Evidence-Based Prosthodontics

Fundamental Considerations, Limitations, and Guidelines

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INTRODUCTION

The traditional model of care in dentistry involves use of individual clinical expertise and patient treatment needs to provide dental care (Fig. 1). This model of care has been used for centuries across the world and is primarily based on observations, beliefs, and personal and expert opinions. Although this model has not led to any

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devastating effects in dentistry, it precludes systematic assimilation, acceptance, and assessment of new treatment effects. Furthermore, it provides minimal confidence to clinicians for making clinical decisions for new scenarios and new treatments. The term, evidence-based practice, is defined as “the conscientious, explicit and judicious use of current best evidence in making decisions about the care of the individual patient. It means integrating individual clinical expertise with the best available external clinical evidence from systematic research.”¹ This definition stems from the medical perspective, and dentistry is more familiar with the term, EBD.

Currently, there is no definition for evidence-based prosthodontics but it is understood that it encompasses the application of EBD with respect to prosthodontics. According to the American Dental Association (ADA), EBD is defined as “an approach to oral healthcare that requires the judicious integration of systematic assessments of clinically relevant scientific evidence, relating to the patient’s oral and medical condition and history, with the dentist’s clinical expertise and the patient’s treatment needs and preferences.”² Therefore, the EBD process is not a rigid methodologic evaluation of scientific evidence that dictates what practitioners should or should not do but also relies on the role of individual professional judgment and patient preference in this process (Fig. 2).³

NEED FOR EVIDENCE-BASED PROSTHODONTICS

With rapid advancements in dental materials and dental technology and improved understanding of clinical outcomes, a surfeit of research has been published in prosthodontics and dental implant-focused literature (Box 1). Furthermore, a surplus amount of published research exists in interdisciplinary fields that are of critical importance to prosthodontics. It is well known that not all published literature is scientifically valid and clinically useful. Therefore, a critical analysis of the quality of published research and consolidation of the excess scientific information is necessary to render them significant and useful. In an extensive analysis of scientific publications between 1966 and 2005, Harwood⁴ noted that there were 44,338 published articles in prosthodontics. Of these, there were 955 randomized controlled clinical trials (RCTs) (2%). Nishimura and colleagues⁵ identified 10,258 articles on prosthodontic topics between 1990 and 1999 and estimated that to stay current in the year 2002 would require reading and absorbing approximately 8 articles per week, 52 weeks per year, and across 60 different journals. These numbers do not include published articles on implant dentistry. Russo and colleagues⁶ identified 4655 articles published between

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Fig. 1. Traditional model of care in dentistry involves use of individual clinical expertise and patient treatment needs to provide dental care.
1989 and 1999 dedicated to implant dentistry and estimated that to stay current in the year 2000 would require reading and absorbing approximately 1 to 2 articles per week, 52 weeks per year. It is not difficult to assume that these numbers are significantly higher in the year 2013 and will continue to grow due to increased growth in the number of journals and publications, underscoring the need for computer-based clinical knowledge systems and for clinicians to acquire new skills to use the best available scientific evidence (BASE) (Box 2).

EPIDEMIOLOGIC BACKGROUND

The epidemiologic background for evidence-based practice dates back to the nineteenth century, to the work of John Snow, who is widely regarded as the father of modern epidemiology. Snow rejected the popular miasma theory as the cause of the cholera outbreaks in England. Through a systematic method of data collection and analysis, Snow established a classic case-control study and traced the cholera outbreaks to drinking water contamination from the sewage systems. His ideas were rejected, criticized, and not embraced until several years after his death. Similar to Snow’s experiences, other landmark events in modern epidemiology include

| Box 1 |
| **The need for evidence-based prosthodontics** |
| • Enable the recognition of best available scientific evidence in prosthodontics. |
| • Consolidate the scientific information overload in prosthodontics and related literature. |
| • Scrutinize the scientific basis for existing prosthodontic treatments. |
| • Improve current and future treatments. |
| • Encourage improvement in the quality of clinical research as well as in reporting. |
| • Distinguish and advance the specialty of prosthodontics. |
Semmelweis' important discoveries on hand washing intervention to drop maternal mortality rates and childbirth fever and Doll and colleagues' systematic observations on cigarette smoking and its association with lung cancer. Several other similar events have all had a significant impact on worldwide public health.

Pioneering efforts in the twentieth century by Archibald Cochrane called for state-of-the-art systematic reviews (SRs) of all relevant RCTs in health care, leading to the creation of the world-renowned Cochrane Collaboration in 1993 to organize all medical research information in a systematic manner in the interests of evidence-based medicine. The term, evidence-based medicine, itself was first described in the medical literature in 1992 by a working group of a similar name, who stated that this would be a new way of teaching the practice of medicine. The ADA has espoused the principles of evidence-based practices since its inception and has made remarkable progress over the past 20 years to render popularity to the current known principles of EBD for use in clinical practice and dental education.

**CONSIDERATIONS IN PROSTHODONTICS**

An important difference between medical and dental models of care is the level of control a patient has about how, when, and whether it is even necessary to treat a dental condition. This is especially true in the discipline of prosthodontics. Prosthodontics is a unique dental specialty that encompasses art, philosophy, and science and includes reversible and irreversible treatments. Therefore, an absolute extrapolation of evidence-based concepts from medicine to prosthodontics is not possible. Treatment outcomes, which are a core element of prosthodontics, however, render themselves well for application of principles of EBD. There are 3 predominant items that are important to understanding challenges in reporting treatment outcomes in prosthodontics.

**Defining the Outcomes of Clinical Interest**

Key issues in defining clinical outcomes in prosthodontics are multifaceted due to the inherent nature of the treatment. Some examples of these issues include differentiating success versus survival, complications versus consequences, and prosthesis outcomes versus patient-centered outcomes. Another important characteristic is defining the appropriate endpoint of a clinical study. Hujoel and DeRouen have categorized clinical endpoints (outcomes) as surrogate endpoints and true endpoints. Surrogate outcomes include measures that are not of direct practical importance but are believed to reflect outcomes that are important as part of a disease/treatment process. True outcomes, however, reflect unequivocal evidence of tangible benefit to patients. Both types of outcomes are important in prosthodontics, because surrogate outcomes are helpful for preliminary evidence and true outcomes are helpful for definitive evidence (Table 1).

**Box 2**

New skills required by clinicians to adopt evidence-based prosthodontics

- Asking the appropriate research question for a clinical situation of interest.
- Acquiring information through efficient scientific literature search.
- Appraising the acquired information.
- Applying the acquired information to clinical practice, along with individual clinical expertise and patient preferences.
- Assessing the results of the applied intervention to optimize the clinical situation.
Duration Needed to Appropriately Study the Outcomes

The time period needed to study a clinical outcome of interest depends on the definition of a treatment outcome, surrogate or true endpoint desired, treatment effect desired, and adverse events related to a treatment under investigation. Currently, there is no consensus in prosthodontics on definitions for preliminary, short-term, or long-term studies. Therefore, it becomes the prerogative of the investigator, editor, and reader to decide if the result of a study reports on short-term or long-term outcomes. Often, a study with a follow-up period of up to 6 years is described as “long-term follow-up” where only a meager number of samples have actually made it to a 6-year follow-up and the rest have a follow-up of less than 2 years. It is understood that preliminary and short-term studies have high clinical impact when they report failures of a particular treatment; only long-term studies can have high clinical impact for treatment success. Treatment success reported in short-term studies, however, can lay the justification whether additional research is needed.

Minimum Sample Needed to Study the Outcome of Interest?

The sample size of a study depends on the difference in treatment effect desired. In prosthodontics, it is difficult to obtain large sample sizes from a single study center because of the elective and expensive nature of prosthodontic treatment, which has led to a large body of published research in the prosthodontic literature with small sample sizes. For a study to have a large clinical impact and provide sufficient evidence to change a particular clinical practice, sample size is critical. Currently, there is no consensus in prosthodontics on definitions for sample sizes as small, moderate, and large. The validity of defining such sample sizes is currently unknown.

LEVELS OF EVIDENCE AND PROSTHODONTICS

Evidence in medicine has been popularly categorized into 5 hierarchical levels and widely represented as a pyramid with the “weakest/lowest level of evidence” at the base and the “strongest or highest level evidence” at the apex (Fig. 3). This gradation
has been used by several health agencies across the world. Although the 5 hierarchical levels of evidence and the pyramidal representation may be popular in medicine, the applicability of this paradigm to prosthodontics is questionable because few articles in prosthodontics comprise RCTs and large cohort studies, implying that most current clinical practices in prosthodontics are all based on “weak evidence.” Additionally, 2 critical elements of importance to prosthodontics that are omitted from the evidence-based pyramid are sample size and duration of a study. As previously discussed, these 2 elements can significantly affect the way evidence has an impact on clinical practices. For example, results from a cohort or a case-control study with a very large sample size and/or a long-term follow-up on all-ceramic crowns can have a better impact on clinical decisions compared with results from an RCT with a small sample and a short-term follow-up. In this scenario, in spite of RCT regarded as the “strongest evidence,” it would fail to be used by clinicians for confident decision making. Furthermore, major medical breakthroughs have originated from cohort and case-control studies, which are considered by many as “weaker” forms of evidence. The terms, weak and strong, are subjective and exclusive and do not lend themselves to an unbiased assessment of best available evidence in prosthodontics. Therefore, an alternative approach for prosthodontics literature is suggested. The suggested paradigm involves a horizontal spectrum encompassing 3 stages of evidence—preliminary evidence, substantive evidence, and progressive evidence (Fig. 4).

**Preliminary Evidence**

**Expert/experience-based opinions, philosophies, theories, and biologic plausibilities**

Expert opinion is the oldest form of evidence in health care for centuries and continues to remain one of the most popular forms of evidence in contemporary dentistry because it is easy for clinicians to acquire and apply the presented evidence. Expert/experience-based opinions and monographs have dominated the art component of

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**Fig. 3.** Evidence in medicine has been popularly categorized into 5 hierarchical levels and widely represented as a pyramid with the “weakest/lowest level of evidence” at the base and the “strongest or highest level evidence” at the apex. This model may not be applicable to prosthodontics.
prosthodontic literature for almost a century. Additionally, they have a strong representation in the discipline of dental occlusion, dental techniques, choice of dental materials, and dental technology. Expert opinions, philosophies, theories, and biologic plausibilities are all important, because they provide a starting point to initiate and propel new ideas, theories, and innovations and develop further research. Unfortunately, many expert opinions are biased and scientifically not validated. As a result, several popular opinions and philosophies in prosthodontics have not been clinically validated. Some examples include need for balanced occlusion in complete dentures, designs for removable partial dentures, tooth preparation designs, types of restorations in fixed prosthodontics, and many others.

**Laboratory studies and animal studies**

A large body of research in dentistry falls into the category of laboratory studies and animal studies. Compared to clinical research, this type of research is easier to conduct, accomplished faster and allows different types of hypotheses to be tested in a controlled setting. In prosthodontics, due to rapid emergence and advancements of new dental materials, dental technology, and improved biologic understanding, these studies are important because they provide a good foundation before proceeding with clinical studies. Pioneering work on osseointegration done by PI Branemark in his animal/laboratory studies and its subsequent development through progressive research is a testimony for this type of preliminary research. In the discipline of dental materials, independent investigators with a clinical understanding should verify research done by the industry. Studies with promising results should then be progressed to subsequent stages of research. Unfortunately, this paradigm is not often followed in prosthodontics and many dental materials and technology have been used clinically based on laboratory studies alone.

**Case reports and case series**

A single case report/case study describes the unique characteristics and treatment of a single patient, and a case series describes the treatment in a group of patients. With regards to sample size, currently there is no consensus on when a study can be defined as a case series versus a cohort study. It is understood, however, that case series are descriptive in nature and involve a small heterogeneous sample as opposed to a cohort study, which is observational and analytic in nature. Nevertheless, case reports and case series have high sensitivity for detecting novelty and form the basis for detecting new concepts, etiologic clues, side effects, and new treatments and have contributed to major breakthroughs in medicine. In prosthodontic literature, case reports/series typically depict management of unique situations through unique techniques and/or unique materials. Such reports not only help clinicians in management
of similar situations but also aid in laying the foundation for future laboratory studies and clinical trials.

**Substantive Evidence**

**Cross-sectional studies/surveys and descriptive studies**

A cross-sectional study is defined as a study measuring the distribution of some characteristic(s) in a population at a particular point in time. Essentially, the exposure and outcome are measured simultaneously, at the time of the survey. This study design is helpful for preliminary analysis of the prevalence of a condition/disease at a given point of time and for investigating the potential risk factors or causes of the condition. An example in prosthodontics is a cross-sectional study to analyze the prevalence of halitosis in patients with fixed complete dentures. In this example, because there is no temporal assessment, it is difficult to conclude that halitosis is related to fixed complete dentures. However, if significant numbers of samples are from a certain social or ethnic background, have a history of smoking or poor oral hygiene, then the researcher can investigate further to delineate the risk factors.

Descriptive studies are studies that describe a particular characteristic and any related changes due to an intervention. They are commonly reported in prosthodontics with respect to anatomic variations and esthetic-related characteristics. Therefore, temporal considerations, cause-effect analysis, and survival outcomes are usually not applicable to such studies, which does not mean that the evidence from these studies is “weak.” Major understanding of complete denture principles and esthetic dentistry has resulted from such studies. These studies are specific to a given population, however, and describe preliminary data or trends that may or may not be extrapolated to different populations. Some descriptive studies, however, have large sample sizes encompassing different countries and races.

**Case-control studies**

A case-control study is defined as “a study that compares people with a specific disease or outcome of interest (cases) to people from the same population without that disease or outcome (controls), and which seeks to find associations between the outcome and prior exposure to particular risk factors.” Case-control studies are not commonly described in the core prosthodontics literature, probably because prosthodontics typically does not deal with diseases and cure but with treatment outcomes. Compared with cohort studies, they are inexpensive and afford potential for large sample sizes. As a rule, they cannot prove causation, so cohort studies and RCTs are subsequently needed to test a causal hypothesis. Therefore, they are often associated with controversies and have a potential for propaganda by the media. A popular recent example that is relevant to prosthodontics is a case-control study linking the risk of meningiomas and dental radiographs.

Case-control studies are of great value, however, when cohort studies or RCTs cannot be performed due to ethical and patient safety reasons, when controversial causal claims are made by case reports and case series. A popular recent example relevant to prosthodontics is a case series on 4 patients linking zinc-containing denture adhesives to neurologic diseases. Multiple case-control studies would now be required to show converse results before obtaining ethical approval to perform prospective cohort studies and RCTs to examine cause-effect relationships between zinc-containing denture adhesives and neurologic diseases.

**Cohort studies**

A cohort is a well-defined group of persons who have had a common experience or exposure and are then followed-up to determine the incidence of new diseases or
health events. Therefore, by definition, they have the potential to establish causal relationships between exposure and disease. Historically, large cohort studies have produced powerful data that have had an impact on public health around the world. Some of these include the Framingham Heart Study examining cardiovascular disease and dietary cholesterol, the Physicians’ Health Study investigating aspirin and b-carotene on beta heart disease, and cancer and the British doctors’ cohort study examining smoking and lung cancer. It is understood that to have a meaningful clinical impact, cohort studies require large sample sizes and a long follow-up period. In general, there are 4 kinds of cohort studies: prospective, retrospective, nested case-control, and case-cohort study.

Some examples of cohort studies with long-term follow-up, which have had a significant impact on prosthodontics, include Tallgren’s 25-year follow-up study on reduction of the residual alveolar ridges in complete denture wearers and a 20-year follow-up study by Douglass and colleagues on cephalometric evaluation of vertical dimension changes in patients wearing complete dentures. Unfortunately, such studies are uncommon because they are expensive, time-consuming, and difficult to execute without a significant loss to follow-up of patients. Therefore, short-term cohort studies have become widely popular in the prosthodontics literature, but they do not have the potential to change clinical practices or provide enough data for confident clinical decision making. Furthermore, many cohort studies in prosthodontics with longer follow-up periods lack adequate sample sizes and do not report a life table (survival) analysis.

A life table (or a cohort life table) in epidemiology is defined as “a table depicting the survival data of a cohort of individuals in a clinical study or trial. This is essentially the number of items alive and under observation (not lost to follow-up) at the beginning of each year, the number surviving in each year, the number lost to follow-up each year, the conditional probability of survival for each year, and the cumulative probabilities of survival from the beginning of the study to the end of each year.” Life table methods subsequently allow several forms of statistical measures to be used for analysis. Some popular examples used in prosthodontics literature include Kaplan-Meier probability of survival method and the Cox proportional hazards model. Life table methods are extremely important in understanding long-term prosthodontic treatment outcomes, because they allow appreciation of attrition/loss to follow-up of samples from the beginning to the end of the study. Systematic reviews performed on observational studies that claim long-term success/survival have often exposed extremely low sample sizes remaining at the end of the study. Furthermore, different samples in a cohort study are followed-up for different time periods and, without a life table, extraction of useful data is impossible. Therefore, for an observational study in prosthodontics to contribute meaningful evidence to clinicians, providing a life table is paramount.

**Progressive Evidence**

**Randomized controlled clinical trials**

RCT is defined as “an experiment in which two or more interventions, possibly including a control intervention or no intervention, are compared by being randomly allocated to participants.” Because they are interventional/experimental in nature, they have a high sensitivity to prove causation and also yield quantitative data. They are regarded as the best-known method to minimize/control bias, which is defined as a systematic error or deviation in results or inferences from the truth. Due to these primary factors, they are often considered to provide the “highest level” of evidence in medicine. In addition to medicine, randomization is also widely popular in education,
criminology, social work, food industry, and international development. Because of their interventional/experimental nature, RCTs are conducted only after observational and descriptive studies have shown no safety concerns for patients.

In contrast to medicine and even other disciplines in dentistry, RCTs are not popular in prosthodontics for various reasons. In Harwood’s extensive analysis of 44,338 prosthodontic publications between 1966 and 2005, only 955 articles (2%) were RCTs. In another study by Dumbrigue and colleagues in 1999, only 1.7% of articles published in prosthodontic journals met the minimum criteria to be included in central register of RCTs. The same investigator in another study in 2001 noted that only 16% of RCTs published in prosthodontic journals attempted to control bias, indicating the low quality of the RCTs. Similarly, Jokstad and colleagues in 2002 noted that methods of randomization and allocation concealment were not described in 70% of RCTs published in prosthodontic journals. A recent study by Pandis and colleagues in 2010 compared and ranked the quality of RCTs published in top journals across 6 different specialties of dentistry. Their results showed that RCTs published in prosthodontics ranked the lowest among all specialties. All these findings demonstrate the lack of popularity of RCTs in prosthodontics.

Due to the elective and expensive nature of prosthodontic treatment and associated heterogeneity, RCTs are expensive, time consuming, and not easily acquiescent for a large sample size and long-term follow-up. Furthermore, unlike other disciplines, controlling bias is challenging because randomization, double blinding, or even single blinding is difficult and several treatments involve patient input, making it difficult for allocation concealment. All of these are possible reasons for lack of popularity of RCTs in prosthodontics. It is important, however, to understand a few important elements of RCTs that are relevant to prosthodontics and scrutinize them in the published literature.

Methods of randomization Randomization is defined as “the process of randomly allocating participants into one of the arms of a controlled trial.” Broadly, they can be classified as fixed allocation randomization or adaptive randomization and both methods have inherent advantages and disadvantages. Fixed allocation randomization can involve (1) a simple method, such as use of a random integer table; (2) a block method, involving blocks of integers, symbols, or alphabets (usually blocks of 4, such as ABBA); or (3) a stratified method, involving division of the members of population in homogeneous subgroups before sampling. Adaptive randomization methods include baseline adaptive randomization and response adaptive randomization. They are designed to change the allocation probabilities as the study progresses to accommodate imbalances in numbers of participants or in baseline characteristics between the two groups. They also accommodate the responses of participants to the assigned intervention. Another form of allocation that is not truly random is quasirandomization. This entails allocation based on a patient’s medical record number or date of birth or by simply allocating every alternate person. Such methods of allocation are easy to manipulate, leading to a selection bias.

Blinding/masking Blinding in a clinical trial is defined as “the process of preventing those involved in a trial from knowing to which comparison group a particular participant belongs. The risk of bias is minimized when, as few people as possible know, who is receiving the experimental intervention and who the control intervention. Participants, caregivers, outcome assessors, and analysts are all candidates for being blinded.” Due to the elective nature and the amount of control a patient has over his or her prosthodontics treatment, it is important to recognize that is difficult to perform double-blinded or triple-blinded studies.
Concealment of allocation  Allocation concealment in a clinical trial is defined as “the process that is used to ensure that the person deciding to enter a participant into a RCT does not know the comparison group into which that individual will be allocated.” It is widely accepted that the method of allocation concealment should be used as an assessment of the quality of an RCT as it has significant potential to bias the results of a study.

Parallel-group trial or crossover trial  Parallel-group trial or independent group trial is a popular form of RCT and is defined as “a trial that compares 2 groups of people concurrently, one of which receives the intervention of interest and one of which is a control group.” Some parallel trials have more than two comparison groups and some compare different interventions without including a nonintervention control group. In contrast, a crossover trial refers to “a type of clinical trial comparing 2 or more interventions in which the participants, upon completion of the course of one treatment, are switched to another.” A recent example of a well-designed crossover trial design in prosthodontics is a comparison between a 2-implant unsplinted overdenture, a 2-implant bar-supported overdenture, and a 4-implant bar-supported overdenture, where the participants were randomly allocated to receive the prosthesis in various orders of treatment. After the predetermined follow-up period, the participants were then allowed to cross over and receive the subsequent prosthesis. Concerns in crossover trials include the need for additional duration of the study and need for minimizing the influence of one treatment on another (called carryover effect) by allowing a pause (called a washout period). An additional challenge of consideration is the first-encounter bias among patients. This form of bias may lead to a nepotism and influence treatment satisfaction among patients.

Single-mouth trial or split-mouth trial  Single-mouth trials are the popular form of RCT in prosthodontics and involve allocation of 1 treatment of interest per mouth. Split-mouth trials refer to a type of clinical trial comparing 2 or more interventions in which the participants are subjected to random allocation of 1 treatment of half of the mouth and another treatment/no treatment of the second half of the mouth. Depending on the intervention, the mouth can be essentially split into maxilla versus mandible, right versus left, or anterior versus posterior areas. The primary objective of using a split-mouth design is to eliminate all components related to differences between subjects from the treatment comparisons and thereby reduce the error variance (noise) of the experiment and obtain a more powerful statistical test. Comparisons made on a within-patient basis have a disadvantage, however, in that unless a prior knowledge indicates that no carryover effects exist, reported estimates of treatment efficacy are potentially biased. Therefore, an important consideration is whether treatments for each side of the mouth are performed sequentially or simultaneously. An example of a split-mouth trial in prosthodontics is a comparison between all-ceramic crowns and metal-ceramic crowns between right and left sides of the mandible. In this example, although carryover effect may be less significant, all other factors need to be homogenized between the 2 treatments, such as opposing occlusion, opposing restorations, treatment tooth number, patient’s primary chewing/guiding direction, and so forth.

Intention-to-treat analysis or per protocol analysis  Intention-to-treat analysis and per protocol analysis are important terms that describe strategies for analyzing data from RCTs. In an intention-to-treat analysis, all participants are incorporated in the arm to which they were assigned, whether or not they received the intervention given to that arm. Intention-to-treat analysis prevents bias caused by the loss of participants,
which may interrupt the baseline equivalence established by randomization and which may reflect nonadherence to the protocol. Per protocol analysis involves an analysis of the subset of participants from an RCT who complied with the protocol adequately to ensure that their data would be likely to exhibit the treatment effect. This subset may be defined after considering exposure to treatment, availability of measurements, and absence of major protocol violations. This form of analysis may be subject to bias because the reasons for noncompliance may be related to treatment.

**Systematic reviews and meta-analysis of RCTs only**

An SR of the literature is defined as “a review of a clearly formulated question that uses systematic and explicit methods to identify, select, and critically appraise relevant research, and to collect and analyze data from the studies that are included in the review.” A meta-analysis is defined as “the use of statistical techniques in an SR to integrate the results of included studies.” They provide validity for published studies regarding the thoroughness of controlling systematic errors in research methods, sampling, data collection, and data analysis. SRs are significantly different from a traditional literature review, which does not necessarily have a focused question and does not have an accounted search or quantifiable data, and the review itself is subjected to author bias. Therefore, traditional literature reviews primarily serve to answer background questions, such as Who? When? Why? What? Where? and How?, and other descriptive information but do not necessarily answer a clinical question for a patient at hand. SRs help to answer foreground questions because they compare treatments and can answer clinical questions. The focused question for an SR usually follows the PICO format, which comprises (1) patient population of interest, (2) intervention of interest, (3) control/alternative interventions, and (4) outcome of interest.

In medicine, SRs of RCTs are popularly regarded as the gold standard for evidence-based practice. This thought process may not be applicable to prosthodontics due to the well-recognized paucity of RCTs itself. The world-renowned Cochrane reviews published by the Cochrane Collaboration include SRs of only RCTs in dentistry. Cochrane reviews are distinguished from other SRs by their claim of having stringent guidelines and low risk of bias and are updated every few years. Due to stringent inclusion criteria and paucity of RCTs, a majority of Cochrane reviews in dentistry currently conclude with “lack of sufficient evidence” to recommend one treatment versus another. It is expected that with progress and better understanding of clinical research, these conclusions can be more definitive but their impact on prosthodontics is unknown at this time.

**Systematic reviews and meta-analysis of observational studies or all clinical studies**

SRs and meta-analyses of only observational studies or including all clinical studies (both RCTs and observational studies) are widely popular in dentistry as well as in prosthodontics because such reviews are better poised to analyze more studies/data to answer a given clinical question, in comparison to SRs of only RCTs, where data are scarce. Through an exhaustive critical analysis and data consolidation of all clinical studies, they remove the burden from a clinician to independently identify and scrutinize best studies for clinical decision making. In a study analyzing data from observational studies and RCTs, Concato and colleagues concluded that the results of well-designed observational studies (with either a cohort or a case-control design) do not systematically overestimate the magnitude of the effects of treatment compared with those in RCTs on the same topic. The investigators also contended
that the popular belief that only RCTs produce trustworthy results and that all observational studies are misleading does a disservice to patient care, clinical investigation, and the education of health care professionals.35

It is important to recognize, however, that the risk of bias is high in SRs of observational studies compared with SRs of RCTs only. The impact of this risk of bias in clinical decision making for prosthodontics is unknown at this time. Creugers and Kreulen36 performed an SR of all SRs in prosthodontics published over a 10-year period. Two pairs of SRs were identified as dealing with comparable items (survival of fixed partial dentures and survival of single crowns). They concluded that both SRs produced similar results, but the outcomes of the evaluated SRs may be used as prognostic data and cannot be used for direct comparison of treatments.36 With the inundation of publications related to observational studies in prosthodontics, it is expected that the popularity of SRs will continue but it is important that SRs are updated periodically to include new studies and enable prospective and accurate comparison of treatment outcomes.

GUIDELINES FOR REPORTING EVIDENCE

With the burgeoning publication growth in prosthodontics, it is necessary for investigators to comply with certain guidelines for reporting scientific evidence. Several consensus groups and task forces in medicine have suggested various guidelines. The common goal of all guidelines is to improve scientific reporting and ensure standardization so that they allow an accurate assessment of the presented evidence. Popular guidelines are described further.

CONSORT

Consolidated Standards of Reporting Trials (CONSORT) is a popular guideline for reporting RCTs.37 A group of scientists and editors in 1996 developed this statement to improve the quality of reporting of RCTs. The objective of CONSORT is to provide guidance to investigators about how to improve the reporting of their trials and to be clear, complete, and transparent. Several medical and dental journals, including the Journal of American Dental Association, require investigators to report the findings of their RCTs to satisfy the CONSORT. The CONSORT checklist includes 37 items that cover the entire report of a trial, ranging from the study title to the source of funding.

TREND

Transparent Reporting of Evaluations with Nonrandomized Design (TREND) was created in 2003.38 In contrast to CONSORT, the objective of TREND is to provide guidance to investigators to standardize and improve the reporting of studies with non-randomized designs (cohort and case-control studies). The TREND checklist includes 22 items that cover the entire report of a study, ranging from study title to external validity.

PRISMA

The objective of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)39 is to provide guidance to investigators to standardize the reporting of SRs and meta-analyses. Initially, a group of scientists and editors in 1996 initiated a document called Quality of Reporting of Meta-analyses (QUOROM), and, in July 2007, QUOROM was changed to PRISMA. The PRISMA checklist includes 27 items that cover the entire report, ranging from abstract to the source of funding.
PRISMA also provides a flowchart to enable investigators to describe a standardized search process.

**MOOSE**

Meta-analysis of Observational Studies in Epidemiology (MOOSE) was created in 1997.\(^{40}\) The objective of MOOSE is to provide guidance to investigators to standardize the reporting of meta-analyses from nonrandomized studies. The MOOSE checklist includes 35 items, ranging from background to funding source.

**SORT**

Strength of Recommendation Taxonomy (SORT) has emerging popularity in dentistry.\(^{41}\) It was developed by a group of family physicians in 2004 to classify the level of evidence for a study and provide recommendations. The objective of SORT is to provide a patient-oriented guidance to assess the quality, quantity, and consistency of evidence and allows investigators to rate individual studies or bodies of evidence. The recommendations are rated as either A, B, or C based on consistency and quality of patient-oriented evidence.

**AMSTAR**

Assessment of Multiple Systematic Reviews (AMSTAR) was developed in 2007 as an instrument to assess the methodologic quality of SRs.\(^{42}\) It consists of 11 questions to analyze the quality of an SR, such as “Was a comprehensive literature search performed?” and “Was a list of studies (included and excluded) provided?” Each of these questions has 4 possible answers for the investigator: “Yes,” “No,” “Can’t Answer,” and “Not applicable.” This helps investigators critically analyze the quality of a published SR.

**LIMITATIONS OF EVIDENCE-BASED PROSTHODONTICS**

There are some well-known limitations to EBD, and prosthodontics is no exception. Such limitations include applicability of research to a specific patient population, publication biases, paucity of current data, cost, and ethics. Prosthodontics is a unique specialty encompassing art, philosophy, and science and an absolute extrapolation of evidence-based concepts widely described in medicine is impossible. Establishing exceptional evidence, however, for prosthodontic treatment outcomes is paramount for the present and future of the specialty. One of the most popular criticisms for applying concepts of EBD to prosthodontics is that the information gained from clinical research may not directly answer the principal clinical question of what is best for a specific patient. This is because it is acknowledged that the homogeneity and characteristics of patients participating in clinical trials may be significantly different from those seen in dental offices. It is important to recognize, however, that EBD does not advocate absolute adoption of clinical evidence but calls for an integration of the clinical evidence along with the dentists’ clinical expertise and patient needs and preferences. EBD does not provide a cookbook that dentists must follow nor does it establish a standard of care.\(^{3}\) According to the ADA, the EBD process must not be used to interfere in the dentist/patient relationship nor be used entirely as a cost-containment tool by third-party payers.\(^{3}\)

**CURRENT AND FUTURE PERSPECTIVES**

Compared with the traditional model of care, EBD is relatively new and, with progress in time, multiple clinical questions for which currently there is weak evidence or
minimal/insufficient evidence should be resolved. Long-term survival and success of
treatment, core components of the specialty of prosthodontics, is an important arena
for channeling efforts and resources to help further distinguish the specialty of pros-
thodontics. To facilitate this process, however, it is important to establish a consensus
in prosthodontics on defining the 3 core elements previously described: defining prosthodontic outcomes, duration needed for a meaningful understanding of prosthodontic outcomes, and sample size needed to make meaningful conclusions. Because prosthodontics is a unique specialty, a consensus is necessary to establish explicit
guidelines for reporting of prosthodontic outcomes (suggested acronym, GROPO).
Similar to numerous guidelines described in medicine, these guidelines can be exclusive
to prosthodontics and ensure that investigators provide standardized reporting of
their studies in order for them to be clear, complete, and transparent and allow inte-
gration of their evidence into clinical practice.

In order to teach and understand evidence-based prosthodontics, clinicians need
to attain new skills pertaining to computer-based knowledge systems. These skills
are necessary for asking, acquiring, appraising, applying, and assessing scientific ev-
idence for the pertinent clinical situation. Current popular resources include Web sites
of PubMed/Medline, ADA Center for EBD, Cochrane Library, and Center for
Evidence-Based Dentistry. The 2 popular journals dedicated to EBD are Journal of
Evidence-Based Dental Practice and Evidence-Based Dentistry. Another important
avenue for practicing prosthodontists is participation in practice-based research net-
works (PBRNs), which has gained national momentum in the United States. A dental
PBRN is an investigative alliance of academic researchers and practicing dentists.43
The accord provides clinicians with an opportunity to propose or participate in
research studies conducted in their own offices that address everyday issues in
oral health care. These clinical studies, conducted in participating dental offices
with consenting patients, help expand the profession’s evidence base and further
refine care.43 Perhaps a PBRN focused on prosthodontics and/or prosthodontists
can be assembled in the near future that can provide answers to specific clinical
questions chosen by the specialty and for the specialty of prosthodontics.

REFERENCES


2. ADA Center for Evidence-Based Dentistry. Available at: http://ebd.ada.org/about.


