

Textbook of
CLINICAL CHIROPRACTIC
A SPECIFIC BIOMECHANICAL APPROACH

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For My Mother and Father

Preface

Clinicians often find it difficult to communicate the techniques that they practice. Due to the isolation of clinical practice, there has been a paucity of literature available for the practicing chiropractor or student, since few clinicians have taken on the task of documenting what they do. This text focuses in a specific manner on the clinical applications that chiropractors provide on a day-to-day basis. The list of contributors, practicing chiropractors as well as academicians, demonstrates that the clinical practice of chiropractic serves as the basis for the book.

Textbook of Clinical Chiropractic provides a very specific approach to the art of spinal adjusting; the adjustive maneuvers presented facilitate normal biomechanics. Too often, manipulative procedures have been applied with blatant disregard for normal physiology and anatomy. Care in applying the adjustive art is stressed throughout the text. The flexible pediatric spine, which is resilient to seemingly innocuous forces, deserves the same carefully applied adjustment that an adult's spine would require. If the clinician carefully applies the adjustment in all instances, regardless of the age or state of the patient, then he or she should be more able to accommodate the patient suffering from severe spinal trauma, such as a disc herniation, spinal fracture, or dislocation.

In Chapter 1 we present a brief discussion of some philosophical principles integral to the practice of chiropractic. We have attempted to show the integration and mutual dependency of the philosophy, science, and art in chiropractic. Often, an ambiguous notion of any of the above aspects hinders the intellectual progress of the practicing clinician. A refreshing perspective is presented, free from dogma and pseudophilosophical constructs. We close the chapter with a look at how the adjustive art is applied and how one can most effectively learn this skill. Ease of learning was never a parameter in the development of the adjustive strategies presented throughout the text. Perhaps an insight into the psychomotor aspects of learning the adjustive art will facilitate competence in this area.

It is not enough to know in a general way how the spine moves, to have an ability to motion palpate to determine a fixation, and then follow up with a manipulation. Just as the neurosurgeon must have an intense understanding of the anatomy of the brain prior to operation, so the chiropractor should be an expert in the anatomy and biomechanics of the region in question. In Chapter 2 we provide a valuable reference source on the biomechanics of the spinal column. The reader will appreciate the clinical extrapolations that are derived from the biomechanics literature.

The vertebral subluxation complex and its component signs and symptoms are presented in Chapter 3. It has not been sufficient for us to describe the functional lesion in an abstract manner. Instead, we have integrated the pathological information into two case studies to demonstrate how the nature of the pathology can provide useful information toward the ultimate application of an adjustment.

Chapters 4 and 5 cover the spinal examination procedures from a clinical and radiologic standpoint. Aspects of general orthopaedics and neurology are not presented in detail, since much of this information is readily available elsewhere. The palpatory aspects of the examination and how to recognize normal and abnormal spinal function from a radiologic perspective are described. The numerous radiologic illustrations and roentgenometric analyses should facilitate a practical understanding of the role of plain film radiology in chiropractic.

Chapters 6 and 7 are devoted to the low back. The reader will appreciate how each adjustive maneuver is described in a comprehensive manner with a focus on the interactive biomechanics. A three-dimensional coordinate system superimposed over each illustrated adjustment is found throughout. Only through visualizing the three-dimensionality of the pattern of thrust can the clinician hope to deliver the most comfortable and effective adjustment.

The subject of scoliosis, especially the adolescent idiopathic variety, is presented in Chapter 9. We believe that chiropractors can make a substantial contribution in this area. With a thorough knowledge of the relevant subject matter, the importance of early screening and appropriate management can be appreciated.

Chapters 8, 10, and 11 cover the diagnosis and management of mechanical disorders of the thoracic and cervical spine. Where applicable, specific disorders are discussed in detail and appropriate adjustive maneuvers are presented. The subjects of interscapular pain, acceleration-deceleration injuries, and torticollis are presented with specific clinical management strategies.

Dr. Rowe has done an excellent job of explaining the role of chiropractic care in the management of patients who have suffered spinal fractures or dislocations. Chapter 12 reviews the concept of spinal stability in relation to these severe injuries. The radiologic and clinical findings of numerous case studies are presented. Broad generalizations are difficult for any patient suffering from severe spinal trauma, but a case-specific approach should provide the doctor with a basic understanding of how these patients, when appropriate, can be carefully managed.

The need for information regarding appropriate spinal management in patients with a visceral concomitant disorder has long been overdue. Despite a lengthy history of chiropractic therapy for these manifestations, only recently have case studies and clinical trials begun to appear in the literature. Of course, many individuals may require combined allopathic and chiropractic care. However, should the patient have a spinal lesion, it is imprudent to withhold treatment, provided such therapy does not hinder other management approaches.

Pediatric care is presented in Chapter 14. It is becoming increasingly apparent that a preventive approach is especially relevant to spinal pathology and the subsequent neurologic manifestations that can result. The numerous illustrations will provide the doctor with a foundation for applying the adjustment in the newborn or toddler patient. Applications of chiropractic care during pregnancy are also presented.

Extravertebral disorders such as temporomandibular joint dysfunction and extremity afflictions are presented in Chapters 15 and 16. Each specific disorder is followed by ample illustrations, enabling the doctor to immediately implement the adjustive maneuvers into his or her practice.

Perhaps the practicing clinician will comprehend the tremendous need for participation in research. Research by practitioners is critical for the growth and scientific development of our profession. This text should serve as an agenda for future clinical research rather than as a final statement of facts. For the student, it is hoped that this book will facilitate the sometimes difficult process of learning the art of being a doctor.

The patients, whom we all will ultimately provide our services for, have provided the necessary impetus for the completion of this work. Their needs can best be served through the development of standards of practice based on clinical methods that have been subjected to scientific scrutiny. It is now time for all of us to accelerate our efforts toward this end.

Gregory Plaugher, D.C.
Sunnyvale, California

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Many individuals have been involved in the completion of this textbook. One particular individual deserves special mention. Bong Mo Yeun illustrated the book in rapid fashion despite his tremendous personal loss during the process. His wife, Bo, succumbed to a long struggle with cancer while the final line drawings were being completed. The suffering of humanity has inspired this writing, and if the book helps the patients we have dedicated our lives to serving, then our efforts will not have been in vain.

My associate editor, Dr. Mark Lopes, has been a mentor of mine for several years. When I was overwhelmed by the magnitude and pace of the project, he provided the necessary push for completion. Two other mentors, Dr. Richard Gohl and Dr. Edward Cremata, provided many case materials and generally served as sources of inspiration in the clinical realm. All of the contributors deserve much appreciation. The majority of these individuals took time away from their private practices or academic duties to finish their assignments in a timely manner. The tone set by each chapter should provide the reader with a refreshingly clinical perspective.

The Editorial Advisors perused the drafts of the manuscripts for grammatical errors and content. Several members also provided case materials. Drs. Alex and Douglas Cox served as willing models for the majority of the photographs of the adjustment set-ups. Several patient models also helped: Beth Sneidar, Twyla Sederstrom, Wendi Marks, Julie Lumley, Melissa Cox, and Victoria Jette. Sue Adler provided library assistance, and Laura Tucker and Joy Rasmussen helped with typing. Dr. Bill Ruch provided the cadaveric illustrations.

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For those I have neglected to mention due to the harried nature of my existence for the past two years, I extend my appreciation.

Most importantly, this book is dedicated to the memory of C. S. Gonstead (1898-1978), who provided the foundation upon which this text is based.

G.P.

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1 Introduction to Clinical Chiropractic

JOSEPH C. KEATING, JR., GREGORY PLAUGHER, MARK A. LOPES, and EDWARD E. CREMATA

ROLE OF PHILOSOPHY AND SCIENCE IN CHIROPRACTIC

More substantive scientific investigation in chiropractic has occurred in the past decade than in all the previous history of the profession. This long overdue revolution has been welcomed by some, feared by others, and ignored by many. It may be premature to expect otherwise, for the accumulating volume of scientific data has not yet had a significant impact on the ways in which chiropractic is actually practiced. The sorts of decisive clinical experiments that could determine the disadvantages and relative merits of various chiropractic methods of helping back pain patients, for example, are only now beginning to appear in the literature (1). Studies to determine the effectiveness and relative effectiveness of chiropractic interventions for patients with visceral and behavioral health problems, however, are not yet on the drawing board.

Necessarily, therefore, chiropractic has been and will continue to be practiced based on less-than-ideal information. The same can also be said for all other health disciplines, and were we to return in a millennium we would still be confronted with the uncertainty of the individual, for science will never be so complete as to offer precise answers for all the idiosyncratic problems that patients bring to us. The problem of inadequate information is especially severe in chiropractic, however, because of our long survival struggle with organized medicine. Chiropractors have insisted, based on a century of clinical experience, that there is value to the art and that patients have a right to receive the alternative, complementary, primary care, and specialty services that doctors of chiropractic provide. Although successful to a point in the legislative halls of various states and provinces (e.g., in obtaining licensing laws and independent boards of chiropractic examiners), the claims and political strategies that have helped to win legal relief have also served to warp attitudes toward the nature of science and its role in health care (2,3).

Consequently, an extraordinary diversity of (frequently contradictory) misconceptions about clinical science can be identified (4,5) (Table 1.1), ranging from the error of equating science with medicine to the untenable notion that science is "truth." Along the way, we have likewise become confused about the relationships among science, philosophy, and technique. These uncertainties

provide barriers to developing the science and art of chiropractic to its full potential.

This is a book about technique in the clinical science of chiropractic. Although the authors repeatedly and most appropriately caution the reader about the tentative and largely untested nature of patient care, it may be well to review the characteristics of a genuine philosophy of the science of chiropractic. An appreciation of the appropriate philosophical and scientific context within which clinical methods are offered herein, can provide several benefits (such as guidance, inspiration, and comfort) to those who value and wish to understand better and apply the wisdom gained through practical experience. For those for whom this work serves as an introduction to chiropractic, a consideration of the character of philosophy in health science may encourage the sort of open-mindedness and tolerance for uncertainty that are so essential to both research and clinical practice.

Philosophical Principles in the Science of Chiropractic

All scientific activity is based on assumptions, some of which are shared by all sciences and some of which are unique to particular disciplines. Medical scientists, for example, have long adhered to the concept of disease. From this prescientific assumption, many testable hypotheses have been explored, some of which have been abandoned, some of which are generally accepted, and others which are still too poorly studied to permit firm conclusions. The discipline of physics has no use for medicine's disease construct but shares with medicine and astronomy an *a priori* (untestable) belief in the orderliness of causes and effects, and in the potential discoverability of cause-effect sequences.

Table 1.1.
Common Misconceptions About Research in Chiropractic

- | |
|--|
| 1. Chiropractic is a proven, complete science |
| 2. Research is unnecessary, since chiropractic is a "deductive science" |
| 3. The purpose of research is to prove that chiropractic works |
| 4. The primary goal of chiropractic research is to prove the neurological basis of the subluxation |
| 5. Research is someone else's responsibility |
| 6. Research is too expensive for chiropractic |
| 7. Chiropractors cannot do research because they have not been trained |

No one can prove or disprove the existence of disease, nor can we objectively test whether causation is “true” or “false.” The *a priori* assumptions (principles) of science are not subject to the scientific method of hypothesis-testing. Although the surgeon may mistakenly believe that in identifying a lesion he or she has discovered the disease, in fact only a sign of disease has actually been observed. The disease construct (which includes homogeneous clustering of signs and symptoms, knowledge of prognosis, knowledge of etiology, and derivative implications for patient care) cannot be located in space. Disease has no physical location, except in the minds of those who find it a more or less useful means of thinking about the health problems that patients bring to doctors. The concept of disease can no more be verified or falsified than can the idea of a supreme being. Such matters of faith (assumptions) may be more or less useful but cannot be scientifically proven or disproven; they are prescientific. These assumptions provide a part of the philosophical base of science. Exemplary of the prescientific principles and metaphors of chiropractic are the “supremacy of the nervous system,” the “healing power of nature,” and the concept of reciprocal influence between the structure and the function of the body.

The testable propositions offered by the members of a scientific discipline are known as hypotheses and theories. A theory may be thought of as one or more hypotheses; a hypothesis is a tentatively offered assertion about some aspect of the natural world that can potentially be verified or refuted by examining the natural world. For example, if we believe that a particular method of adjustive intervention will produce change in spinal motion at a particular segmental level, we might design an experiment to test the validity of this proposition. A well-designed experiment would include methods of controlling for or eliminating rival hypotheses, such as spontaneous change, natural oscillation, or instrument error. Publication of the results of such an experiment will lend credibility (or cast doubt) on our hypothesis, and may prompt other investigators to attempt to replicate or extend our research. If positive (confirmatory) evidence accumulates in the scientific literature, our hypothesis may eventually become widely accepted, not as truth, but as the best available approximation to truth.

It is important to note the tentativeness of hypotheses and theories, whether they have been tested, inadequately tested, or not yet tested at all. There is no absolute threshold of confidence in science, no plateau beyond which all doubt is forever abandoned. To doubt the tentative nature of all scientific knowledge is to forget the many lessons of the history of science. Consider, for example, the confidence with which physicists adhered to the relatively simple mechanical concepts of Newton for several centuries. Yet, in the face of the wisdom offered by Einstein’s theory, Newtonian “truths” were abandoned (or absorbed) in favor of the more comprehensive theory of

relativity. Although we ordinarily have more confidence in hypotheses that have repeatedly survived rigorous experimental tests than in those that are yet untested, we must be prepared to alter our theories in the face of better explanations (i.e., more comprehensive, better evidence). Science and scientists have much to be humble about.

Chiropractic is not merely science but is also a profession with a social purpose: to improve the health and welfare of human beings. Like other applied or clinical sciences, therefore, chiropractic has adopted a number of principles that guide the acquisition and implementation of scientific knowledge. For instance, chiropractors (like other health professionals) adhere to the Hippocratic maxim to “do no harm.” Such ethical precepts are not scientifically testable, are neither true nor false, and do not ordinarily give rise to testable propositions. These sorts of principles, unlike the concepts of disease or causation, are not prescientific; they might be thought of as extrascientific, or as part of the professional principles of the discipline rather than as part of the philosophy of science. All health professions and applied sciences, however, seem to agree on the appropriateness of such principles. These professional principles can also supersede scientific principles and motivations. For instance, the surgeon might wish to know the efficacy of a particular operation, yet be unable to conduct the required placebo-controlled clinical experiment because of ethical barriers. In such instances the needs of the patients (as protected by professional principles) outweigh the clinician-investigator’s desire to know.

Chiropractic encompasses all three of these sorts of ideas: prescientific assumptions, testable hypotheses, and professional principles (Table 1.2). During our century of clinical practice and political struggle, however, we have sometimes failed to distinguish among these categories. *A priori* assumptions have been offered as incontrovertible philosophical truths; scientifically untested hypotheses have been proclaimed as proven facts; professional principles have been misconstrued as scientific explanations. Although a historical analysis of how political and legal machinations have produced this confusion is beyond the scope of this chapter, it is important to recognize the confusion to plan for a legitimate philosophy of the science of

Table 1.2.
Principles and Metaphors of a Philosophy of the Science of Chiropractic

*Clinical conservatism (first, do no harm)
*Disease (reliable clusterings of signs and symptoms)
*Epistemology of science (scientific method)
*Holism
*Homeostasis and the self-healing capacity (“Innate Intelligence”)
*Professional autonomy
*Structure-function reciprocity
*Supremacy of the nervous system (strategic role of the nervous system)

chiropractic. If we can distinguish among assumptions, hypotheses, and ethical and professional imperatives, we can then also take pride in developing a first-class science and art of chiropractic, and thereby improve our technique and increase patient benefits.

Let us consider a few of the constructs that have traditionally been offered by chiropractors.

Innate Intelligence

Since its introduction by D.D. Palmer in 1906 the concept of “Innate Intelligence” has been a source of derision (6), not infrequently from critics who themselves acknowledge the “healing power of nature.” The source of this criticism is not the idea that humans are self-repairing and self-maintaining biological entities (which is a legitimate prescientific assumption). Neither have chiropractors been criticized because their recognition of an intrinsic healing capacity has encouraged a conservative orientation to health care by chiropractors, nor because the Innate metaphor encourages (or should encourage) a humility about the great limits to our understanding of human biology. Indeed, these are very positive aspects of Palmer’s theory of Innate Intelligence. These aspects are mirrored in other sciences and professions by other names. The famous physiologist Walter Cannon poetically termed his heuristic notion of homeostasis the “Wisdom of the Body,” and chiropractors share their respect for the *vis medicatrix naturae* and conservative health care with biofeedback psychologists, naturopaths, osteopaths, and others.

Why has an idea with so many positive and useful connotations brought such scorn on chiropractic and divisiveness within the chiropractic ranks? There are at least two reasons. Firstly, D.D. Palmer and many of his successors have defined the intrinsic healing capacity of patients as a fraction of Universal Intelligence (God), and in so doing have offered a religious construct as part of a scientific explanation (theory). In so doing, Palmer rendered his theories untestable, because spirits and deities are outside the realm of the observable and testable. Innate Intelligence cannot “explain” physiological functions but is instead another label for them. The development of scientific explanations for biological processes is the work of biologists, who are not content to offer names in place of testable cause-effect sequences. In this context, Innate serves as a substitute for biological curiosity and scientific investigation; better to acknowledge our infinite ignorance of the complexities of human physiology than to mask such ignorance by attributing physical processes to spiritual entities. Moreover, the spiritual intricacies of the Innate concept, such as the triune of Innate, Educated and Universal Intelligence, or the distinctions Palmer made between the “spirit” and the “soul,” are viewed as superfluous from the perspective of science. Fortunately, the founder of chiropractic allowed that chiropractic

could be competently practiced without adherence to his ideas about Innate/God.

Secondly, D.D. Palmer offered Innate Intelligence as a source of his knowledge of the correctness of his hypotheses; he tells us (7) that his 1910 volume, *The Chiropractor’s Adjuster*, was written “under spiritual promptings.” Spiritual insight has no role in science, however, and is contrary to the epistemology of science. *Epistemology* is that branch of philosophy which concerns itself with the nature of knowledge (See below). As noted earlier, science proceeds to construct knowledge of the natural world by posing and testing hypotheses, by discarding those which fail to stand up to scientific tests, and by pursuing those which seem to best explain the facts determined in objective investigations. This epistemology, also known as the *scientific method*, is certainly not the only way in which we may come to know “reality.” It is the method used in science, however, and knowledge systems that offer spiritual insights to support their beliefs are inherently at odds with the philosophy of science.

Despite these criticisms, Palmer’s notion of Innate includes a number of connotations that are quite legitimate and appropriate for a science of chiropractic. Palmer originally devised chiropractic in reaction to the horrendous abuses suffered by patients at the hands of the trial-and-error empiricism of turn-of-the-century heroic medicine in the Midwest. Recognition of the organism’s ability to repair itself and to maintain health under appropriate conditions encouraged Palmer (and has prompted chiropractors ever since) to maintain a conservative, relatively noninvasive orientation to assisting patients. This is not to say that chiropractic is risk-free (8) but rather to acknowledge that chiropractic methods are probably less risky overall than the rapid advance of high-technology medicine and surgery in this century (9). Recognition and respect for biological self-regulation by chiropractors may be seen to perpetuate the ancient Hippocratic maxim “first do no harm.” In this sense, then, the construct of Innate may be considered to promote caution in clinical practice, and hopefully also a thirst among doctors for ever better information about how the body works. As a practical matter, the practitioner of any chiropractic system must decide, in each and every case, what would be the best way to facilitate the patient’s inherent recuperative powers: to do nothing, to apply a particular chiropractic method, or to seek additional or alternative health services.

Epistemology of Science

As suggested above, the branch of classical philosophy that concerns itself with the nature of knowledge is known as *epistemology*. In addition to the unfortunate offering of spiritual insight as a way of knowing the value of chiropractic, D.D. Palmer also offered several other epistemologies for his theories and methods (5,10). These episte-

mologies include founding authority, rationalism and private, uncritical empiricism; none of these methods of knowing the value of chiropractic are consistent with the philosophy of science, although two of these (rationalism and private empiricism) are legitimate sources of chiropractic hypotheses. Regrettably, Palmer did not offer his theories with the tentativeness that characterizes a clinical experimenter:

Chiropractic is a proven fact—it is a science demonstrated by the art of adjusting. As we become acquainted with its principles, founded upon laws as old as the vertebra, we make less failures. The science can only be developed along the lines laid down by the Founder (11).

A genuine science of the art of chiropractic cannot be shackled to the theories and methods of its seminal thinker. Rather, science requires the flexibility to pose and test new hypotheses and techniques and the ability to discard those procedures and ideas that do not stand up to the rigorous reality testing of the scientific method. Similarly, the idea that a hypothesis or procedure is valid or effective merely because it is consistent with or can be deduced from the knowledge of the basic sciences must be rejected: just because a procedure makes sense is no guarantee that “it works.” Nor can the private, unsystematic or uncritically published observations of doctors substitute for the rigors of controlled trials of chiropractic methods. Although clinical observations and deductions from basic science do have valuable roles to play in the clinical discipline of chiropractic (as sources of hunches, hypotheses, and theories), these are necessary but not sufficient (12) to establish the scientific validity and effectiveness of the theories and methods that comprise the chiropractic art.

The alternative is an epistemology in which hypotheses are offered tentatively, tested carefully, and conclusions are published in scientific periodicals where everyone has the opportunity to criticize investigators’ assumptions, research methods, and interpretations of results. This process is central to science: a system of gradual public accumulation and refinement of the knowledge base. Moreover, this is a process for and to which the chiropractor is especially well situated to contribute; who better to observe, record, and publish the phenomena of chiropractic science than the Doctor of Chiropractic? The tangible product of this activity is the chiropractic scientific literature, as represented by the outstanding periodicals noted in Table 1.3. The goal is not to “prove that chiropractic works” (which is little more than an advertising slogan) but rather to develop and demonstrate improved quality of care for patients.

These comments (and perhaps the epistemology of science) may not sit well with many doctors; a century of struggle with political medicine has taught the profession that adamant, albeit unsubstantiated, assertions and claims have great political value (3). Nevertheless, as we now commence the era of chiropractic science, the very

same bold claims, anti-scientific epistemologies and philosophical strategies that have earned the profession some measure of legal security impede chiropractic’s development.

Most of the technique knowledge offered throughout the rest of this volume is based on a sound knowledge of the basic sciences and accumulated clinical chiropractic experiences. Shall we be embarrassed at how little of this information has undergone rigorous scientific testing, or should we be excited about the possibilities to be explored? An appreciation of the epistemology of science leads us to the latter. The attitude of the chiropractic clinician-investigator ought to be a balance between caution and humility (in drawing conclusion and making claims) and creativity and enthusiasm for the possibilities inherent in the chiropractic art (13).

Supremacy of the Nervous System

Since the time of D.D. Palmer’s second theory (11,14) and those theories of Solon M. Langworthy, D.C. (15), chiropractors have adhered to the prescientific construct of neural supremacy (16). Although originally offered as a scientific truism (17), this construct is more appropriately and usefully construed as an *a priori* assumption. For instance, biopsychologists and others have explored the possibilities of training the nervous system (e.g., through biofeedback procedures) to alter and improve disturbed physiological processes. Similarly, chiropractors also use a variety of methods that may be derived from the notion that the nervous system exerts a profound and pervasive influence in health and illness. For example, hypotheses about the meaningfulness of subluxation and the usefulness of adjusting are testable propositions that are consistent and derivable from the metaphor of neural supremacy. Interestingly, the legal mandate of the chiropractor in California is to maintain the “structural and functional integrity of the nervous system.” We should note that no one can prove or disprove that the nervous system is supreme, any more than we could prove that the kidney or the liver is the “master organ.” Nevertheless, the metaphor of neural supremacy can and has given rise to many testable hypotheses and methods, and in this capacity is quite appropriate.

A philosophical challenge for chiropractic practitioners is to formulate testable propositions about the nature and potential consequences of neural dysfunction as a consequence of structural abnormality and about the role of adjusting in resolving such lesions. Of course, these philosophical imperatives lead directly to the even more daunting task of designing, conducting and reporting (in scholarly journals) the results of such trials of chiropractic theories and methods. Although such tests will not prove or disprove the metaphor of neural supremacy, they can demonstrate the usefulness of this *a priori* principle for a genuine science of chiropractic.

Table 1.3.
Recommended Scholarly, Professional and Scientific Periodicals for the Chiropractor

Journal Title	Editor and Editorial Address	Annual Subscription Cost (1990–1991)	Comprehensive Indexing	Topics
Chiropractic History	Russell W. Gibbons; 207 Grandview Drive South, Pittsburgh, PA 15215 U.S.A.	\$35 (included in dues of the Association for the History of Chiropractic)	Bibliography of the History of Medicine of the National Library of Medicine (USA), CLIBCON Index ^a	History
Chiropractic Journal of Australia	Rolf E. Peters, D.C. and Mary Ann Chance, D.C.; P.O. Box 748 Wagga Wagga, NSW 2650 Australia	\$50 (Australian) within Australia, \$65 overseas	Australasian Medical Index, British Library Complementary Medicine Index, CLIBCON Index ^a	Science, history, professional and educational issues
Chiropractic Sports Medicine	Robert Hazel, Jr., D.C.; 220 Vroom Avenue, Spring Lake NJ 07762 U.S.A.	\$50; students: \$35	Biosciences Info Services, CLIBCON Index ^a Excerpta Medica, Phys Ed Index	Science, professional issues
European Journal of Chiropractic	Simon Leyson, D.C.; Gwendwr, 16 Uplands Crescent, Uplands, Swansea SA2 OPB Great Britain	\$76.50 (U.S.)	CLIBCON Index, ^a Current Awareness Topics Service (British Library)	Science, history, professional and educational issues
Journal of the Canadian Chiropractic Association	Alan Gotlib, D.C.; 1396 Eglinton Avenue West, Toronto, Ontario, Canada, M6C 2E4	\$57 (Canadian)	CLIBCON Index ^a	Science, history, professional and educational issues
Journal of Chiropractic Education	Grace E. Jacobs, D.A.; 590 N. Vermont Ave., Los Angeles, CA 90004 U.S.A.	\$25	CLIBCON Index ^a	Educational issues, scholarly research in education, science, history
Journal of Chiropractic Technique	Thomas F. Bergmann, D.C.; 735 Keokuk Lane, Mendota Heights MN 55120 U.S.A.	\$48; students: \$25	CLIBCON Index ^a	Science, history, professional and educational issues
Journal of Manipulative & Physiological Therapeutics	Dana J. Lawrence, D.C.; 200 E. Roosevelt Road, Lombard, IL 60148 U.S.A.	\$68; students: \$40	BIOSIS, CLIBCON Index, ^a Current Contents Excerpta Medica, Index Medicus, USSR Academy of Sciences	Science, some history, professional and educational issues
Journal of Manual Medicine	J. Dvorak, M.D.; Dept. of Neurology Wilhelm Schultess Hospital Neumunsterallee 3 CH-8008 Zurich Switzerland	\$119 (U.S.); DM 158.00		Science, professional issues

^aCLIBCON (Chiropractic Library Consortium) Index to the Chiropractic Literature

Clinical Conservatism

The chiropractor's use of relatively less risky health-care procedures has already been noted. This self-imposed limitation does not, however, absolve the doctor of responsibility for wrestling with the thorny ethical dilemmas that practice presents. Respect for patient welfare and the inherent recuperative powers of the body demands that chiropractors question their use of all methods, because the risks of all health-care procedures are always relative. The doctor ought to weigh how much better or worse off a patient would be if nothing is done, or if referral were made to another kind of doctor.

Clinical conservatism also implies a concern for the ethical dilemmas involved in chiropractic research. For instance, when are posttreatment x-rays justified? Does the doctor's desire to know whether structural changes have resulted from adjusting justify further radiation exposure, or must potential patient benefit outweigh such

risks? Can the chiropractor assume that "chiropractic works" so as to justify any form of assessment or intervention? What ethical conflicts would be presented in a comparative trial of chiropractic versus medical/surgical methods for patients with scoliosis? A commitment to clinical conservatism implies a willingness to think such issues through and to be guided firstly by the patient's best interests.

Subluxation

Is the chiropractic notion of subluxation a philosophical principle (i.e., an *a priori* assumption or metaphor) or is it a scientific proposition? Could it be both? Is subluxation a scientifically proven fact? Is the existence of a chirolesion essential to the profession (18)?

Most chiropractors are able to agree at a conceptual level on a definition of the classic chiropractic lesion.

Likely to be included in that definition is some combination of structural abnormality and consequential alteration of function. Agreement ends here. To the authors' knowledge, no operational definition of subluxation has ever been scientifically substantiated, although a great many different theories and methods of subluxation-detection have been offered. What little consistency and agreement there are on the definition of the chiropractic lesion revolve around the reality and meaningfulness of subluxation, whatever the ubiquitous critter may be. We rarely question whether subluxations are "real." Are subluxations more or less real than the concept of disease?

The idea of subluxation is so overburdened by connotations and political implications (10) that the use of the term "subluxation" as a catchall label for the "manipulable lesion" sometimes hinders rather than promotes good clinical science. Worthy first steps in resolving the confusion over "subluxation" involve: 1) differentiating among its philosophical (metaphoric) versus scientific/hypothetical/operational versus dogmatic definitions, 2) loosening our rigid grip on the subluxation concept as the *sine qua non* of chiropractic, 3) increasing research efforts to establish an objectively reproducible and clinically relevant subluxation definition, and 4) lessening reliance on the subluxation in the political arena. Chiropractic as a profession has the right and the ability to sustain itself whether or not subluxation is a meaningful concept.

Professional Autonomy

The overwhelming majority of chiropractors agree that the chiropractic art and science is the privilege and responsibility of doctors of chiropractic and that chiropractors have a right to organize and self-regulate. The organization of the profession ought to proceed in a manner consistent with DCs' self-professed mission to improve the health of patients. Like the concepts of neural supremacy and clinical conservatism, the principle of professional autonomy is a matter of choice and is neither true nor false.

The principle has its limits, however. To the extent that chiropractic-the-profession aspires also to be chiropractic-the-science, it necessarily assumes the responsibilities of a science. Prominent among these is the obligation to share its knowledge and wisdom freely with all interested parties (19). As we noted earlier, science is a public process of information refinement through publication and critical debate. There can be no private science of chiropractic, and contributions from nonchiropractors ought to be judged according to their content rather than their profession of origin.

Professional autonomy and self-regulation also require that individual doctors participate in the collective activities of the whole, and abide by the ethical standards of the profession. If chiropractic-the-profession aspires to be a scientific discipline, then it must assume

responsibility for policing itself. We might also expect the profession to pool its knowledge and resources so as to further knowledge development and implementation. The recent initiatives to develop standards of quality of care through publication (20) and standard-setting conferences (21) are encouraging.

ART IN CHIROPRACTIC

Clinical Art

The interactive process between patient and physician is complex. Coulehan (22) has discussed the clinical art of chiropractic, offering suggestions on how to optimize the patient encounter. The physical skill of the spinal adjustment has often been referred to as the art of chiropractic. Coulehan considers the adjustment the manual art, and the interactive process between doctor and patient, the clinical art. Qualities of the clinical art include: a) empathy, the ability to sense a patient's experience and feeling accurately and to communicate this understanding to the patient; b) genuineness, the ability to be oneself without hiding behind a role or facade; c) unconditional positive regard, the ability to accept and validate patients just as they are. The patient will respond to these qualities by developing trust, thus reducing anxiety. Relieving tension in the mind is at least as important as in the spinal column. The strategic role of the nervous system in maintaining homeostasis and the chiropractor's role in facilitating it does not stop at the foramen magnum.

Doctors are trained to identify and treat lesions, diseases, maladies, infirmities, etc. Patients, on the other hand, suffer illnesses that are experiences of disparagement in states of being and in social function—the human experience of sickness (23). The identifiable lesion is not always directly related to the patient's state of being. It is important for the doctor to recognize this potentially dichotomous relationship between lesion and illness in facilitating patient recovery. Whether the doctor wills it or not, all doctor/patient encounters are sets of social and interpersonal transactions (24). The patient is inevitably going to be affected in important ways by the relationship with the doctor. To render quality patient care, it is imperative that the doctor increase the knowledge and the skill he or she brings to bear on that relationship. We must abandon the notion that we need to "subtract" the patient to get to the disease; rather we must learn to observe the body **and** to hear the patient (23,25).

Manual Art

In keeping with the clinically practical focus of this text, we have chosen to present some of the nuances of the chiropractic manual art. A discussion of how the student can optimize the learning environment and the rationale behind the specific techniques presented follows.

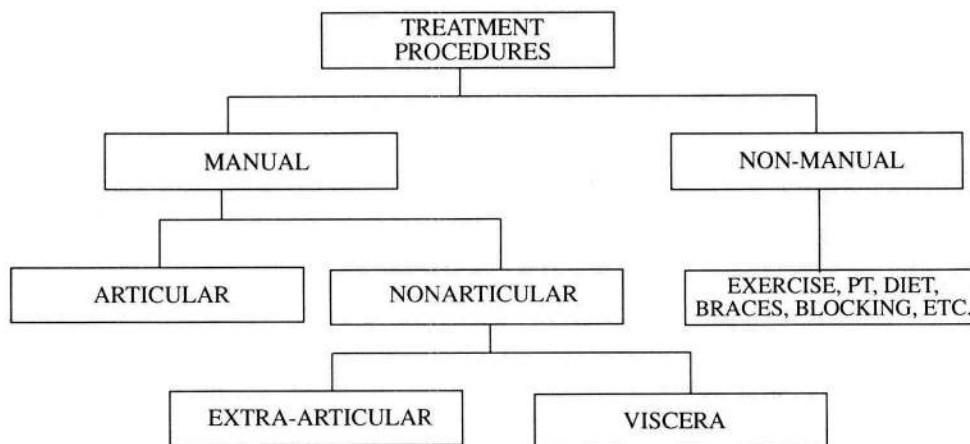


Figure 1.1. Chiropractic treatment procedures. Modified from Bartol KM. A model for the categorization of chiropractic treatment procedures. *J Chiropractic Technique* 1991;3:79.

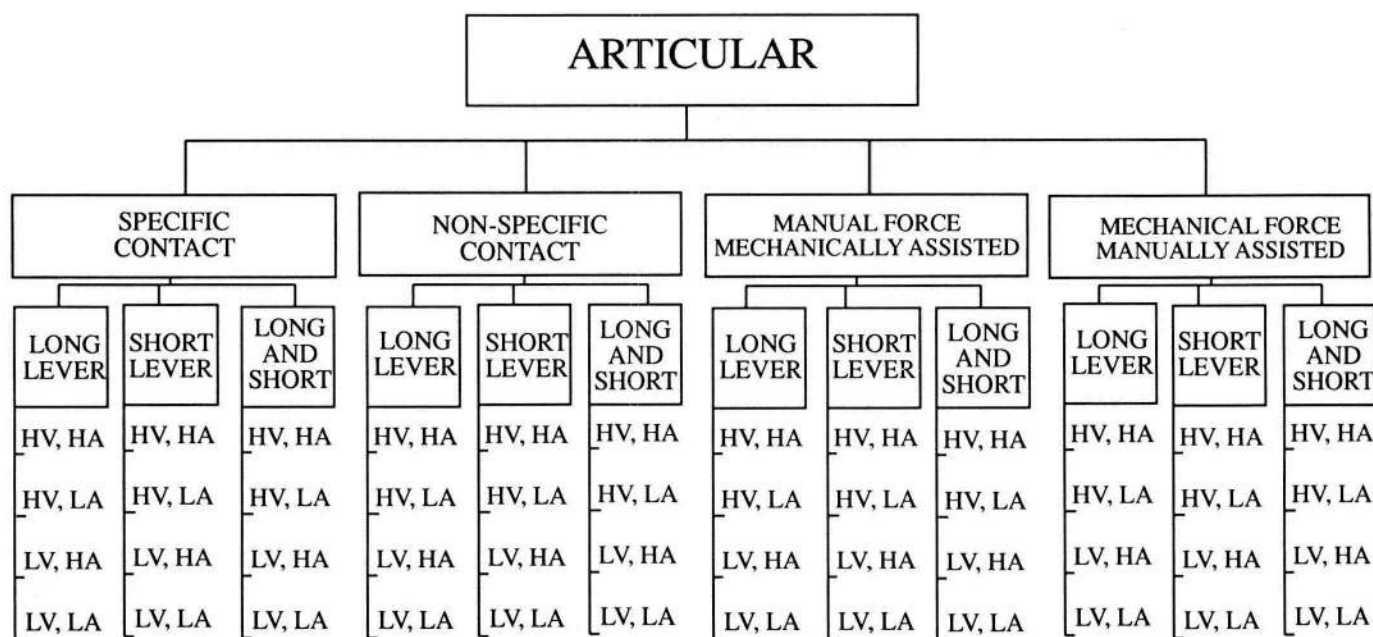


Figure 1.2. Articular procedure descriptions. H = High, L = Low, V = Velocity, A = Amplitude. Modified from Bartol KM. A model for the categorization of chiropractic treatment procedures. *J Chiropractic Technique* 1991;3:79.

SHORT LEVER SPECIFIC CONTACT PROCEDURES

A model for the categorization of chiropractic treatment procedures has been presented by Bartol (26). The ACA Council on Technique has developed this flow chart based on the “method of delivery” as a means for categorizing the different technique procedures (Figs. 1.1-1.2). An emphasis on specific, short lever arm adjustments will be found throughout this text. There are several reasons why we have adopted this approach.

Primum Non Nocere. “Above all, do no harm,” is a principle that all health care providers must consider first before performing any examination or treatment procedure.

A listing system is used to determine the relative position (positional dyskinesia) of the subluxated segment in need of an adjustment. The articulation will assume a position that is reflective of the ligamentous damage that is present. The use of a specific adjustment, three-dimensionally directed away from the direction of misalignment, is to avoid additional harm to the supporting ligamentous elements.

The specific adjustment also protects normal, nonsubluxated segments. By using mechanically advantageous pretensioning (preload), end-range positions, the practitioner can protect the normal segments from any trauma caused by the adjustive thrust.

Patient Management. Specificity during the adjustive thrust combined with limiting the number of spinal segments adjusted at any one time, assists the practitioner in the clinical management of the patient. A more direct or causal relationship may be inferred, when fewer spinal segments are adjusted at one time or in a series. These adjustments are then compared with both subjective and objective factors of the patient's response to treatment. The clinical importance of this approach is quite obvious when comparison is made to the rigors of a clinical trial (i.e. controlled clinical trials), where the limiting of variables is necessary to determine the effects of interventions.

Compensation. Gonstead, Gillet, Jirout, and others have taught that the spine compensates for subluxated/fixated motion segments. These compensatory segments or spinal regions are often hypermobile, edematous, and tender. Specificity during adjustive thrusts may protect these irritated areas from manipulative thrusts. A comprehensive examination will assist the practitioner in differentiating primary subluxations from secondary compensations.

LEARNING THE ADJUSTIVE ART

Learning the psychomotor skills of adjusting within the confines of a college curriculum, has been problematic. Because highly complex, coordinated movements require considerable time to master, the student is usually faced

with insufficient skills when beginning patient care. There are many ways in which to optimize the learning environment. Perhaps a look at how technique is typically taught with an analogy from baseball can provide a useful perspective:

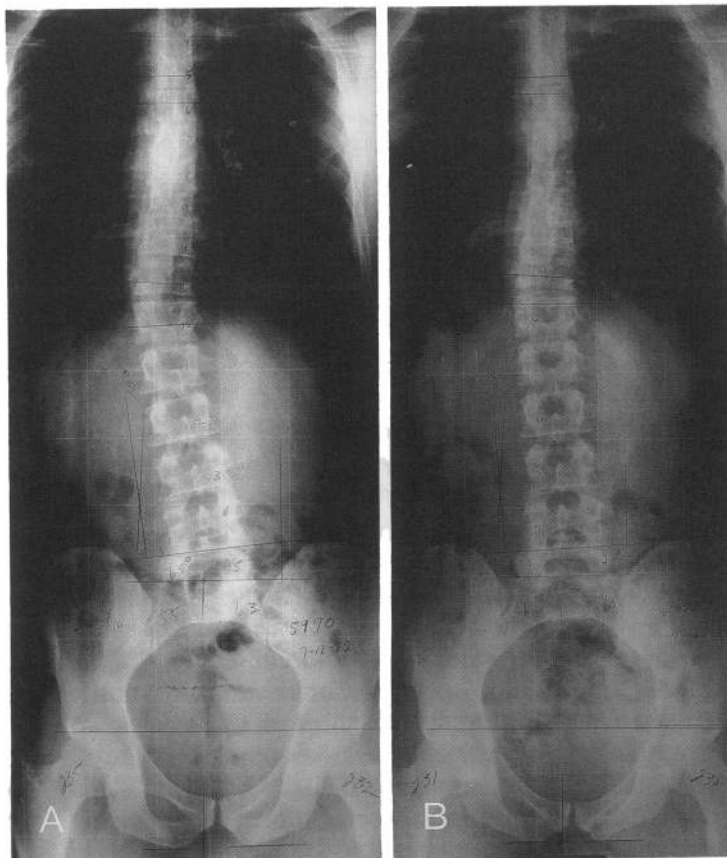
The novice pitcher is being instructed on how to throw baseballs across home plate in the strike zone. Instead of allowing the pitcher to see the strike zone, it is covered with a shadow.

The first pitch is thrown into the abyss. It does not result in a strike (or joint movement for that matter). The instructor moves the elbows, shoulders, arms, and legs of the pupil, to a position which, on release of the throw (or thrust), will theoretically result in a strike. The throw is repeated, with a similar outcome.

The key to someone throwing strikes, or making a successful adjustment, is to know, to see, or to imagine the result of each pitch or thrust. Alterations can then be made (some subconsciously) in the motor system to change the throw or release of the ball or thrust. If chiropractic students could see the effect (i.e., joint displacement) of the thrust both during and after, then their bodies could conform to the new requirements more easily.

Videotaping the student's movements can sometimes provide useful information. It is more important for the student to study the movements of a successful adjust-

Figure 1.3A, Pretreatment radiograph demonstrating a left convex scoliosis, a lateral flexion malposition at L5, and positional dyskinesias of the sacrum and innominates. **B,** Post-treatment radiograph showing improvement in scoliosis and intersegmental displacement of the lower back. Patient was not antalgic and comparative examination was made after 6 weeks of care.



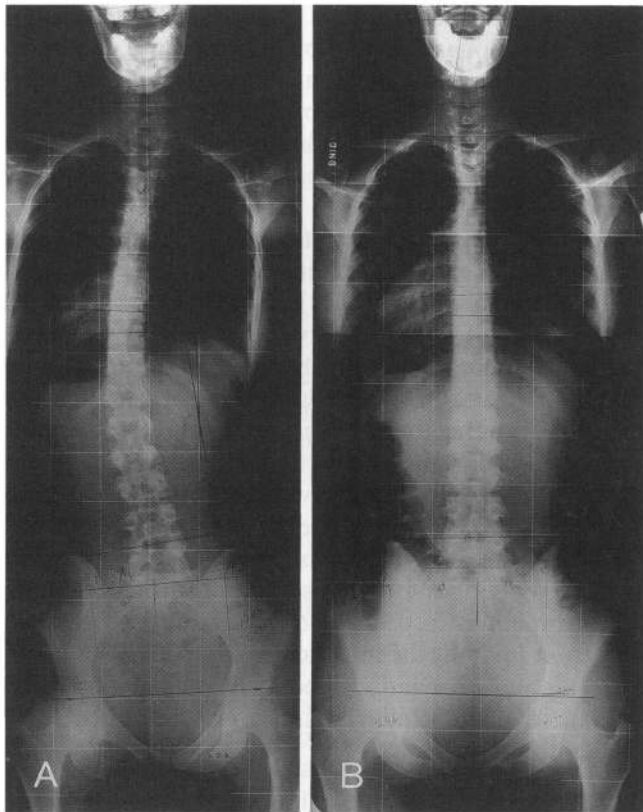


Figure 1.4A, Pretreatment radiograph. Patient is not antalgic. **B,** Posttreatment radiograph shows dramatic improvement in the intersegmental and postural displacements. Unfortunately, it is not always so easy.

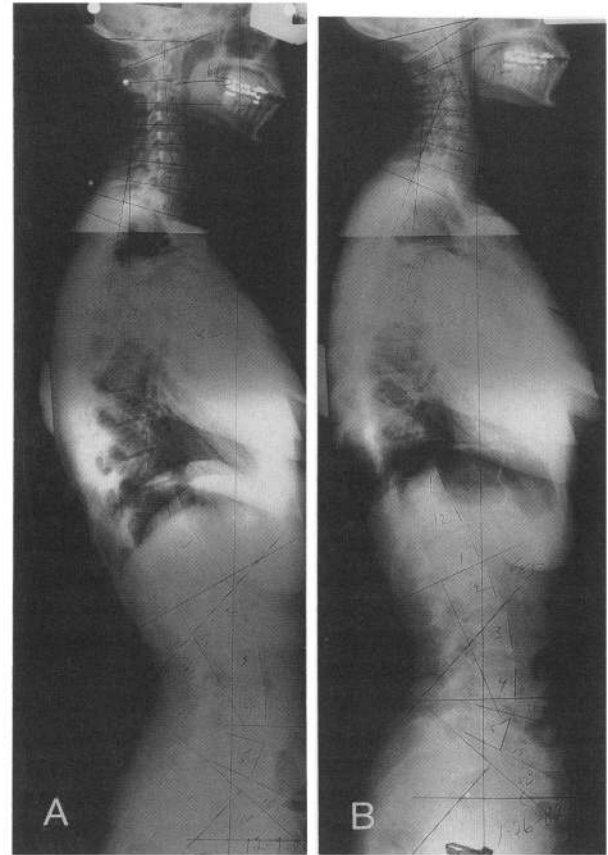


Figure 1.5A, Pretreatment radiograph. Notice the failure of the cervical lordosis to be balanced over the lumbar lordosis. **B,** Posttreatment radiograph after approximately 6 weeks of care. Notice the return of the cervical lordosis and the overall improvement in the postural configuration of the full spine.

ment either through video or direct observation. The attempt is then to duplicate the instructor's actions.

There are many ways to image the spinal column, but at present, only those methods using ionizing radiation have widespread availability. How then can the radiograph be used as a strike zone to maximize the effectiveness of a thrust? First, the positions of the various segments and their global postural configurations can be readily determined. For many adjustments the primary objective will be to move the segment forward (i.e. posterior to anterior). If the force is not directed through the center of mass of the segment this will cause forces to be dispersed more at adjacent levels (27). Second, pre- and postradiographs after successful and unsuccessful adjustments can provide the student with a visual picture of the effects from differently directed forces. If the radiograph demonstrates improvement in position or movement, then this can be used as a conceptual "goal," as it were, similar to how a baseball pitcher will conceptualize a strike before the throw (Figs. 1.3–1.6). If the force is directed inappropriately, then this too will be evident (Fig. 1.7). These mental pictures cannot be emphasized enough. When the novice positions for a set-up, at best, they will be thinking about line of drive in relation to the

spinous process being contacted. The doctor, however, will have a mental picture of the three-dimensionality of the listing and the pattern of thrust that will be directed through the center of mass of the segment.

The cerebellum is chiefly concerned with coordinated movements. The cerebrum can interfere with these activities. Let us say, for example, that one hundred red bricks were placed end on end on a flat terrain. Most people would have no trouble at all walking along the narrow row of bricks, placing one foot in front of the other. If an individual was intoxicated in the above scenario, impaired cerebellar activity would hinder the walk. To show how the cerebrum can interfere with the task the row is now raised 50 feet above the ground. Most people would now have tremendous difficulty in negotiating the task. This is because they would be thinking (i.e., a cerebral activity) about the possibility of falling. The same scenario applies to the adjustment. Although a visual picture of the pattern of thrust is necessary, thinking intensely about the event or other matters tends to incoordinate the activity (Fig. 1.8A). Many times, the reason for an unsuccessful adjustment is that the individual is concentrating on matters

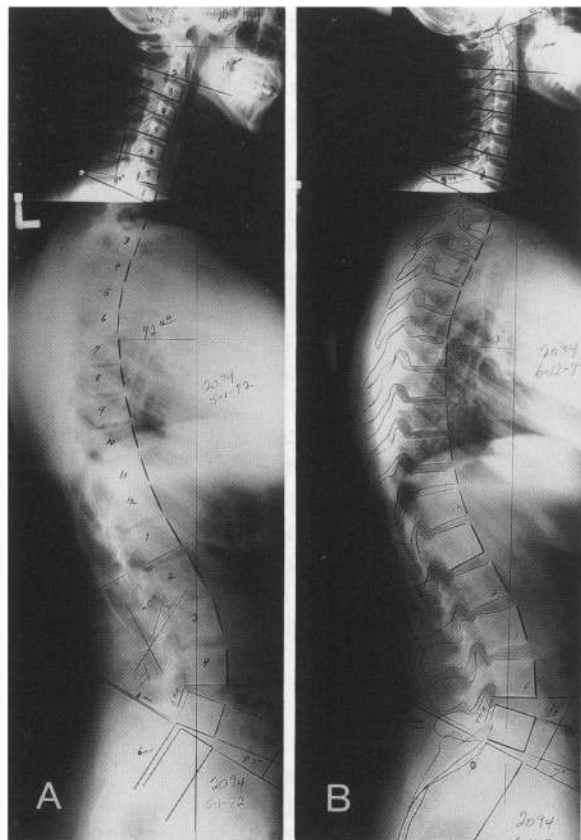


Figure 1.6A, Pretreatment radiograph showing retrolisthesis at L5 and L4 and a kyphotic cervical spine. **B,** Posttreatment radiograph after approximately 6 weeks of care. Notice the return of the cervical lordosis and reduction of the retrolisthesis at L5.

unrelated to the performance of the coordinated thrust. These distractions must be kept to a minimum, especially when one is beginning to learn the adjustive process (Fig. 1.8B). Cerebral activities are of course extremely important during the diagnostic work-up. The doctor must then “switch gears” when performing the psychomotor activity.

Scientific investigation into the role of imagery in facilitating the learning of adjustive skills has been provided by Josefowitz et al. (28). Two groups of students were evaluated for their ability in performing a spinous push adjustment for the lumbar spine. The first group mentally rehearsed performing the adjustment, and the second group imagined the spine and the positive outcome of the adjustment. The performance of the group who imagined the spine improved significantly more than the group who rehearsed the physical aspects of the adjustment. It is clear from this report that the continued practice of having students observe an instructor making an adjustment is suspect. Students are likely to benefit more from studying the intricacies of the biomechanics of the spine and pre- and comparative radiographs (both static and dynamic) and from imagining the positive outcome of the adjustment.

SUMMARY

This excursion into the philosophy, science, and art of chiropractic has been far from comprehensive. Nevertheless, it is hoped that the reader will have sensed the mutual

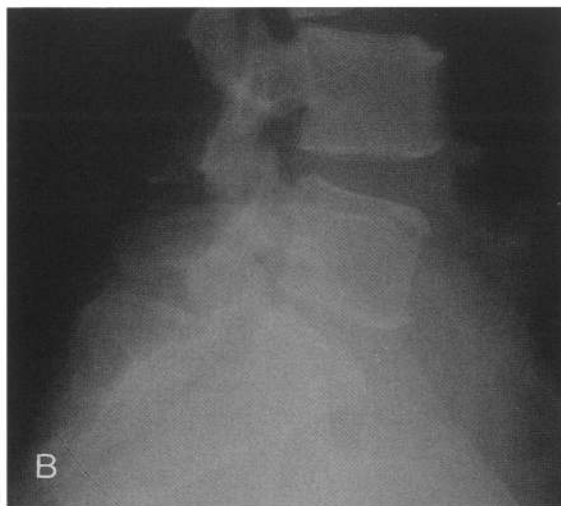


Figure 1.7A, Pretreatment radiograph demonstrating minimal retrolisthesis of L5 on sacrum. Motion palpation assessment revealed marked restriction in forward translation (+Z) of the sacrum. The patient was adjusted 10 times. Clinical findings suggested marked improvement in motion of the sacrum, a condition which was inconsistent with the radiologic picture. A comparative

radiological examination was therefore performed. **B,** Posttreatment radiograph after (12 adjustments) demonstrating a clear retrolisthesis of L5, most likely caused by adjusting the sacral base forward. Even in the absence of clear contraindications to manipulation (e.g., lytic metastasis of the contact vertebra), chiropractic procedures are not entirely benign.

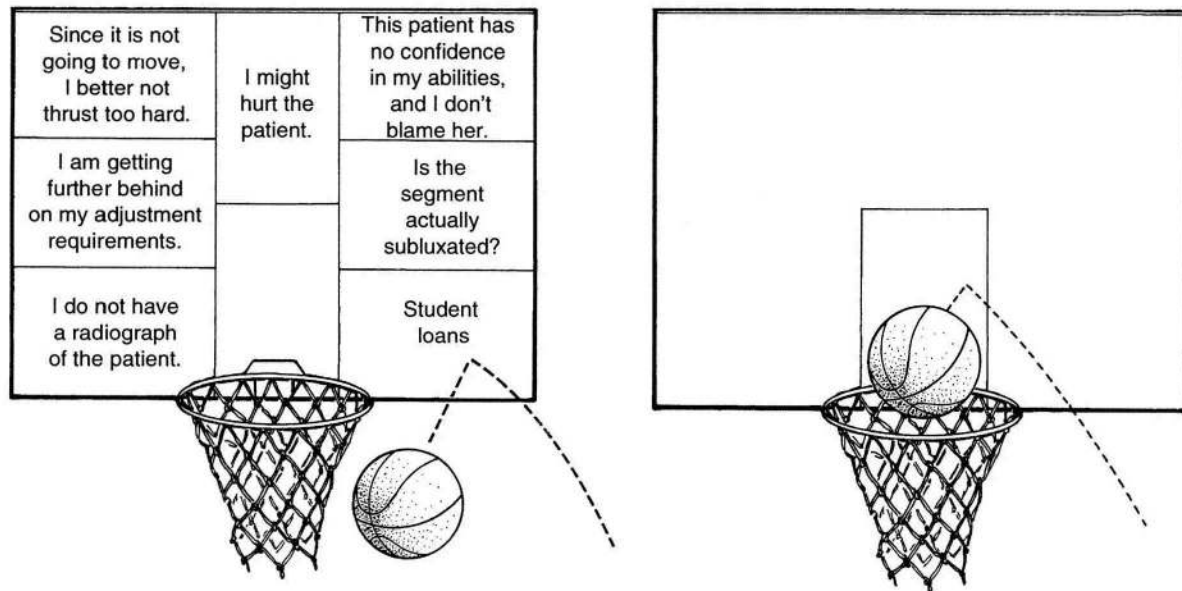


Figure 1.8 (Left) Thinking about matters disrupts cerebellar function and leads to a missed basket. (Right) A clear backboard results in two points.

dependence among philosophy, science, and technique (art) in chiropractic. The exchange among components of the discipline of chiropractic is necessary and desirable, and requires some mental exertion. Rather than serving as a defensive, political crutch for the profession, philosophy ought to be a source of guidance and inspiration for the development of a first-class science of chiropractic technique. Prepared by a familiarity with the legitimate roles of all three areas of chiropractic thought, the chiropractor can take pride in what we have learned so far and maintain enthusiasm for the task awaiting us.

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2 Clinical Anatomy and Biomechanics of the Spine

GREGORY PLAUGHER with the assistance of MARK A. LOPES

Biomechanics of the spine has historically been presented as an abstract subject, somehow separate from clinical applications. This chapter has been written to bring each anatomical and biomechanical premise or fact directly into the clinical situation, thus providing a central focus. The chiropractor must be an expert in spinal biomechanics and have the ability to apply the information in the clinical situation.

The spinal column is a complex structure. This complexity can often confuse the student clinician. Fortunately, some areas of the spine are well studied, such as the lumbar spine. There are insufficient basic science data or clinical research for other regions of the spine. Furthermore, the organization of such a complex topic is difficult because of the multiple interactions between the separate anatomical parts and physiological components.

The spinal column has the primary function of protecting the delicate spinal cord and nerve roots from injury. Protection of the nervous system is provided primarily by the articular structures (e.g., bone, ligament), but mechanisms do exist in the nervous system itself (e.g., spinal cord) that protect it from injury.

The function of protection takes place in a very hostile environment, one in which large loads and bending moments are encountered and transmitted, during which demands of normal physiologic movement must necessarily be preserved. In this awkward environment, things often go awry and injury results.

The presentation of clinical anatomy and biomechanics of the spine can take a number of directions. This discussion proceeds from the inside out, highlighting the major focus of the chiropractic physician, the nervous system.

SPINAL CORD

Biomechanics

Much more is to be learned about the physical properties and the functional mechanics of the spinal cord. When removed of circumferential attachments, nerves, and dentate ligaments, the spinal cord will lengthen by 10% under its own weight in the vertical position. This very flexible behavior changes to stiff resistance when an attempt is made to deform it further (1). The load-displacement curve for the spinal cord, therefore, has two distinct phases (Fig. 2.1):

1. The first is characterized by a large displacement with minimal applied forces.
2. The next phase shows little deformation under larger forces.

Forces in the initial phase are up to 0.01 N (0.04 oz.). The second phase can support 20–30 N (4.5–6.7 lb/f) before the tissues begin to rupture.

The spinal cord must adapt to the changes in length of the spinal canal during physiological motion. Flexion and lateral bending will effectively lengthen the spinal canal, necessitating accommodation by the cord and nerve roots (Fig. 2.2). Most of the change in length occurs at the posterior portion of the spinal cord (Fig. 2.3A-B). Two mechanisms are responsible for the change in length. The first is characterized by a folding/unfolding accordion-like action of the posterior cord. The second, which is only responsible for approximately 25 to 30% of the length change, is due to the elastic stretch/compression of the spinal cord tissue itself. In the cervical spine, the neutral, lordotic cervical region shows the posterior cord folded like an accordion (Fig. 2.3A). During flexion, the cord first

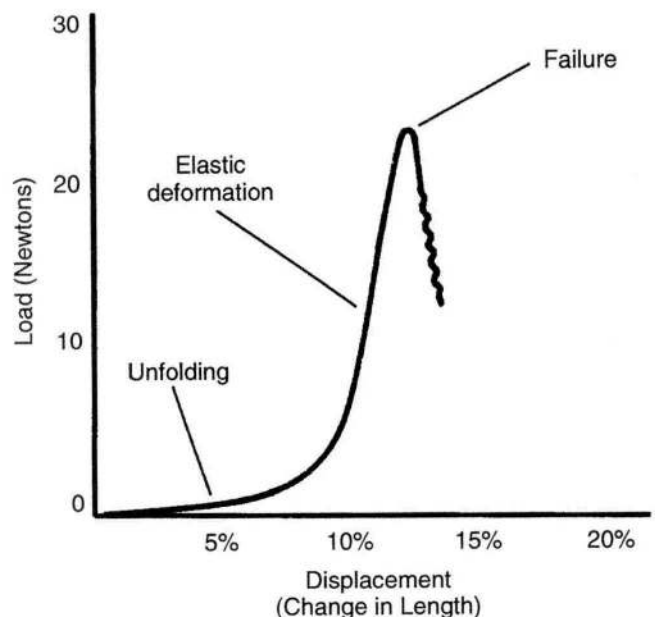


Figure 2.1. The load displacement curve for the spinal cord. Based on data from Brieg A. Adverse mechanical tension in the central nervous system. Stockholm: Almqvist & Wiksell International, 1978.

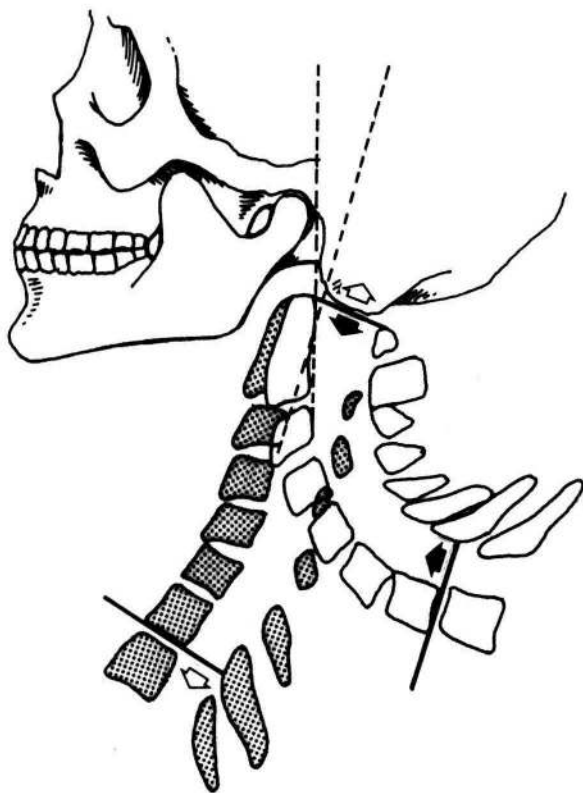


Figure 2.2. The spinal canal shortens during extension and lengthens during flexion.

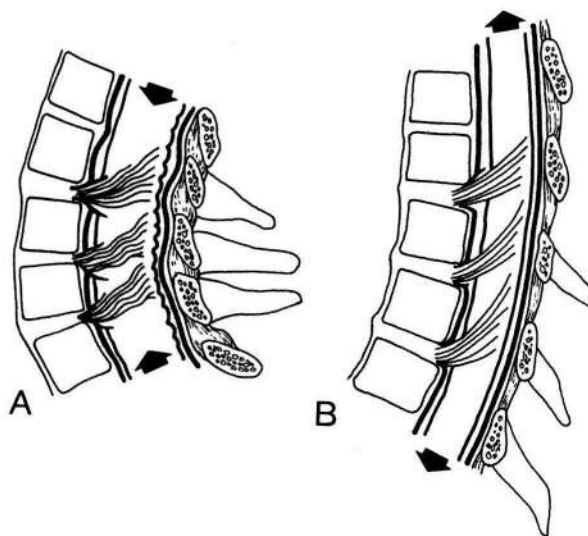


Figure 2.3. Mechanism by which the spinal cord changes length (See text). A, Neutral Position. B, Flexion.

unfolds with a minimal increase in its tension, followed by some elastic deformation near full flexion (Fig. 2.3B). When moving into extension, the spinal cord first folds, then elastically compresses. With hyperflexion of the neck or static postures of marked kyphotic angulation, the potential for spinal cord stretch is increased. Central ner-

vous system disorders, such as tic douloureux or cervical migraine, can often be provoked with cervical flexion (1).

FUNCTIONAL SPINAL UNIT

The term functional spinal unit (FSU) or motion segment refers to two adjacent vertebrae and the ligamentous and soft tissue elements that connect them. In the thoracic spine the posterior rib articulations are also included in the description. The motion segment has the same functional characteristics as the region of the spine of which it is a part (2,3). The articulations from occiput to C2, and the sacroiliac region, are described in detail in Chapters 6 and 11. The anatomical parts of the FSU or motion segment from C2 to S1 are as follows (Fig. 2.4):

1. The central joint: vertebral bodies, intervertebral disc (annulus and nucleus), anterior and posterior longitudinal ligaments;
2. The posterior joints and articular capsule; and
3. The ligaments between the neural arches: supraspinous, interspinous, intertransverse, and the ligamentum flavum.

The effect of annular and nuclear injury at a single FSU on movement has been demonstrated by Panjabi et al. (4). A lumbar motion segment was tested before and after annulus removal, and later, with a combination of annulus and nucleus removal. The mechanical properties were determined by imposing a predetermined torque around each of the cardinal axes (X,Y, Z) (Fig. 2.5). Vertebral movement after each application of torque was then measured in degrees. As can be seen in Figure 2.6, although both injuries had effects, nucleus removal (with annulus injury) caused the most increase in motion. This occurred in all directions, excluding compression (–Y)

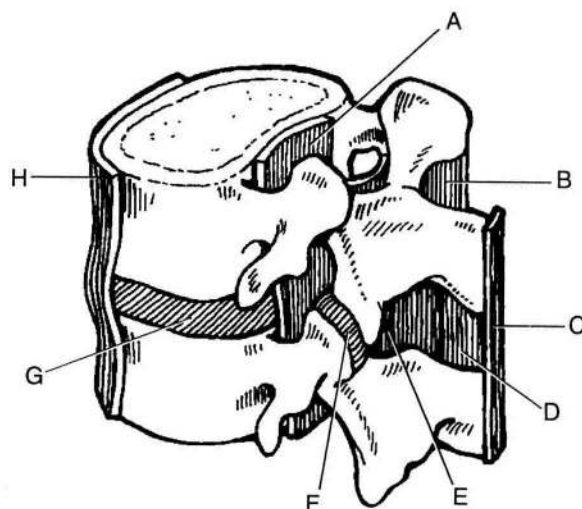


Figure 2.4. The functional spinal unit or motion segment. A) posterior longitudinal lig., B) intertransverse lig., C) supraspinous lig., D) interspinous lig., E) ligamentum flavum, F) articular capsule, G) intervertebral disc, H) anterior longitudinal lig.

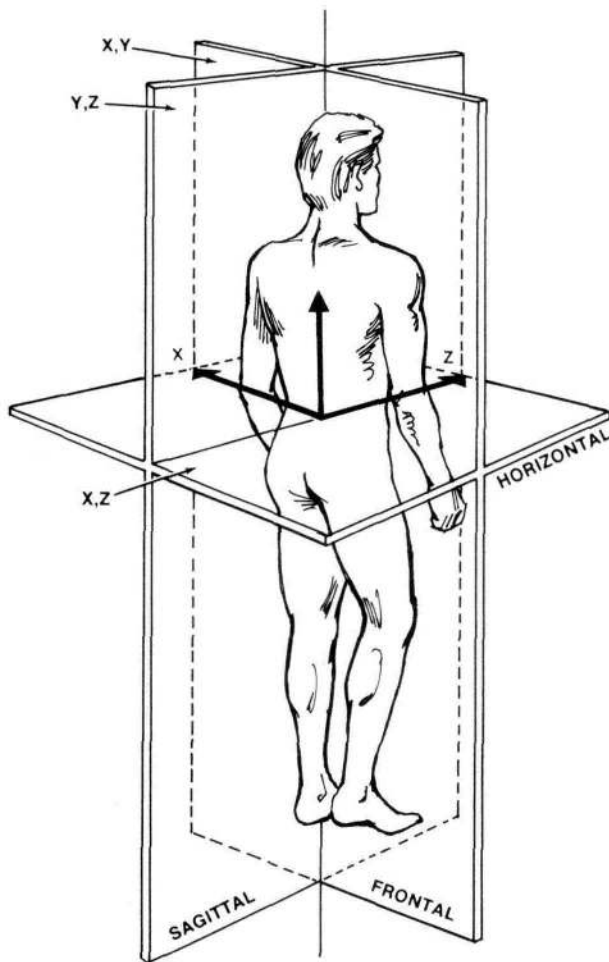


Figure 2.5. The cardinal planes of the human. Each plane is formed by two axes. The sagittal plane is formed by the Y and Z axes, the coronal plane by the Y and X axes, and the transverse plane by the X and Z axes.

or bending towards the side of injury ($+\theta Z$). The lack of significant biomechanical change after experimental injury at the disc of the motion segment when loaded under compression has been termed the “self sealing phenomenon” (5).

With the effects of specific disc injuries in mind, the implications for exercise or ergonomic prescription, are as follows:

1. The patient should not laterally flex away from the side of injury as this will cause the greatest increase in motion.
2. Movements that cause compression at the site of the injury, such as extension for a posterior, central annular bulge, or right lateral bending in the case of right sided disc injury, should be encouraged. If these movements increase pain or dysfunction, then they should be discontinued.

Panjabi et al. (4) have postulated the process whereby the effects from injury at a single FSU spread to the surrounding motion segments, thus influencing entire spinal regions (Fig. 2.7). Unequal movement of the FSU caused

by central injury will then spread to the posterior articulations (Fig. 2.8).

Three-Joint Complex

Function and dysfunction at the motion segment should be analyzed from a three-joint perspective (6). The disc and the two facet joints make up a tripod of complex joint interactions. The center of axial rotation (θY) for the disc and the facets is close to the center of the disc (7). This center, about which the vertebra rotates, will change position when there is motion restriction (fixation dysfunction). This is usually due to trauma and adhesions in portions of the disc or facet joints. The center or axis of rotation can also change position because of ligamentous laxity or rupture. The changed axis will load the joints of the FSU in an asymmetrical manner. This asymmetrical loading renders the individual susceptible to continued reinjury when the spine is loaded symmetrically, because the dysfunctional motion segment will cause loads to be focused at particular sites. The abnormal movement of the FSU, from damage to the disc alone, will gradually lead to subsequent injury and degeneration at the posterior joints. Lumbar facet degeneration rarely occurs before disc degeneration (8).

Intervertebral Disc

Annulus Fibrosis. The annulus fibrosis consists of a narrow outer zone of collagenous fibers and a wider inner zone of fibrocartilage which surrounds the nucleus pulposus (9). The annulus consists of approximately 15 to 25 distinct layers—depending on the circumferential location, the spine level and the age of the individual (10). The architectural pattern of the annulus is a fabric of lamellae with all the fibers in each lamina running in the same direction. The adjacent laminae have a similar structure, but these collagen fibers run in the opposite direction. The fiber angle, with respect to the horizontal, varies within the lamellae. Gallante (11) has determined that the fiber angle is approximately 28 degrees for the outer layers and 22 degrees for the inner lamellae (Fig. 2.9).

This angle to the horizontal increases when the posterior annulus is distracted, such as during forward bending. Collagen fibers are strongest when loaded along their longitudinal axis. Gallante (11) has further shown that the annular fibers tensed at 30 degrees to the horizontal are approximately three times stronger than those fibers that are loaded horizontally.

The tensile strength of the lumbar annulus is greatest at the posterior and anterior periphery (12). These areas are loaded most during flexion and extension motion. Although there is added strength for resisting flexion this is not true for axial rotation (Y axis). During axial rotation, the torque is applied perpendicular to the fiber orientation (Fig. 2.10) of the annulus. The annulus is

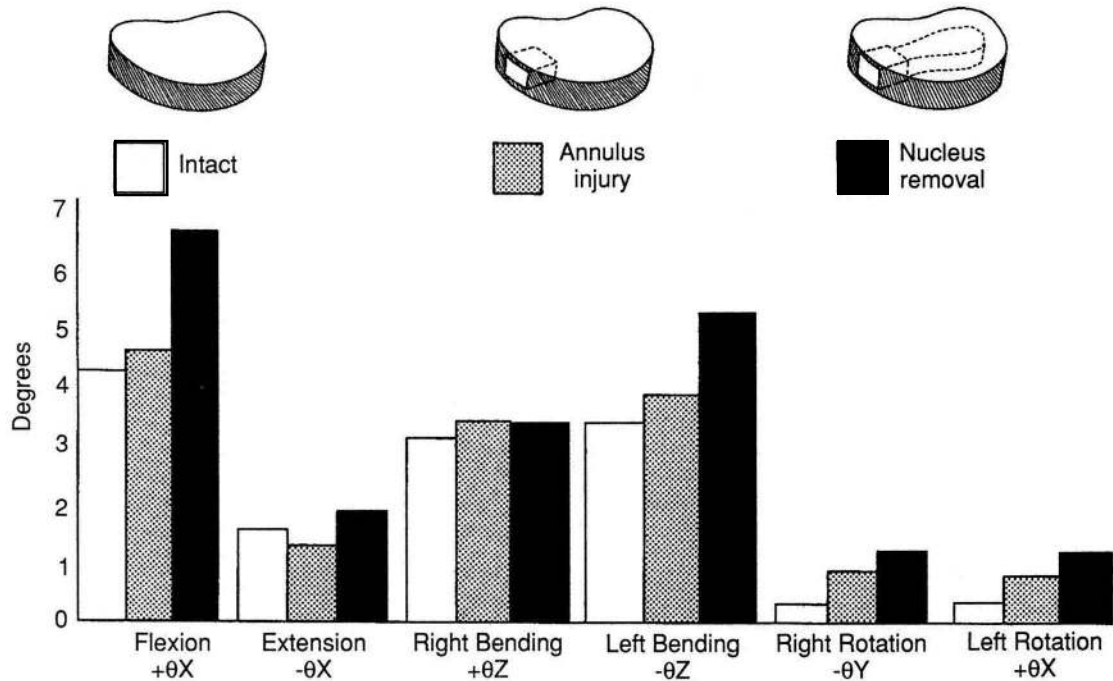


Figure 2.6. Six instability tests for a lumbar motion segment after experimental partial annular injury and, partial annular and nuclear removal. Modified from White AA, Panjabi MM. Clinical biomechanics of the spine. 2nd Ed. Philadelphia: J.B. Lippincott, 1990:13.

STRUCTURAL INJURY RESULTS IN ASYMMETRIC MOVEMENT OF ONE VERTEBRA WITH RESPECT TO THE SUBJACENT VERTEBRA



SINCE EACH VERTEBRA SURROUNDING THE INJURED DISC ARTICULATES WITH THE VERTEBRAE BOTH ABOVE AND BELOW, FOUR VERTEBRAE OR THREE FSUs ARE AFFECTED

Figure 2.7. Single joint injury leads to multiple levels of involvement.

THE DISTURBED KINEMATICS OF THE FSU WILL LEAD TO UNEQUAL MOVEMENTS OF THE RIGHT AND LEFT FACET JOINTS



UNEQUAL LOAD SHARING



HIGH LOAD ON ONE FACET



CARTILAGE DEGENERATION, FACET ATROPHY, NARROWING OF THE IVF

Figure 2.8. The pathogenesis of spinal degeneration.