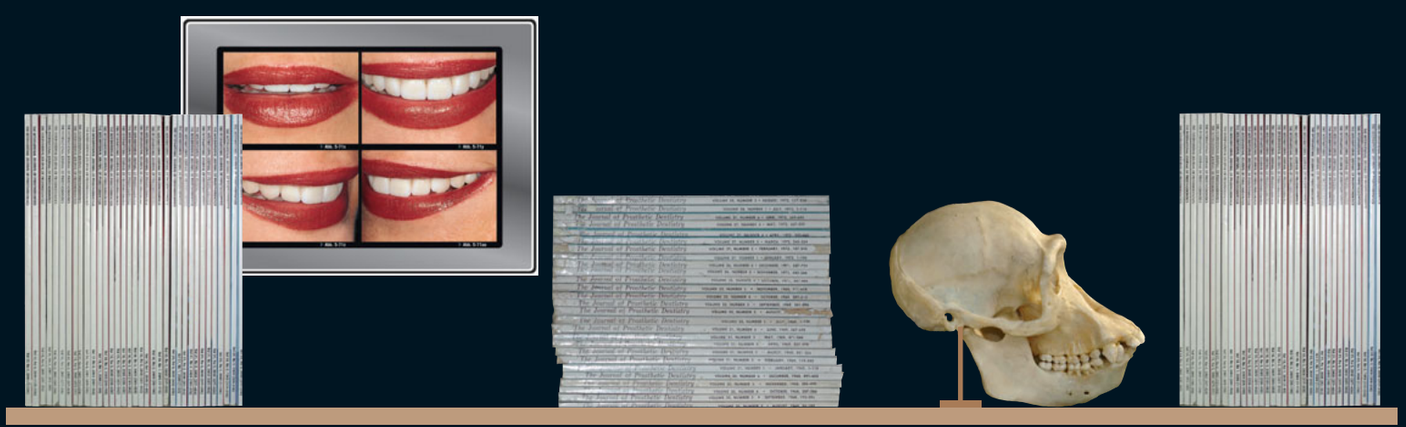
# The Science and Art of Occlusion and Oral Rehabilitation




Martin Gross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with contributions by

Stefano Gracis
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# Foreword

## George Zarb

Paradigm shifts in any aspect of the health sciences tend to enhance collective clinical objectivity as well as encourage more robust scientific inquiry. Dentistry has had its fair share of such scholarship shifts in the past half century; with osseointegration, adhesive restorative materials and occlusion immediately springing to mind. These three compelling changes have profoundly influenced both dental education and practice and continue to alter many of clinical dentistry's traditional patient management protocols.

It should be readily acknowledged, as this outstanding text so lucidly demonstrates, that occlusion is no longer the empirical and controversial topic it used to be for those of us who undertook specialty training four or five decades ago. As a scholarship focus, occlusion gradually outgrew its anecdotal legacy; and thanks to emerging data and insights into neuroplasticity, led to gradual recognition of its complex biological and behavioural framework. This quickly usurped the specialty driven parochial approach to the topic as it became apparent that the scientific method could also be applied to the study of occlusion – a necessity, given the challenges of practising dentistry in an era of unprecedented development in scientific bio-technological information.

I hasten to add that old approaches were certainly not be denigrated since they enabled clinicians of my vintage to respond to our patients' immediate needs. We did our best in the absence of evidence-based determinants of safe treatment outcomes and an inadequate understanding of the pathogenesis of disease processes, which were sometimes manifest at the all-too-visible and tangible occlusion level. As dentists, we treated what we saw and saw what we treated; and our presumably successful clinical management outcomes only reinforced our preconceived insights and associated hypotheses. However, we did welcome the new information that challenged old perceptions and convinced us that all ideas, irrespective of their lineage, need to be questioned and redefined on an ongoing basis if this important branch of dentistry was to not fall between the cracks of objectively derived and replicable data analysis.

This text takes stock of the exciting continuum of occlusion's development as a best-evidenced based synthesis of what is now scientifically rigorous and clinically circumspect. It emphasizes ever so convincingly, the essential clinical message provided by basic and behavioural scientists about the remarkable accommodation potential of the masticatory system to subtle and gross changes in the occlusal status. It is an authoritative and detailed text, in fact exhaustive in the relevance of its contemporary clinical scope and wisdom. I have little more to add other than to encourage its deserved wide readership to enjoy its common sense and prudence; and to respectfully suggest that the word be spread that this is a book that belongs in practising dentists' libraries and on dental schools' recommended reading lists. And above all to congratulate the author on synthesizing a complex body of information in such a sensible and impressive manner.

George Zarb

# Contributors and Acknowledments

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To Fanny

# Contents

# 1 Occlusion: State of the Science, State of the Art

## Contents



# Introduction

The objective of this book is to provide a current text that is clinically oriented and clinically relevant. The book is directed at practicing dentists who would like to update or improve their knowledge on the theoretical rationale of current clinical concepts and evidence-based justifications of routine restorative procedures from a simple single restoration to the most involved fixed and removable prosthodontic cases.

In addition to reviewing the "state of the science," this book will review the "state of the art" by presenting current clinical concepts and practices together with a selection of treated clinical cases. A separate chapter will deal with models of clinical decision-making and treatment planning involved in clinical cases.



## The need for a new book on occlusion

There are numerous excellent experienced dentists who feel that they should have a more profound knowledge and understanding of the subject of occlusion and its interrelation to all the aspects of restorative dentistry. Like the subjects of implants and esthetics, the subject of occlusion was generally not covered in depth at the undergraduate level in many schools. Dentists who attended organized accredited postgraduate programs have a more profound grounding in the theoretical and conceptual literature and background of the topic. This has the advantage of providing a theoretical and clinical knowledge base for application to the full range of clinical disciplines and restorative procedures. Many clinicians may feel that they lack this knowledge base, which is often not dealt with systematically in continuing education courses. This book will make an attempt to provide, in part, an appreciation of the wide interrelating aspects relating to this topic.

A distinction will be made between "science" and "art" with an attempt made to present an outline of the state of the science as background knowledge while relating it directly to clinical questions and dilemmas. The text will be centered around a series of clinical questions posed in this chapter . The first part will attempt to present the science or the current "body of knowledge" or "base of evidence" as it relates to these clinical questions. The second section will attempt to marry the state of the science to the state of the art and to present current therapeutic concepts and procedures.

Dentistry is continuously developing and changing the "body of knowledge" and surrounding conceptual and clinical concepts, and accepted procedures are undergoing continuous revision with the steady flow of new studies, paradigms, and technologies. This necessitates continuous updating of knowledge to evaluate current risk and predictability levels of therapy. The goal here is to attempt to explain current concepts and reflect the state of knowledge relevant at the time of publication. As levels of evidence improve, concepts and ideas will need to be changed accordingly.

## The clinical scope of occlusion in clinical dentistry

Occlusion cannot be presented out of context from all of the other interrelating aspects of periodontics, esthetics, orthodontics, implant dentistry, evolving technologies, removable prosthodontics, and temporomandibular disorders. These will be addressed in a clinically relevant perspective, both at the "state of the science" level and at the "state of the art."

Many occlusion concepts have followed a constrained format and present the basic criteria of occlusion in relation to the class I model with a few exceptions, leaving the clinician with some simplified basic principles. These are often insufficient since the clinician immediately encounters flaws in these oversimplified paradigms, taking the form of countless "exceptions to the rule" that result from case-specific individual variables. He or she is commonly left with treatment planning and therapeutic dilemmas without appropriate guiding parameters and these clinical dilemmas often have to be resolved with clinical intuition, experience, trial and error approaches, or expert advice. The objective of this book is to define and explore current paradigms with their multiple flaws, exceptions, ambiguities, and resulting clinical dilemmas. An attempt will be made to provide some clinically relevant therapeutic conclusions, relating to the best available evidence and illustrated with clinical cases from experienced clinicians and former graduate students. The fundamentals are presented initially to review the basic elements, emphasizing semantics and definitions and defining problem areas where definitions and concepts merge to create confusion in subsequent clinical applications.

# Semantics

**Correct word** "The search for the *mot juste* [correct word] is not a pedantic fad but a vital necessity. Words are our precision tools. Imprecision engenders ambiguity and hours are wasted in removing verbal misunderstandings before the argument of substance can begin."[1]

Attention is paid to semantics as it relates to descriptions, phenomena, and concepts. Many variations, contradictions, and ambiguities exist due to problems of confusing and unclear semantics. Where possible, variations in meaning and interpretation will be discussed based on terms used in *The Glossary of Prosthodontic Terms*.[2]

Semantics and the common use of terms, initials, abbreviations, and acronyms are important elements in the field of occlusion. Physical, anatomical, functional, and non-functional phenomena are expressed by their descriptive terms or acronyms. Often these terms are not clear for many reasons. It is possible that the same term has been used in different texts over the years and the description of the physical phenomenon has varied with the definition. Slight differences in meaning have generated changes in usage over the years. Thus old and current texts can appear with conflicting terminology.

Also, concepts denoted by a term have changed over the years and lead to a term being changed, thus becoming associated with a conceptual historical period. Paradigm shifts in understanding and application of interrelating form, function, and concept have further created the necessity to clarify the semantics, their meanings, and ultimately their correct application in diagnosis and therapy. Glossaries representing sponsoring international associations in internationally circulated publications have led the way in this area for many years. *The Glossary of Prosthodontic Terms* has come out every few years with a comprehensive glossary that defines many of the terms most commonly employed in prosthodontics and in the field of occlusion.[2] This has reflected changes in meaning and concepts over the years. Many inaccuracies, inconsistencies, unclear definitions, and often even errors have remained. However, since this is a dynamic, ever-changing field

that is subject to change, new research and paradigm shifts in terminology will continue to be clarified and improved upon over the years. This text attempts to clarify some areas of ambiguity, unclear meaning, double meaning, descriptive errors, and paradigm shifts. Their significance is emphasized as they are supposed to reflect and describe the terms that must be the building blocks of unambiguous description, understanding, and ultimately clinical diagnosis and therapy. The explanations and interpretations offered here too will need adapting over the years to come as ambiguities are hopefully clarified as knowledge and science provide better answers and interpretations than those we are able to make today.

Many examples of traditional semantic descriptive and conceptual difficulties may be cited and others will be discussed more fully in the text. For example, "centric occlusion" (CO) has changed variously to "intercuspal contact" (IC), "intercuspal contact position" (ICP), "muscular position," "maximum intercuspal position" (MIP), and "maximum intercuspation" (MI). The term "temporomandibular disorders" (TMDs) or "craniomandibular disorders" (CMDs) has historically reflected the current concept and has been "Costen's syndrome," "temporomandibular dysfunction," "temporomandibular joint (TMJ) dysfunction," "mandibular dysfunction," "myofascial pain dysfunction," and others. The term "anterior guidance" means different things to different people. Anterior guidance implies the guidance of the anterior teeth in excursive movements. However, lateral excursions, when guided by group function, are directed on both posterior and anterior teeth, thus the term becomes ambiguous. As a purported optimal therapeutic concept linked to posterior disocclusion and "mutual protection," further ambiguity arises. Occlusal interferences are notoriously difficult to define, with different texts describing different mechanisms for what is interfering with what and what might be the potential consequences. In addition, the distinction between a single posterior eccentric contact and an acceptable posterior guiding or gliding contact is still far from clear. The terms and concepts of "rest position," "clinical rest position," and "physiologic rest position" are further examples of unclear terms intimately liked to current and changing levels of knowledge and paradigm shifts. Many more examples exist and will be dealt with as they arise in the text. Where applicable, synonymous terms will be used together. Traditional terms will be used interchangeably with more current terms to reflect the familiar with the new. An old-fashioned bridge is also a fixed partial denture (FPD) and, recently, a fixed dental prosthesis (FDP). Thus, a hopefully not-too-heavy emphasis is placed on semantics with past, present, and maybe future definitions, meanings, and relevancies presented as they impact the science and art of treatment planning and therapy.

## Occlusion

Occlusion is defined in the eighth edition of *The Glossary of Prosthodontic Terms* (GPT8) as "the static and dynamic contact relation of the teeth."[2] This is in many respects an oversimplification. Considered in a wider context, occlusion encompasses a myriad of interrelating factors. These are intimately related to the health, disease, morphologic integrity, function, dysfunction, and esthetics of the stomatognathic system and host.

A conceptual definition could be that of a multifaceted interface between the teeth, the host, the component parts of the masticatory system, and psychosocial complex, function, parafunction, and dysfunction.

### Occlusion in restorative dentistry

Restorative dentistry is concerned with restoring and maintaining health, function with comfort, and esthetics to the dentition. The term "restorative dentistry" would in this concept be compatible with the term "prosthodontics" defined in GPT8: "prosthodontics is the dental specialty pertaining to the diagnosis, treatment planning, rehabilitation and maintenance of the oral function, comfort, appearance and health of patients with clinical conditions associated with missing or deficient teeth and/or maxillofacial tissues using biocompatible substitutes."[2,3] The implication that these parameters are the domain of this specialty, while unintended, is unfortunate as obviously non-specialists do all these things. A more all-embracing collective term of "reconstructive dentistry" is used in some circles, but the more familiar traditional term of "restorative dentistry" will be used in this text.

### Integrated restoration of form, function, and esthetics

The restoration of form, function, and esthetics involves the interaction of several clinical disciplines, and the life-long learning and updating of current concepts and the dental literature. Occlusion is an integral part of this complex and must be considered in relation to all the related disciplines and elements. Occlusion in one way or another is intimately related to implants, esthetics, prosthetics, conservative dentistry, periodontics, orthodontics, oral and maxillofacial surgery, and temporomandibular disorders.

### The changing emphasis and role of occlusion

The need to understand and define the role of occlusion within the charge of restoring and maintaining form, function, and esthetics is clear. Knowledge, concepts, and emphasis in relation to the subject of occlusion have changed considerably and will probably continue to change over the years to come. The objective of this book is to attempt to portray the status of occlusion as it stands today with a clear emphasis on clinical implications with respect to tooth- and implant-borne prosthodontics.



# Evolution of occlusal concepts

The human dentition and its occlusion is the product of an evolutionary process that occurred over 30 million years (as currently dated) (Fig 1-1). This manifested itself in the development of vertebrates, amphibians, and mammals with survival strategies intimately related to the masticatory system. This was integral to the procurement of food and its mastication and transfer into the necessary components of the Kreb cycle. Dentitions and the masticatory system adapted through the herbivorous, carnivorous, and omnivorous stages, each with distinctive dental and skeletal configurations. As mammalian evolution passed from omnivorous apes to hominins and Homo erectus; dern urban men and women, with the current normal variation of skeletal and occlusal form evident today.

Dental disease and tooth loss are not restricted to modern man. While dental disease increased with cooking and greater usage of refined carbohydrates, prehistoric evidence of tooth loss is seen together with efforts to replace missing teeth.[4] The ability to restore missing teeth was a function of available technologies starting with the carving of wood and ivory dentures. Complete dentures developed from ivory and vulcanite to methyl methacrylate. Partial dentures and fixed restorations also developed from gold and chrome cobalt castings to the full range of restorative and prosthetic options available today. Occlusal concepts and the use of dental articulators have also evolved in conjunction with these changing therapeutic technologies (Fig 1-2). Concepts of balanced occlusion and gnathology and mutual protection have been tested and challenged and altered where necessary to conform to current aspirations for evidence-based therapy.

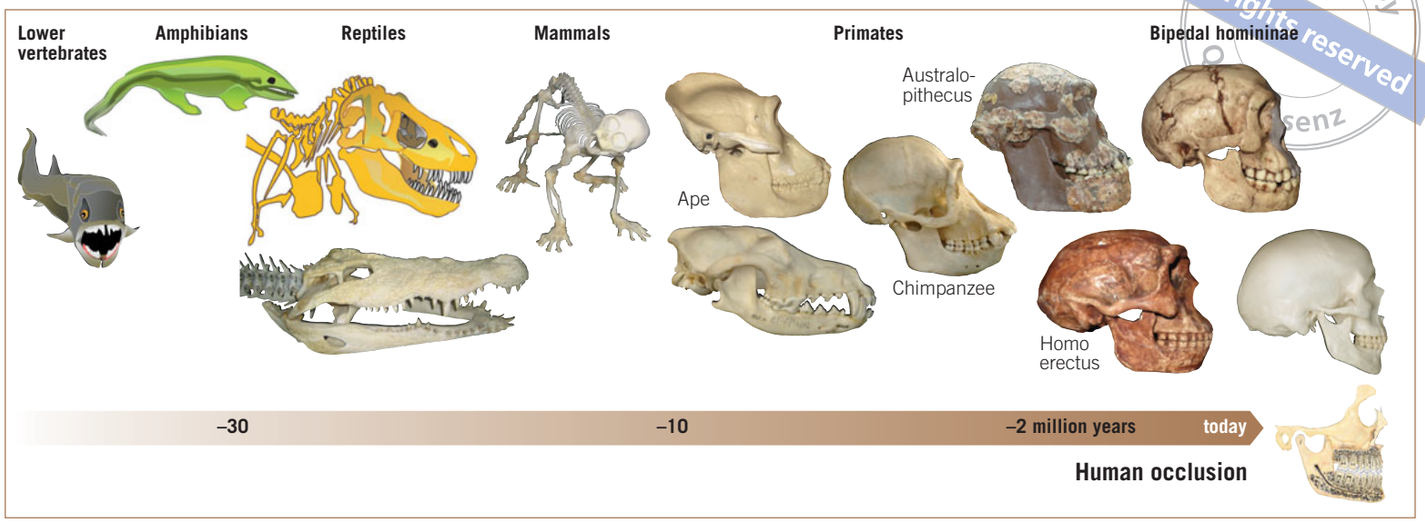


Fig 1-1 Human occlusion when viewed in the context of the evolutionary process has taken 30 million years to evolve to its present state.

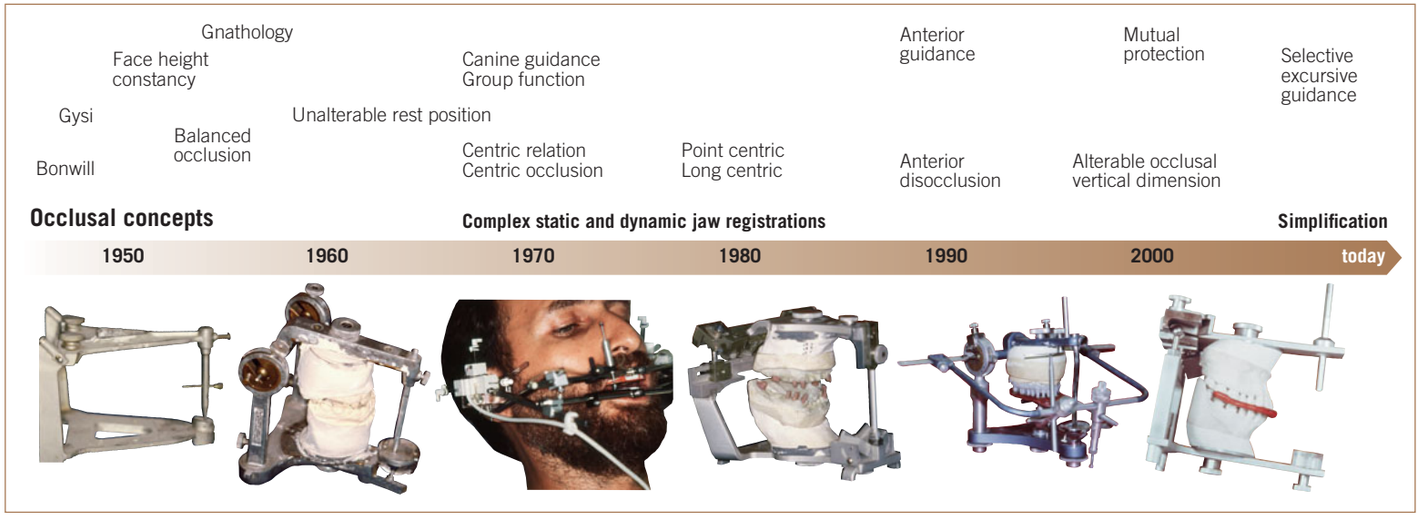


Fig 1-2 Occlusal concepts have evolved together with developing restorative technologies. Articulators developed in conjunction reflecting changes in therapeutic concepts governed by the current state of clinical art and its available science.



# Changing attitudes and paradigms

Attitudes toward the subject of occlusion have undergone several changes over recent decades (Fig 1-3). In the 1960s and 1970s, occlusion was developed into something akin to a formal discipline. Clinical philosophies, occlusal determinants, ridge and groove directions, articulators, and the undefined feeling that failure to follow the rules would lead to mandibular dysfunction, occlusal trauma, or worse were dominant. The lack of scientific evidence fostered rigorous debate over topics such as chin point versus bimanual guidance, cusp to fossa versus cusp to marginal ridge, or canine versus group function. Articulators were hallowed as a panacea and associated with concepts and so-called philosophies such as "gnathology" or other such schools of thought. In the 1980s and 1990s, more and more research and changing attitudes led to a paradigm shift that tended to downplay the importance of articulators and the role of occlusion, particularly as a causative factor in TMDs. The emphasis on the etiological role of occlusion in TMDs has declined considerably.[5] The need for complex articulators has diminished. Lack of knowledge was in the past often couched in terms such as "philosophies" and "therapeutic concepts" that could neither be proved nor disproved. In today's clinical and academic atmosphere of transparency there is a need to redefine accepted therapeutic concepts and paradigms in the context of the "best available evidence," "therapeutic risk," and "predictability and patient-centered outcomes."[6] The need to define the decision-making process in establishing an unambiguous diagnosis, treatment objectives, and treatment plans can today be reevaluated in light of the best available evidence (BAE) and evidence-based dentistry (EBD).[7,8]

Occlusion is not a simple manifestation of the static and dynamic contact relation of the teeth. Perceived in a wider context, occlusion should be considered as a part of the complex of the entire stomatognathic system that includes the psychophysiological and psychosocial makeup of each individual. The objectives of restoring the occlusion in dentitions with lost dental and supporting structures should be clearly defined and should encompass considerations designed to restore form in relation to esthetics, function, and comfort that encompass the full range of individual clinical determinants: the psycho-physiological, perceptual, behavioral, and psychosocial makeup of each and every

Fig 1-3 Articulator used as a door stop (a). Articulator attributed with mystical powers (b).

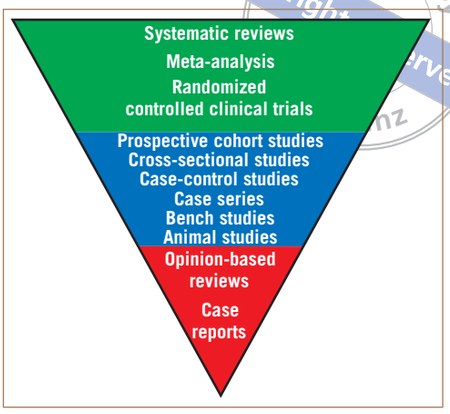


Fig 1-4 Hierarchy of evidence and best available evidence. A hierarchy of validity of evidence is described attributing relative validity of varying studies and publications. Systematic reviews of randomized controlled clinical trials (RCTs) represent the highest level and anecdotal case reports the lowest.[6,22]

patient. The World Health Organization's goal for the year 2000, which aspired to maintain a natural dentition of not less than 20 teeth throughout life, is reinforced by a systematic review that this proposed dentition will assure an acceptable level of oral function.[9]

# State of the science, state of the art

Clinical dentistry is a mixture of clinical science and clinical art. In many clinical situations the science is inadequate or inconclusive. Consequently, clinical practice has evolved as a complex of accepted practices and procedures based, when possible, on the best available evidence or in many cases on inherited therapeutic traditions and practices approved of as "accepted clinical parameters of care."[10] This may be described as the "clinical art."

# Best available evidence: the hierarchy of evidence

There is of late a considerable emphasis on the benefits and need for "evidence-based practice."[6-8] The objective is to base clinical practice on the best available scientific evidence.

If clinical decision-making must be based on the best available evidence, the clinician must be aware of what constitutes the best available evidence at a particular point in time. This requires an ongoing familiarization with the dental literature. This is no mean feat as the literature is very extensive and continuously growing. It is almost impossible for a busy practitioner to read all the available literature and it is becoming increasingly so for the academic. One must therefore rely on quality reviews and often forgo the ability to critically review much of the available evidence oneself. In addition, there remains the need for a method of converting a consensus of the literature into a practical tool that can make evidence-based decision-making a reality.

A further difficulty is that there are many different types of studies and publications with widely varying levels of validity and clinical relevance. Hierarchies of the best available evidence have been described[6,12-14] and are illustrated in Fig 1-4.

## Evidence hierarchies' benefits and limitations

Hierarchies of evidence may have varying applications and relevance, which will be influenced by the research topic under consideration and the "study question." Selection of a particular study design will depend on the study population the disease or treatment intervention and the outcome.

The hierarchy of studies illustrated in Fig 1-4 is a workable model applicable to clinical outcome studies and cause-and-effect study questions. If the question is not cause and effect then the relevance may be weakened. Various review and analytical systems are available and a hierarchy of preappraised evidence has been described and termed as the 6S system.[13,14] This describes a system of analysis that ranges through:

- Studies – original articles published in journals
- Synopses of studies – evidence-based abstraction journals
- Synthesis – systematic reviews (eg, Cochrane Library)
- Synopses of syntheses – online registry of systematic reviews, evidence-based abstraction journals
- Summaries – evidence-based clinical practice guidelines, evidence-based textbooks
- Systems – computerized decision support systems.[13,14]

# Study types

## Experimental study

An experimental study is a research study used to test causal relationships between variables. Results are usually expressed as a percentage of certainty, described as statistical significance. Statistical significance is a statement of the probability that the finding is a true causal relation and not a chance occurrence. The conventional standard for attributing significance is a finding that occurs fewer than 5 times in 100 by chance. Experimental studies can be randomized and non-randomized.[15]

## Observational study

Observational studies can be analytical or descriptive.[15] An observational study is a method of investigation involving description of the

association between intervention and outcome. In a randomized controlled study, each subject may be randomly assigned to a treatment (intervention) group or a control group before the start of the treatment.[24]

## Studies may be longitudinal or cross-sectional

Observational studies may be longitudinal or cross-sectional. Longitudinal studies study populations and outcomes over time. Cross-sectional studies study a population at a particular point in time. Both are a type of observational study.

## Randomized controlled clinical trials (RCTs)

An RCT is a prospective randomized controlled clinical trial that conforms to the necessary requisite of statistical significance. With suitable power, a statistically significant finding indicates that there is a very small probability (say 5% or 1%) that the finding occurred by random chance. It is worth noting that if the finding is statistically significant, the associated confidence interval (usually a 95% confidence interval) is important in interpreting how precise that "finding" was and how it may relate to other similar populations. It is also worth noting that statistical significance does not always mean that a finding has clinical relevance.

Prospective studies control the testing parameters in advance. The use of a control allows for a comparison between the treatment effects versus a non-treatment control group. Randomized selection of the treatment versus the control ensures a lack of bias in the selection of the treatment modality, treated population, and the control population. Treated populations can possess varying and often unknown modifying and confounding characteristics. Randomization with sufficient numbers of patients helps to randomly distribute these unknown confounding characteristics among the groups, thereby reducing or eliminating their confounding effects.

This model has some significant limitations and disadvantages, despite being purportedly optimal. Primarily, the study population must be one in which the entire population requires the same type of treatment and has the same diagnostic criteria. From this population, a randomized selection must be made to establish treatment and control groups, raising a significant ethical problem in not treating individuals who require the treatment. This may limit the ability to make a study of this nature.

## Longitudinal studies

A longitudinal study is a correlation research study that involves repeated observations of the same subject or group over extended periods of time. Longitudinal studies may be prospective or retrospective. Longitudinal studies include cohort studies and case series studies.

## Cohort studies

A cohort is a group. In statistics, a cohort is a specified group of individuals, subjects, or patients that are studied. Cohort studies sample a cohort, as a group with common properties or characteristics in a selected time period, studied at intervals through time. This can be retrospective or prospective.[15] A cohort study is a non-randomized clinical trial. This usually involves two groups of subjects/patients, of which one receives an exposure of interest and one does not. These cohorts are followed for an outcome of interest. Exposure of interest may be a particular treatment modality. Cohort studies can use odds ratios and risk ratios.[15,16,23]

Large samples of normal and abnormal populations can give significant information on the distribution of dentalc characteristics, such as skeletal jaw relations, intercuspal contacts, and excursive tooth guidance.[17-20] Extensive studies of large population samples, for instance, have failed to reveal a correlation between occlusal interferences and signs and symptoms of temporomandibular disorders.[9,19-21] Cohort studies can isolate associations and risk factors, but they have less power to detect causal relationships than do experiments. Because of the repeated observation at the individual level, they have more power than cross-sectional observational studies, by distinguishing individual differences that do not change over time, and by the observation of events over time. Longitudinal studies distinguish short-term from long-term phenomena.

## Odds ratio and risk ratio

The odds ratio and risk ratio are measures of association, used to express results of dichotomous (two-part) outcomes, eg, sick versus healthy.[15]

An odds ratio is a ratio of the likelihood that an event will happen versus the likelihood that an event will not happen. Odds ratio may express the ratio of the odds of having a target outcome in an experimental group relative to the odds in favor of having the target outcome in a control group.

A risk ratio is the frequency of outcome in an exposed group divided by the frequency of outcome in an unexposed group. This may be a measure of the risk of a certain event happening in one group compared to the risk of the same event happening in another group.[15]

## Case series studies

Case series studies (also known as clinical series) consist of a report on a series of patients with an outcome of interest. No control group is involved.[16] The included patients may also have experienced an exposure of interest, but this is not necessarily the case. A case series can be retrospective or prospective. This is a type of observational study. Case series may be consecutive or non-consecutive. They may be confounded by a selection bias, which limits conclusions on the causality of correlations observed.

## Benefits of case series studies

In spite of their lack of controls and randomization, case series and individual case observation still have a role to play in clinical research as parameters of medical routines and procedures for predictive levels of evidence. For future ontological development, case observations with dynamic individual variety will need to be categorized qualitatively by a taxonomy of treatment courses with methodological potential to be of predictive value within the hierarchy of evidence.[27] Benefits of case series have been described as helping "clinicians understand clinical reality and represent their dental experience and will gain importance in the future."[27]

## Case-control studies

A case-control study is a study identifying patients who have an outcome of interest and control patients without the same outcome, and looking back to see if they had the exposure of interest.[16]

These are commonly used to investigate rare conditions. It would be very hard to study these patients using other study forms, as there are so few of them. Therefore, they are identified because an "outcome/disease" has occurred. They are then matched (as perfectly as possible)

to a "control" – the data is then "dredged" to try to hypothesize factors that may be associated with the outcome. It generates hypotheses only, not conclusive evidence. But, often, it is the best type of study that can be completed, given the circumstances. The quality of the matching of the controls is central to the quality of the conclusions. A case-control study can use odds ratios.[15]

## Cross-sectional studies

Cross-sectional studies observe a population at a particular point in time. These are descriptive and can be in the form of a survey. The purpose is to describe a population or a subgroup within the population with respect to an outcome or set of risk factors. The study describes the prevalence of an outcome at a specific point in time. This type of study can use an odds ratio, absolute risks and relative risks (prevalence risk ratios).

## Systematic reviews, meta-analysis

Systematic reviews provide summaries of published clinical outcome studies of sufficiently high criteria to allow direct comparisons. The methods used to collect the material will affect the quality of the reviews. Data may be discussed qualitatively to provide high levels of synthesis or combined quantitatively with a meta-analysis. Meta-analysis is a process of combining the results of studies that have comparable levels of methodology and statistical analysis. Studies with varying time lengths or sub-levels of treatment modality can be compared. When sufficient studies are available that satisfy the criteria of an RCT, this is the strongest predictive outcome tool available.[25] However, at present there are seldom sufficient RCT studies, and, in some cases, cohort or case series studies available to provide relevant clinical outcome conclusions for a great many of the clinical parameters in use in dentistry today.

## Consensus groups

Consensus groups are groups of experts from institutions or associations that combine to produce systematic reviews on selected topics. When the evidence is poor, such groups may be assembled to produce a "consensus' of expert opinion. When RCTs are not available, longitudinal cohort studies, cross-sectional, repeated cross-sectional and case series studies are assessed as the only and therefore the best evidence available.[26]

## Bench studies

Bench studies are valuable and can give insight into the background of clinical situations. Limitations include the degree of difference when comparing the laboratory analogue or testing model, the sophistication of the measuring system used, and the statistical value of the study design. These have been helpful. Models adapted from mechanics using finite element analysis, strain gauges, and photoelastic analysis provide useful insights into strain distribution of occlusal forces.

## Animal studies

Animal studies are very helpful as they give valuable histological or physiological information that would otherwise be impossible to obtain from humans.

The limitations are that extrapolations to the human condition may not always be valid and clinical therapy outcomes may not be directly analogous between humans and laboratory animals.

## Case reports

Case reports also have their place. However, they are anecdotal. They do not compare large numbers of treatments and therefore lack statistical significance and lack value for predictability. Nonetheless, in presenting new treatment modalities they give an indication of individual clinical outcomes or techniques. Their organization into sample groups form the basis of future retrospective or prospective clinical outcome trials.

# Risk and predictability scale

A wide range of these different studies and articles can be found in each area of interest. Some contain a wide array of studies and others have very few and poor quality studies. Their combined content represents the current body of knowledge and BAE. This can vary widely in applicability, validity, and predictive ability for each clinical application. A further problem exists in how to apply this BAE to the clinical situation or individual clinical case and treatment plan. A useful method to consider is to categorize the clinical relevance of this background of information and express it in a categorized numerical or visual analogue scale. This scale sets levels of BAE from high to low quality and validity.

Maximal numbers of RCTs, and meta-analyses with corroborating bench and histology studies will indicate the highest predictability and lowest risk for a truly evidence-based clinical procedure. Alternatively, procedures with the occasional anecdotal case report have a poor base of evidence, potentially higher risk, and low level of predictability.[28]

A linear scale between these two extremes can provide a simplified clinical guide as to the level of evidence, risk, and predictability for specific therapeutic procedures. A limitation of the categorization in this scale is that it is dependent on a degree of subjectivity, which is influenced also by the depth and the level of the analysis and interpretation of the literature. However, in light of the complexity and wide variety of concepts, therapies, and levels of research, this may provide a practical tool for risk and predictability assessment in light of the best available evidence at a particular point in time. A linear scale with categorizations of risk and predictability of high, moderate, fair, and low is illustrated in Figs 1-5 and 1-6.



## Limitations of RCTs

This scale indicates low risk and high predictability at high evidence levels for particular therapies to be successful. Clearly, a systematic review showing a high level of evidence that a particular procedure is unsuccessful and contraindicated shows that there is a high level of evidence of high risk.

Others have graded levels of efficacy of evidence from 1 to 5: 1) individual randomized controlled trials (with narrow confidence intervals); 2) individual cohort studies; 3) individual case-control, cross-sectional, or ecological studies; 4) case report or case series; and 5) expert opinion without explicit critical appraisal or based on physiology, bench research, or "first principles."[16,28]

Limitations of these concepts are that a great many relevant clinical topics and therapeutic parameters and procedures have not been studied sufficiently to produce irrefutable evidence by RCTs. One classic example is of lung cancer being caused by cigarette smoking, which is considered a risk factor. Another topic without convincing RCTs is a lack of robust scientific studies proving the efficacy of using a parachute when jumping out of an airplane.[29]

## Quantification of risk and uncertainty

Clinical decision-making requires the evaluation and quantification of risk and uncertainty. An optimal expression of minimal clinical therapeutic risk may be expressed by high levels of successful clinical outcomes of statistical significance. These are generated from clinical outcome studies of good scientific quality (systematic reviews of randomized controlled multicenter clinical trials). Conversely, low levels of success of similar high-quality outcome studies will express the best prediction of high risk, with risk defined as a negative outcome. Negative

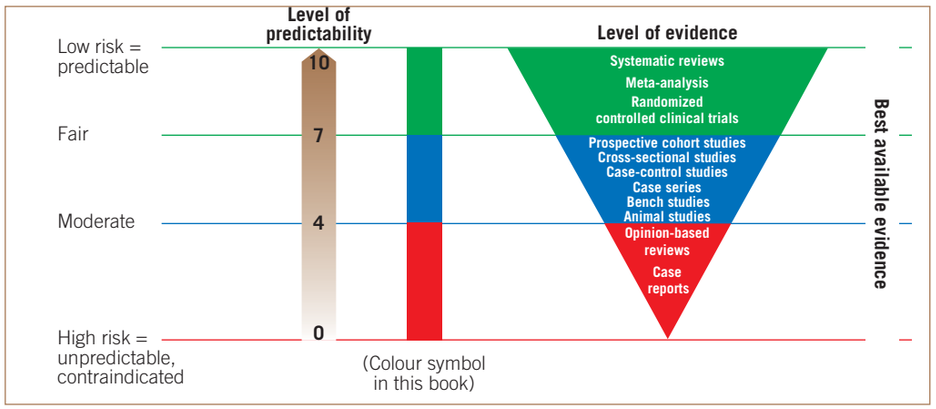


Fig 1-5 A risk and predictability scale may be applied with graduated levels of predictability and risk in an effort to confer clinical relevance to the current best available evidence (BAE) for successful treatment outcome.

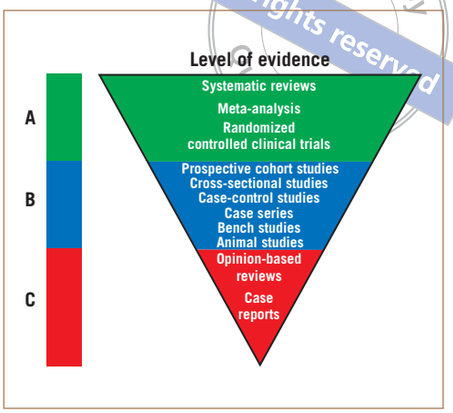


Fig 1-6 Further simplification of this model. **A**) high level of scientific validity (for successful outcome) have low risk and high predictability; **B**) medium levels of scientific validity, moderate risk and moderate predictability; **C**) low values of scientific validity, highest risk and lowest level of predictability.

outcome studies of this nature are rare. An alternative, less robust method is to correlate therapies with the lowest level of scientific support as containing high risk due to the lack of sufficient evidence. Mismatch between the knowledge required and the knowledge available for predicting an outcome is common. However, given the need to make a choice, decision-making must rely on available existing knowledge and reflect on the remaining uncertainties in applying alternative parameters[30-35] (see Chapter 9).



# Risk and causality

## Risk factors versus cause and effect

Many relations of particular conditions to the host are multidimensional and it is commonly not possible to isolate single cause and effect relations. Factors occurring in association are isolated in longitudinal studies as risk factors. A risk factor is a variable associated with an increased risk of disease. Risk factors are correlational and not necessarily causal. Correlation does not imply causation.

In the field of occlusion and TMD, many occlusal factors that were originally considered to have a causal relation with TMD are now viewed as risk factors. These include increased anterior horizontal overlap, unilateral crossbite anterior open bite, and a slide from centric relation to maximum intercuspation greater than 2 mm.[19-22]

## Risk factors and association versus causation

Association shows a particular occlusal feature to exist in a particular percentage of a symptomatic population or to occur in relation to specific signs or symptoms. In order to hypothesize causality, an association must satisfy varying criteria. While percentages of necessary association have been suggested, the required criteria supporting or refuting causation would need to include: strength of association; interstudy consistency; temporal relation; dose–response gradients; and rationality of the hypothesis.[21-24]

# Background body of knowledge

The subject of occlusion has a great many facets and interrelated elements. Each contains interrelating topics and subtopics, each with its own body of knowledge, research, and often extensive literature. This background of knowledge and concepts is continuously changing and being updated, is subject to considerable variability, and is not always composed of sound scientific evidence.

This body of knowledge, illustrated diagrammatically in Fig 1-7, contains multiple interrelating fields. This may contain non-clinical anatomy, physiology, evolution, medical and non-dental fields such as evolutionary biology, genetics, and many more. Many clinically related fields are described in classic texts and have their specific body of basic research, clinical studies, review articles, and case reports. Interposed are evolving technologies, now progressively influenced by commercial marketing interests of "prophets and vendors" affecting the commercial support of clinical outcome studies.[7] Taken all together, these currently combine to serve as the foundations of evolving clinical concepts and accepted clinical practice. In light of the continuous changes that are taking place, the clinician is obliged to make efforts to keep up to date to evaluate these developments in this background of knowledge that forms the basis of clinical concepts and therapies.

# Resolution of complexity

When faced with extreme complexity, the human intellect often copes by resolving a multiplicity of seeming unintelligible factors into simple paradigms or principles that are comfortable but not always logical and often inapplicable.

## Simple

When faced with this complexity of the background of knowledge, natural variability, and lack of sufficient science, clinicians have tended to work with straightforward simplified clinical axioms and paradigms that are generally based on the class I occlusion model. These have often been presented as "philosophies of treatment" that could neither be proved nor disproved. They were based on belief systems and have yet to stand the test of rigorous scientific scrutiny. Many persist to this today. Conceptual models of mutual protection, and protrusive and lateral disocclusion are based on the class I conceptual model and are widely used as idealized clinical therapeutic paradigms. However, when confronted with asymptomatic physiologic naturally occurring occlusions that do not conform to the class I model, the universality of concepts such as posterior disocclusion and purported mutual protection come under question. In addition, a wide range of clinical situations arise that do not immediately lend themselves to being solved by this single conceptual model.

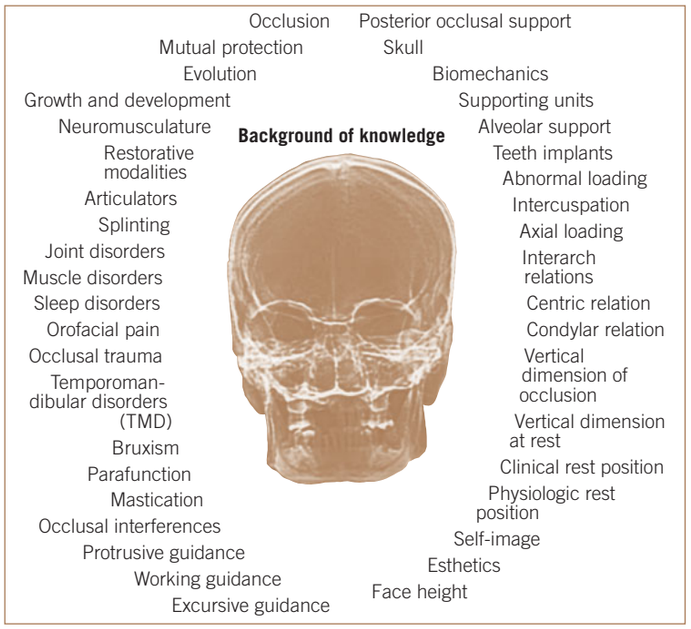


Fig 1-7 The background body of knowledge relating to the subject of dental occlusion. This contains multiple fields and interrelated topics, each with its extensive range of journal publications and research, rendering a seemingly high degree of complexity.

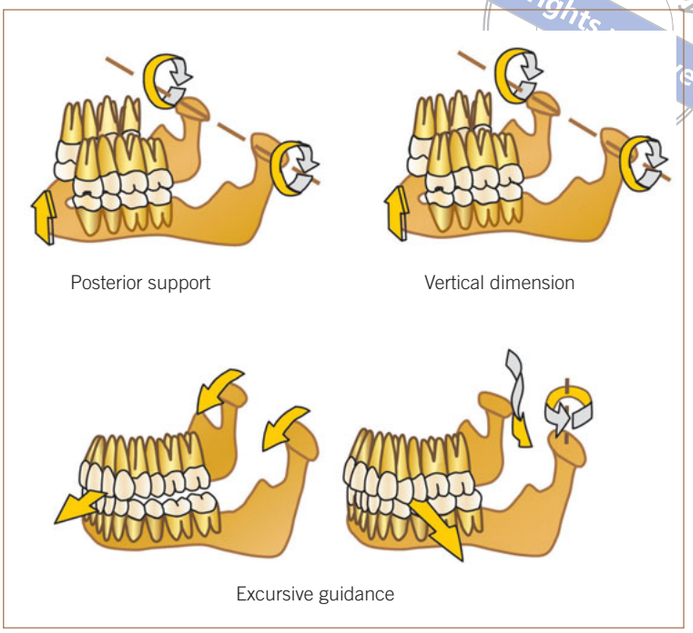


Fig 1-8 Occlusion can be divided into three principal elements: posterior support, vertical dimension, and excursive guidance. Each of the principal elements has its own body of knowledge that needs to be continuously reassessed in light of the best available evidence and changing paradigms. Each is addressed in separate chapters: posterior support, Chapter 4; vertical dimension, Chapter 5; excursive guidance, Chapter 6.

The resulting clinical dilemmas of how best to treat these many exceptions must be resolved by the clinician on a per case basis according to the individual clinical determinants, often without appropriate clinical guidelines or scientific clinical evidence.

### Complex (eclectic)

A more scholarly approach to deal with the inadequacies of oversimplified paradigms is to confront the seemingly complex body of knowledge in a systematic manner and redefine the paradigms where necessary. By defining the constituent components of the whole into sections and subsections, each component may be analyzed and studied. By categorizing the extent of current knowledge and the quality of evidence of various sections and subsections, a picture of the best available evidence emerges which may then be integrated, synthesized, and converted into suitable clinical tools. Inadequate paradigms and concepts can be refuted and revised when possible. Alternative solutions and paradigms can be established. The ability to convert a categorization of the best available evidence into a scalar assessment of risk and predictability can be helpful in the decision-making process of treatment planning and choice of therapeutic modality (Figs 1-5 and 1-6).

## Principal elements of occlusion: posterior support, vertical dimension, and excursive guidance

The occlusion can be divided into three principal elements: the posterior support, the vertical dimension, and the excursive guidance (Fig 1-8). Each element has its own body of knowledge with clinical concepts and paradigms. Many clinical concepts need reevaluation in light of current developments. Each element is defined and addressed in a separate chapter in this text. Confusion and changes in glossary definitions and semantics will be considered as they relate or fail to reflect developments and changing concepts.

Currently relevant and perennial clinical questions need to be addressed in the light of current knowledge, attitudes, and changing emphases. Attitudes towards some issues that were formerly controversial have changed. For instance, the need to provide posterior support to prevent joint disorders and TMDs has been questioned. The importance of restoring intercuspal contact in centric relation or in a slightly anterior centric occlusion relation or long centric is no longer a major issue. Increasing the vertical dimension of occlusion beyond the vertical dimension of rest is no longer considered to be that detrimental. Occlusal interferences are no longer considered to play a significant etiological role in TMDs. The need to provide anterior guidance with posterior disocclusion and the concept of mutual protection have been questioned. In addition, with the advent of dental implantology, several occlusal principles need to be reevaluated as they relate to the restoration of partial and complete edentulism with implant-supported and tooth-supported restorations.

## Clinical art

Evidence-based science more often than not fails to answer many common clinical questions. The practitioner must base his or her diagnostic and therapeutic decisions on what may be considered to be "clinical art." This may be based on guidelines of best available practice, and current paradigms gleaned from multiple sources that may vary by generation, geographic location, and a multitude of varying chance-related and serendipitous factors.

Clinical decisions will ultimately have to be made on several varying levels. These will have to include integration of the current background of knowledge and best available evidence in the relevant related fields, and include considerations of current concepts, paradigms, and principles of accepted current practice. Assessments must be made of predicted levels of risks and final decisions made together with the informed individual patient, considering patient-related psychosocial,

socioeconomic, and psychological aspects in addition to the individual clinical determinants that vary greatly from case to case.

In spite of the reduced emphasis of the role of occlusion in TMD, the topic of occlusion in relation to fixed restoration of the dentition in all its various applications is as relevant as ever. The inquiring clinical mind has, more often than not, not been satisfied with the results of the best available evidence and of traditional paradigms when it comes to answering many perennial clinical questions. Listed below are some current clinical questions which in most cases are not answered by best available evidence (BAE). Their solution must rely on current clinical art and its associated paradigms. These questions will serve as the basis for several chapters (Chapters 4, 5, 6, and 8), where an attempt will be made to supply answers based on the best available science, the best available paradigms, and the best available clinical art.

## Clinical questions

It is convenient to divide these into three sections, comprising the three basic elements of the occlusion: posterior support; vertical dimension; and anterior guidance. "Anterior guidance" as a term denoting excursive tooth guidance is problematic and in the course of the text the term "anterior guidance" will be replaced by the term "excursive guidance" based on arguments to be presented.

**1. Posterior support**

- What constitutes minimum acceptable posterior support?
- What is the minimum number of teeth and contacts necessary to provide posterior support?
- What is the minimum amount of implants and bone support necessary to provide posterior support?
- What is the acceptable interarch, tooth, and implant axial orientation?
- What is the necessary intercuspal contact relation?
- What is the optimal condylar relation and maxillomandibular relation at intercuspation?

**2. Occlusal vertical dimension**

- What is "rest position"?
- Is rest position fixed?
- Is there one critical occlusal vertical dimension (OVD)?
- What happens if OVD is increased beyond the clinical rest position?
- If OVD is increased or decreased, does mandibular posture adapt?
- Does changing OVD change lower face height?
- How should the OVD be established clinically?

**3. Excursive tooth guidance (anterior guidance)**

- Do we need anterior protrusive guidance to separate posteriors in protrusive excursions?
- Do we need anterior and/or lateral guidance to separate non-working in latera contacts in lateral movements?
- Do we need anterior protrusive and/or lateral guidance to avoid occlusal interferences?
- What is the relation of interferences to TMD and parafunction?
- In the absence of anterior diocsclusion are posterior contacts interferences or posterior guiding contacts?
- What is the relation of anterior guidance to mastication and bruxism?
- Is "mutual protection" an acceptable therapeutic model?
- Is the guidance inclination and contour relevant?
- Does a flatter guidance reduce lateral loading?
- What significance does the side shift have on guiding lateral contacts?
- How does splinting affect anterior guidance?
- How distal should working side group function contacts be?
- Can eccentric guidance be selective and pragmatic?
- How is guidance affected by relative distribution of teeth and implants?

**Articulators**

- Do condylar determinants determine anterior and posterior occlusal morphology?
- Which articulator should be used?
- Which articulator functions are necessary?

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