Core ceramic incompatibility remains. Many formulations today.

* Thriving and flourishing in several entrepreneurial continuing education institutions in cooperation and assisted with heavy support from the dental industry.

Table 1. Fixed prosthodontics procedures and technologies adopted by dentists in spite of having no or very weak documentation of clinical efficacy, some of which are still being promoted to patients, e.g. on the Internet.

health technologies and scientific documentation can be that there may be a widespread naiveté amongst dentists towards the dental industry's marketing promises. Yet, the uncomfortable and lingering question is whether it genuinely is the interests of our patients that are always and only at the forefront of our work and practice priorities. It is important for the profession to seek the answers to the question if we are to secure and maintain the public trust. Implementing evidence based medicine at all levels of undergraduate, graduate and post graduate teaching, and in clinical practice, may be one way to rectify the current predicament.

Evidence-based Medicine

People who seek help from professionals have a right to expect that formal measures have been taken to assess the relative merits of the various forms of health care on offer, be these, for example, radical surgery or fixed prosthodontics.[3] There is increasingly wide support for the principle of conducting reliable critical assessments of the effects of health and social interventions on outcomes that matter to the people to whom they are offered.

Debate continues, however, about the methods of assessment that should be used in implementing this principle in practice. Different strategies for continuously improving the effectiveness and quality of health care have been proposed using a plethora of labels: outcomes research, technology assessment, quality management and assurance, clinical guidelines, standards or parameters of care, health economy analyses are terms associated with such activities. A common denominator for these different strategies is concern about the appropriateness of health care, whether on an individual or on a population level. It is in this perspective that one needs to understand the new strategy for teaching medicine introduced in 1991 at the Medical Faculty of McMaster University in Canada and coined *evidence-based medicine (EBM).* One of the reasons for change was that the curriculum until then had been conceptually built on suggestions in a report dating from 1910 submitted to the U.S. government.[4] This report acknowledged that many of the diseases and interventions at the time were poorly understood. Hence, the answers to the cure of patients' ill-health were hopefully to be found primarily in laboratories and not so much by direct patient observations. The report resulted in curricula with a heavy emphasis on pathophysiology and the teaching of basic

sciences, with a mandatory minimum 4 years of studying. Incidentally, this hierarchy still persists in many medical and dental teaching institutions around the world where the teaching of basic subjects, which may be more or less disassociated from clinical practice, precede clinical patient treatment. Over the years since 1910, however, research activities in biological sciences have been formidable, and maintaining an overview is simply overwhelming.

Moreover, at a hitherto unknown point, there is a disconnect between being able to provide necessary and adequate care for a patient and the need to know all current knowledge about basic biology details. Additionally, therapeutic interventions and concepts of care in medicine have undergone rapid and continuous revisions the last three decades that have not been primarily based on basic, but on clinical research.

Understanding clinical research required new skills, such as how to critically appraise all new information rather than rote memorizing facts in basic biology. The brave stance taken by the medical educators at McMaster University was to break away from the Flexner model. Although recognizing that traditional medical training resulted in a more-or-less thorough understanding of basic mechanisms of disease and pathophysiological principles, there was also the perception that education did not adequately prepare the physician for the life long professional duty to continuously assess and evaluate the new diagnostic tests, treatments and guidelines for clinical practice that continuously were presented in the scientific literature.[5]

EBM was at its outset an educational strategy. It is remarkable that its principles have since with an explosive speed been adopted worldwide as an underlying basis for the organization and delivery of all facets of health care within all spheres of biomedicine. There are journals named evidence-based nursing and evidence-based mental health, textbooks entitled evidence-based health care and evidence-based health promotion, and disciplines termed evidence-based physiotherapy and evidence-based dentistry. The common denominator is that the healthcare provider should aim to consistently identify and apply the current best evidence in preparing treatment strategies and care of patients. What can be considered as best scientific evidence will vary depending on what type of clinical problem one is faced with (Table 2). It is imperative to recognize that a lack of evidence from optimal study design does not automatically invalidate a clinical

1. Clinical findings 2. Diagnostic tests 3. Differential diagnosis	• clearly identified comparison groups, at least one of which is free of the target disorder or derangement; either an objective diagnostic standard (e.g. machine-produced laboratory result) or a contemporary clinical diagnostic standard with demonstrably reproducible criteria for any objectively interpreted component (e.g. report of better-than-chance agreement among interpreters) • interpretation of the test without knowledge of the diagnostic standard result • interpretation of the diagnostic standard without knowledge of the test result • an analysis consistent with the study design • for pre-test probabilities, also a consecutive series or random sample of patients from a clearly defined setting
4. Etiology	• clearly identified comparison group for those at risk for, or having, the outcome of interest • controlled trials; cohort-analytical studies with case-by-case matching or statistical adjustment to create comparable groups; or case-control studies • masking of observers of outcomes to exposures (this criterion is assumed to be met if the outcome is objective [e.g. all-cause mortality or an objective test]) • observers of exposures masked to outcomes for case-control studies and subjects masked to exposure for all other study designs • interpretation of the diagnostic standard without knowledge of the test result • an analysis consistent with the study design
5. Therapy 7. Prevention 8. Education	• random allocation of study participants to different interventions • outcome measures of known or probable clinical importance for at least 80 percent of participants who entered the investigation • an analysis consistent with the study design
6. Prognosis	• an inception cohort of persons, all initially free of the outcome of interest • Follow-up of at least 80 percent of patients until the occurrence of either a major study endpoint or the end of the study • an analysis consistent with the study design

Table 2. Specific criteria needed to be completed for studies to be considered as good evidence.

practice or belief. Lack of evidence of effectiveness is not the same as evidence of no effectiveness. Unfortunately, many have problems differentiating between these two phrases.

The Scientific Evidence for Fixed Prosthodontic Treatment

Managing patients to be restored with fixed prostheses follows a sequence of steps, each supported by a body of clinical research that serves as the foundation for best patient management (Table 3).

Table 3. Steps involved in the provision of a customized FDP.

I. THE PATIENT'S PROBLEM AND PERCEPTION OF TREATMENT NEED VERSUS OBJECTIVE TREATMENT NEED

Reasons for variations in perceived problems caused by missing oral tissue.
Patient oral health literacy and need for oral health education.

II. IDENTIFYING THE THERAPEUTIC OBJECTIVES

- Criteria used to define need versus outcome, morphologic, functional, esthetic, psychometric and/or subjective?
  How valid and reproducible are these criteria?
  Who should define "minimum satisfactorily" outcome criteria?
- Cost-effectiveness and utility versus other treatment alternatives?

III. BEST PROCEDURES FOR FABRICATING AN FDP

- Diagnosis of the state of the occlusion and the quality of abutment teeth
- Technical procedures, including estimated risk for technical and biological complications

Clinic	The laboratory
1. preprosthetic care including periodontics and endodontics	
2. determine need and choice of post and core	
3. select and handle biomaterials properly	
4. perform adequate tooth preparation	
5. select and handle impression material and technique	
6. select and handle provisional solution	
	7. choice of die material
	8. choice of investment
	9. choice of casting
10. select and handle cement material and technique	
11. determine recall frequency and level of maintenance	
12. best intervention to empower patient to maintain adequate oral hygiene and self-care?	

IV. JUDGING THE TREATMENT PROCESS AND FINAL OUTCOME

- To what extent were the therapeutic objectives reached?
- Were there adverse outcomes?
- Did technical and biological complications occur that reduced the probable longevity?

I. Patient's problem and perception of treatment need versus objective treatment need

Patients with missing hard and soft oral tissues seek professional care with a multitude of perceived needs and treatment expectations in the context of correcting an apparent physical manifestation, a functional disability unease, a psychological strain and any degree of social stigma discernment.

Missing oral tissues per se are not, and seldom lead to, a pathophysiological process. As a consequence, prosthodontic care should be regarded as elective and as such, the patient's values and preferences take precedence in all treatment decisions. Moreover, because prosthodontic care can be costly, financial constraints often influence the final treatment decisions. Comparisons across country borders have clearly shown that the payment system influences the choice of prosthodontic technical solution.[6]

Investigators have attempted to elucidate the interplay between patient-perceived needs and rendered treatment by the use of vari-

ous study designs, although the preferable study design is qualitative research or cross-sectional surveys involving representative population samples. Qualitative research aims to make sense of, or interpret, phenomena in terms of the meanings patients and/or clinicians bring to them. Clinical problems are ideally addressed through clearly formulated questions and the use of more than one research method (triangulation) and the analysis of qualitative data can and should be performed using explicit, systematic, and reproducible methods.[7] Several studies in Sweden have focused on the marked variation among patients' expectations, values and priorities that influence treatment decisions, provision of therapy, change in perceived quality of life, practice profile differences and medico-legal dimensions of prosthodontic patient management.[8-11] The psychological impact of having a non-physiological occlusion, tooth misalignment or discoloration, and even losing teeth may range from indifference to great distress and obviously influences patient perception of treatment need.

In many situations, inadequate oral hygiene, most often due to oral health illiteracy, is the patient's main problem and must be addressed prior to considering fixed prosthodontic therapy in order to ensure a positive treatment outcome and reduce the risk of further oral diseases induced by a prosthesis made from a foreign material. Which intervention that works best for motivating and educating patients is best assessed in a randomized controlled trial (RCT). One needs to be aware that the strategies for improving patient motivation for improved self-care that have been shown to work in some cultural and/or demographic settings may not necessarily be universal to all patients.[12]

II. Identifying the therapeutic objectives

The patient's determination to undergo fixed prosthodontics therapy as well as the choice of treatment strategy and selection of technical solution reflect both patients' and dentists' concerns. Examples of concerns within four domains can be identified:

1. **Physiological need:** satisfactory and comfortable mastication, i.e., chewing ability, bite force, maintenance of remaining tissues, dietary longing etc.
2. **Psychological need:** orofacial body image, perceived quality of life, perceived satisfaction with prostheses, self-esteem, interpersonal relations etc.
3. **Longevity/maintenance/risk demand:** minimal risk of

morbidity, provision for easy and routine maintenance, provision for planned and unplanned design modifications, time-dependent wear-and-tear concerns in varying and variable intraoral environments that may become increasingly unpredictable with biological and chronological aging.

4. **Financial impact:** Direct cost of treatment, maintenance costs, indirect costs.

Exploring the interplay between these treatment decision determinants is also best answered using a qualitative research approach or in cross-sectional surveys. The literature describes criteria for evaluating both treatment need and treatment outcome, which can be categorized as morphological, functional, esthetic, psychometric or patient-subjective criteria. Essential questions are how valid and reproducible these criteria are and who should define the "minimum satisfactory" outcome criteria of fixed prosthodontics. Is it the patient, the clinician, society or the insurance companies? As in other areas of medicine, much attention is addressed to patient-selected criteria for treatment success as an adjunct to, or even in contrast to, the professionals' criteria. However, many problems arise because of the previously identified variations in patients' values and priorities.[13,14] Also, patient satisfaction is the result of many other factors besides the actual care that is given[8,9], which confounds the interpretation of patient-selected criteria for treatment success. Some investigators have attempted to compare and contrast conventional FDP treatment outcomes with, e.g., resin-bonded or implant-supported FDPs. An analogous situation is comparing an endodontic treatment plus single crown to extraction, implant placement and single crown. At best, one may limit comparisons to a clinician-defined criterion for treatment success, such as crown esthetics or perhaps cost. However, comparing levels of patient satisfaction becomes meaningless since the patients' values and preferences in the first place determined the choice of one specific treatment over another.

III. Best procedures for fabricating an FDP

Determining the merits of a diagnostic test scientifically is preferably done using a cross-sectional study design that fulfills the criteria listed in Table 4. Examples within the field of fixed prosthodontics are, to appraise a particular aspect of the occlusion or a specific quality of the teeth or implant selected as the prosthesis abutments.

A. VALIDITY. ARE THE RESULTS OF THE TRIAL OF THIS DIAGNOSTIC TEST VALID?			
1. Did the study address a clearly focused issue? *An issue can be focused in terms of the population studied the test given the outcomes considered*	Yes	Can't tell	No
2. Was there an independent, blind comparison with a reference standard? *Was an appropriate reference test used, e.g. biopsy.* *Were test results and the reference standard assessed independently or blindly?*	Yes	Can't tell	No
3. Did the patient sample include an appropriate spectrum of patients? *Consider, age, sex, severity of disease etc.*	Yes	Can't tell	No
4. Did the results of the test being evaluated influence the decision to perform the reference standard? *Was the reference standard performed on all patients?*	Yes	Can't tell	No
5. Were the methods for performing the test described in enough detail to permit replication? *Look for: Details of patient preparation, test technique, and analysis and interpretation of the result*	Yes	Can't tell	No
B. IMPORTANCE. WHAT ARE THE RESULTS?			
6. Are likelihood ratios given or can they be calculated from the data? *Look for: sensitivity and specificity data* *Positive and negative predictive values*	Yes	Can't tell	No
C. APPLICABILITY. WILL THE RESULTS HELP LOCALLY?			
7. Will reproducibility and interpretability of the test be satisfactory locally? *Consider:* • *How the test is carried out* • *Interpretation of test result*	Yes	Can't tell	No
8. Can the results be applied to the local population? *Is disease severity similar* *Are the results generalizable?*	Yes	Can't tell	No
9. Will the results change my management?	Yes	Can't tell	No
10. Are the benefits worth the harms and costs? *This is unlikely to be addressed by the study.* *But what do you think?*	Yes	Can't tell	No

Table 4. Checklist for critical appraisal of papers reporting a diagnostic test (adapted from Sackett et al.[15]).

The documentation of merits of alternative technical procedures, including risks of technical and biological complications during the treatment process, can be appraised by using different study designs. The clinical relevance of any type of study is only one of the factors to be considered. The other crucial question is how sure we can be that

the study describes the truth. Scientific standards set rigorous rules for how the study is carried out – internal validity – as well as to what extent conclusions can be drawn from the findings, depending on the study design – external validity. Certain minimum criteria need to be met in order that study findings can be regarded as good evidence of effectiveness. Some types of clinical questions are best answered by using specific study design and vice versa (http://www.cebm.net/index.aspx?o=1025). What is considered good and poor scientific evidence is based on probabilistic considerations of the potential that bias will be introduced in the research. The theoretically minimum risk of confounding and bias is associated with the RCT study design. Consequently, most authoritative sources consider RCTs or, even better, systematic reviews of RCTs that show consistent similar direction of effects as the best evidence for assessing the effectiveness of therapeutic or educational interventions. Less strong study methodologies in terms of evidence strength are in decreasing ranking: cohort studies with less than 80 % participant dropouts, case-control studies, case series and case-control studies.

Unfortunately, few RCTs have been reported in prosthodontics, and many of these trials are associated with high potential for bias.[2, 16] This fact may partly explain why so many novel treatment concepts using various dental materials and and/or procedures have emerged and disappeared over the last three decades (Table 1). It is remarkable that, except for a few products, the scientific grounds for advocating these new methods have been lacking or poor. Some thirty alternatives to conventional metal-ceramic crowns have been described. Yet, very few are supported by adequate clinical data. Analogous situations exist for impression materials and procedures, bite registration techniques, gingival retraction management, cements and cementation methods, interim materials, etc., albeit with even less data from clinical studies. Critical appraisal of scientific papers reporting effectiveness of an intervention in an RCT is shown in Table 5.

A. VALIDITY. ARE THE RESULTS OF THE TRIAL VALID?			
1. Did the trial address a clearly focused issue? *An issue can be focused in terms of* *– the population studied* *– the intervention given* *– the outcomes considered*	Yes	Can't tell	No
2. Was the assignment of patients to treatment randomized?	Yes	Can't tell	No
3. Were all the patients who entered the trial properly accounted for at its conclusion *– was follow-up complete?* *– were points analyzed in the groups to* *– which they were randomized?*	Yes	Can't tell	No
4. Were patients, health workers and study personnel "blind" to treatment? *– patients* *– health workers* *– study personnel*	Yes	Can't tell	No
5. Were the groups similar at the start of the trial? *In terms of other factors that might effect the outcome such as age, sex and social class*	Yes	Can't tell	No
6. Aside from the experimental intervention, were the groups treated equally?	Yes	Can't tell	No
B. IMPORTANCE. WHAT ARE THE RESULTS?			
7. How large was the treatment effect? *What outcomes are measured?*			
8. How precise was the estimate of the treatment effect? *What are its confidence limits?*			
C. APPLICABILITY. WILL THE RESULTS HELP LOCALLY?			
9. Can the results be applied to the local population? *Do you think that the patients covered by the trial are similar enough to your population?*	Yes	Can't tell	No
10. Were all clinically important outcomes considered? *If not, does this affect the decision?*	Yes	Can't tell	No
11. Are the benefits worth the harms and costs? *This is unlikely to be addressed by the trial but what do you think?*	Yes	Can't tell	No

Table 5. Checklist for critical appraisal of papers reporting interventions, therapeutical, preventive or educational (adapted from Sackett et al.[15]).

IV. Judging the treatment process and the final outcome

The determinants of success of fixed prosthodontic treatment are identical to the determinants of treatment needs, including validity, reliability and relevance to the patient, the clinician and society. The patient's values and preferences are of prime importance when addressing the issue.[8, 9] The preferred study design for appraising patient satisfaction with treatment is RCTs or longitudinal cohort studies, but some problems may also best be elucidated using qualitative research or cross-sectional data. The preferred study design to estimate the incidence of adverse reactions, longevity and risk of technical and biological complications is RCTs or longitudinal cohort studies. Hypotheses about outcomes, etiology and prognosis can also be developed from data recorded in cohort and case series and case-controlled studies. Several meta-analyses show marked variations of longevity and frequency of biological and technical complications due to differences in study methodology design, as well as patients, materials and operators for conventional tooth-supported partial fixed dental prostheses.[17, 18] One needs also to be aware that patients partaking in RCTs in prosthodontics are not necessarily representative of patients as a whole. Ethically, investigators cannot initiate a clinical study if they have a study arm preference, as they will in such cases knowingly subject a study participant to something they believe is an inferior treatment. Conversely, patients who partake in RCTs are meant to be also indifferent to which study arm they are allocated to, given that informed consent prior to the study has been done properly. In the authors' experience, very few patients are indifferent to which fixed prosthodontic solution they wish to obtain. Although there are some RCT designs that aim to incorporate patient and/or clinician preferences in data analyses, there are very few and they are almost non-existent in prosthodontics. Best evidence about the prognosis of patients having received a treatment is considered to be from prospective cohort studies satisfying the criteria described in Table 6.

What are the Bases for Current Clinical Practices?

Dental school training

A characteristic of school training is that the focus is on how to execute basic, technique insensitive and "safe" clinical procedures. These procedures are not necessarily the most modern ones. For example,

A. VALIDITY. ARE THE RESULTS OF THE STUDY VALID?			
1. Was a defined, representative sample of patients assembled at a common point in the course of the disease? *inclusion criteria of sample* *sample selection explained* *adequate description of diagnostic criteria* *clinical and demographic characteristics described*	Yes	Can't tell	No
2. Was patient follow-up sufficiently long and complete? *Known for all or high proportion (→80 %) of patients*	Yes	Can't tell	No
3. Were relevant, objective and unbiased (blinded) outcome criteria (event) used? *Fully defined prognostic variables* *Measurement method details*	Yes	Can't tell	No
4. Was there adjustment for important prognostic factors? *If subgroups with different prognoses are identified, was there adjustment for important prognostic factors?*	Yes	Can't tell	No
B. IMPORTANCE. WHAT ARE THE RESULTS?			
5. How likely are outcome event(s) over a specified period?			
6. How precise are the estimates of these outcomes?			
C. APPLICABILITY. WILL THE RESULTS HELP LOCALLY?			
7. Were the study patients similar to my own? *Do you think that the patients covered by the trial are similar enough to your population?*	Yes	Can't tell	No
8. Will the results make an impact on selecting or avoiding therapy, or about what to reassure or counsel patients?	Yes	Can't tell	No

Table 6. Checklist for critical appraisal of papers reporting prognosis (adapted from Sackett et al.[15]).

conventional dental restorative materials and procedures are used in a variety of situations in preference to more lengthy and technique-sensitive ones. Moreover, for various reasons, several procedures routinely carried out in general practice are not given room in the tightly packed curricula of many dental schools. Examples relevant to fixed prosthodontics are bone and soft tissue augmentation techniques, crown lengthening, periapical surgery and most dental implant-related procedures. Thus, right from graduation day, dentists need to continuously improve their educational and clinical skills and knowledge. The challenge is where to find objective and valid teaching sources to continue the quest for more learning and how to proceed with the best learning strategy within the limited windows of precious time

from a busy clinical practice. Learning how to practice evidence-based dentistry may be a good foundation for this endeavor.

Clinical experience

Unsystematic observations from clinical experience are not a valid way of building and maintaining knowledge about patient prognosis, the value of diagnostic tests, or the efficacy of treatment. The fallacy of using this approach is summed up by a statement attributed to Charles S Greene[19]:

> *The expression "it works in my hands" seems to serve as a standard of validity for some people, despite the fact that a positive clinical response may be obtained because of, in spite of, or irrespective of the treatment rendered.*

What appears to be a successful treatment outcome must always be evaluated relative to a range of other alternative explanations. Examples are (i) spontaneous remission of a condition; (ii) a placebo response as a function of specific treatment characteristics, such as a radical versus a conservative treatment; (iii) costly over-treatment where a simpler solution could be used; (iv) treatment failure, side-effects or adverse consequence of the treatment that do not emerge right away, etc. Correspondingly, previously perceived negative personal clinical experiences can have been caused by (i) rendering a treatment based on an erroneous initial diagnosis; (ii) having established an incorrect cause-effect relationship; (iii) perception of ineffective outcome while the original patient problem was initially multifactorial; (iv) lack of patient cooperation; (v) improper execution of the treatment or patient management; (vi) premature evaluation of the treatment outcome; (vii) limited scope for evaluating the success of the outcome; (viii) psychological barriers negated by lack of patient satisfaction caused by any relevant or irrelevant issue.

Scientific literature

According to the Ulrich's directory of periodicals, there are currenly approximately 1100 scientific journals on dentistry, presenting some 50,000 new articles each year. It is obviously impossible to read in full text more than a fraction of this information. Consequently, clinicians must learn to focus on the quality of the information, rather than attempting to amass this quantity of information. Review papers can be

very helpful guides for one's own, practice but unfortunately, many are considerably author-biased. In an attempt to quality assure reviews, the concept of "systematic review" has been introduced. Systematic reviews must satisfy two basic requirements: the clinical question or topic must be precisely stated with or without a null hypothesis, and

A. VALIDITY. ARE THE RESULTS OF THE REVIEW VALID?			
1. Did the review address a clearly focused issue? *An issue can be focused in terms of:* *the population studied* *the intervention given* *the outcomes considered*	Yes	Can't tell	No
2. Did the authors select the right sort of studies for review? *The right sort of studies would:* *address the review's question* *have an adequate study design*	Yes	Can't tell	No
3. Do you think the important, relevant studies were included? *look for:* *which bibliographic databases were used* *check from reference lists* *personal contact with experts* *search for unpublished as well as published studies* *search for non-English language studies*	Yes	Can't tell	No
4. Did the review's authors do enough to assess the quality of the included studies?	Yes	Can't tell	No
5. Were the results similar from study to study? *Consider whether:* *the results of all the included studies are clearly displayed* *the results of the different studies are similar* *the reasons for any variations in results are discussed*	Yes	Can't tell	No
B. IMPORTANCE. WHAT ARE THE RESULTS?			
6. What is the overall result of the review? *What are the review's bottomline results? (numerically if appropriate).* *What units are these results expressed in?*			
7. How precise are the results? *Are there confidence limits? What are they?*			
C. APPLICABILITY. WILL THE RESULTS HELP MY PATIENTS?			
8. Can the results be applied to my patients? *Do you think that the patients covered by the trial are similar enough to your population?*	Yes	Can't tell	No
9. Were all clinically important outcomes considered? *If not, does this affect the decision?*	Yes	Can't tell	No
10. Are the benefits worth the harms and costs? *This is unlikely to be addressed by the trial.* *But what do you think?*	Yes	Can't tell	No

Table 7. Checklist for critical appraisal of review articles (adapted from Sackett et al.[15]).

there must be a description of how the evidence was obtained, from which sources and with which inclusion and exclusion criteria before extraction of data from the sources.

Systematic reviews may or may not include some form of statistical analysis of the accumulated data from the individual studies, which then identifies the paper also as a "meta-analysis." However, beware that the term is being used for any paper that aggregates data from multiple studies. One needs to exercise caution when interpreting data from meta-analyses, since the quality of conclusions can never be better than the methodological qualities of the data sources. Aggregated data that originate from studies with dubious quality are generally worthless and can even be considered potentially damaging. The American Dental Association maintains a registry of all systematic reviews within all fields of dentistry, and most of them are also supported with commentaries authored by practicing dentists (http://ebd.ada.org). A checklist for critically assessing the methodological quality of systematic reviews is presented in Table 7.

Alternatively, another strategy is to limit the reading to dental journals that focus on presenting secondary papers, e.g., Evidence Based Dentistry and Journal of Evidence Based Dental Practice. Both journals include critical commentaries of primary studies within oral medicine and dentistry that satisfy generally accepted criteria for good scientific quality.

Clinical guidelines, standard operating procedures, parameters of care, etc.

Although the development and use of clinical practice guidelines have a long history in the health professions, research and audits suggest that their success in changing daily practice is modest. Besides the actual guideline development, they have to be disseminated, explained, accepted as objective and implemented by the profession. While the first step is often undertaken properly, the ensuing steps seem to receive less attention. A very helpful tool for developing and implementing clinical guidelines is the international AGREE instrument (http://www.agreetrust.org). A checklist for critically assessing the methodological strength of clinical practice guidelines is presented in Table 8.

The few existing clinical guidelines developed specifically for the field of prosthodontics have been mostly developed by the use of a consensus approach. A problem when using a consensus approach to guide-

A. VALIDITY. ARE THE CLINICAL PRACTICE GUIDELINES VALID?			
1. Were all important options and issues clearly specified?	Yes	Can't tell	No
2. Was an explicit and sensible process used to identify, select and combine evidence?	Yes	Can't tell	No
3. Was an explicit and sensible process used to consider the relative value of different outcomes?	Yes	Can't tell	No
4. Is the guideline likely to account for important recent developments?	Yes	Can't tell	No
5. Has the guideline been subject to peer review and testing?	Yes	Can't tell	No
B. IMPORTANCE. WHAT ARE THE RECOMMENDATIONS?			
6. Are practical, clinically important recommendations made?	Yes	Can't tell	No
7. How strong are the recommendations?			
8. What is the impact of uncertainty associated with the evidence and values used in the guidelines?			
C. APPLICABILITY. WILL THE RECOMMENDATIONS HELP LOCALLY?			
9. Is the primary objective of the guideline consistent with your objective?	Yes	Can't tell	No
10. Can the recommendations be applied to your local population?	Yes	Can't tell	No

Table 8. Checklist for critical appraisal of clinical practice guidelines (adapted from Sackett et al.[15]).

line development is that its conclusions do not guarantee clinical applicability, reliability or validity.[20]

EBM applied to prosthodontics practice

Applying evidence-based medicine in fixed prosthodontics practice is done by conscientiously asking four questions in actual clinical situations when a need for information arises before making a clinical decision:

1. How can I convert information needs into answerable questions?
2. How can I track down, with maximum efficiency, the best evidence with which to answer them (whether from the clinical examination, the diagnostic results, the published literature, or other sources)?
3. How can I critically appraise the evidence for its validity (closeness to the truth) and usefulness (clinical applicability)?
4. How can I apply the results of this appraisal to this particular clinical situation?

Integration of these questions with the individual elements that form treatment decisions for individual patients is one way of describing the

practice of evidence-based medicine. Evidence-based practice is not a type of cookbook medicine. Rather, it is a strategy to integrate the best available external evidence from systematic research with individual clinicians' clinical expertise. Learning evidence-based medicine is a strategy for how to cope with new information; it is not a strategy for how to learn how to know all the answers. Thus, it is not so much about what you have read in the past, but about how you go about daily to identify and meet your ongoing learning needs and to apply your new knowledge appropriately and consistently in clinical situations. One example is to consider the following patient situation:

> *A 45-year-old patient wishes to have an FDP to close a tooth space. The patient solicits your opinion on the advantages and disadvantages of choosing a non-metal prosthesis, which intuitively the patient prefers but knows nothing about. Your task as a conscientious healthcare provider is to empower the patient to leave informed consent to a treatment that you are qualified to offer.*

Posing answerable questions

Well-formulated clinical questions should be directly relevant to the problem at hand and phrased to facilitate searching the literature for a precise answer. To achieve these aims, the questions must be focused, well-articulated and cover the following issues:

1. **The patient or problem being addressed:** How would I describe a group of patients similar to mine?
2. **The intervention or exposure being considered:** What main intervention, prognostic factor or exposure am I considering?
3. **Comparison of the intervention or exposure with alternatives,** when relevant: What is the main alternative to compare with the intervention?
4. **The clinical outcome:** What can I hope to accomplish, measure, improve or affect?

Applying these questions to our example starts with an initial determination of the patient's values, priorities and expectations of the treatment – does the patient emphasize concern about, for example, the esthetics, prognosis or potential adverse biological effects of the chemical components of the FDP? Let's assume that, besides the primary concern about biocompatibility, the secondary objective for this

particular patient is maximum longevity. Thus, our clinical questions can be formulated as follows: Will an adult patient receiving an FDP benefit from a full-ceramic compared to metal-ceramic solution in terms of longevity? Since this is a question about one therapeutic intervention versus another, the best scientific evidence for effectiveness is considered to be data generated in clinical RCTs (Table 5).

Tracking down evidence

Advances in computer technology have improved the possibility of effectively tracking down evidence from the rapidly growing body of medical information. Due to ease of access, the Internet has become the highway to information about almost anything, including oral health and interventions in dentistry, and has, perhaps inappropriately, been labeled "web medicine." A search engine such as Google can produce large numbers of references. Unfortunately, it will take a vast amount of time and energy to sort out the valid versus the speculative, the professional versus the biased, and the commercial versus the independent information - time that most clinicians do not have.

One great value of using the Internet is the possibility of gaining direct access to large bibliographic databases of the scientific literature. One database is the Medline database administrated by the U.S. National Library of Medicine (NLM). The NLM developed the PubMed interface to open a portal into Medline on the Internet (http://www.ncbi.nlm.nih.gov/pubmed). To simplify even further, a "clinical queries" option has also been made available (http://www.ncbi.nlm.nih.gov/pubmed/clinical). Alternatively, Google Scholar (http://scholar.google.com) identifies both published and unpublished scientific literature, i.e., "grey literature".

A very simple search on PubMed clinical queries using the terms "(partial fixed dental prosthesis) and (ceramics)" with a Therapy "narrow search" filter results in identifying 27 human clinical studies and 16 review papers. The majority of these papers will clearly answer the question that has been posed. Interestingly, the same search strategy yielded only 3 clinical trials in the first edition of this textbook, published about a decade ago.

Critical appraisal of the information

The reviews that were identified should be appraised using the critical appraisal criteria shown in Table 7. The clinical trials should be ap-

praised in accordance with the criteria in Table 5. Papers that satisfy only a few criteria are likely to be biased, and the reported findings must be interpreted cautiously.

Applying the new information in the management of your patient

After describing your findings to the patient and discussing the limitations of the findings due to the study design, you agree on what constitutes the best technical solution for your patient. Alternatively, you and your patient agree to find the latest information about metal intolerance, alternatively the risk of material-related adverse biological effects, using some other criteria for selection of valid and reliable studies with optimal study designs.

Concluding Remarks

The somewhat naïve belief in the past that new technologies are always progress has in many ways been replaced by a more sober skepticism in our society. Yet, the implementation of novel devices and biomaterials that are undocumented seems to still prevail in dentistry. It is discomforting to recognize that the marketing focus for many of these new devices falls within the category of "increase/improve/maximize your efficiency/productivity by buying our novel and unique ..." To assess whether there are suppliers of services for dentists determined to become rich fast is to Google any permutations of an "expert search strategy" like "("dental clinic" | "dental office") AND (increase | improve | maximize) AND (productivity | opportunity | growth | income | economy | profit | profitability | turnover |revenue)". The search yield should provide some food for thought. Where there is an abundance of suppliers, there is usually a profusion of market demand. A more sustainable alternative for the dentists who aspire to remain respected health professionals is to practice a judicious and conscientious approach to patient care. An evidence-based approach for consistently providing best patient care can be practiced on a daily basis.

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