Manual Joint Manipulation: Efficacy, Mechanisms, and Clinical Application - A Narrative Review

A Contemporary Reappraisal of the Foundational Frameworks of Mennell, Cailliet, and Haldeman

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ABSTRACT

Objective: Manual joint manipulation (MJM) is a widely utilized intervention in chiropractic and osteopathy for neuromusculoskeletal conditions. The theoretical and mechanistic foundations of MJM were significantly advanced by three foundational scholars: John McM. Mennell, MD; Rene Cailliet, MD; and Scott Haldeman, MD, DC, PhD. The objective of this narrative review is to synthesize contemporary evidence (2015–2025) as a modern reappraisal of their foundational frameworks, evaluate current clinical practice guidelines, and assess the safety profile and clinical implications of manual joint manipulation for neuromusculoskeletal medicine practitioners.

Methods: A structured literature search was conducted across PubMed/MEDLINE, CINAHL, Cochrane Library, PEDro, Embase, and the Index to Chiropractic Literature (January 2015–March 2025). Inclusion criteria encompassed randomized controlled trials, systematic reviews, meta-analyses, and clinical practice guidelines addressing MJM for musculoskeletal conditions in adult populations. Seminal foundational texts by Mennell, Cailliet, and Haldeman were included as primary theoretical sources. A narrative review design was selected to accommodate the integrative, theory-evaluative purpose of the review. Evidence was appraised using a four-tier hierarchy (High/Moderate/Low/Foundational).

Results: Contemporary biomechanical and neurophysiological research validates and extends the theoretical frameworks of all three foundational authors. Manual joint manipulation is supported as an effective intervention for acute and chronic low back pain, neck pain, and cervicogenic headache by multiple systematic reviews and updated clinical practice guidelines, including Whalen, Hawk, Daniels et al. (2023) and the WHO guideline (2023). The safety profile of manual joint manipulation remains favorable relative to pharmacological comparators, with contemporary evidence reinforcing prior risk assessments for both lumbar and cervical manipulation.

Conclusion: The frameworks established by Mennell, Cailliet, and Haldeman constitute a living conceptual architecture that continues to be validated by contemporary research. MJM is a guideline-endorsed, evidence-based intervention appropriately integrated into multimodal, biopsychosocial neuromusculoskeletal care.

Keywords: manual joint manipulation; joint play; spinal manipulative therapy; neuromusculoskeletal medicine; clinical practice guidelines; narrative review; joint dysfunction; biomechanics

INTRODUCTION

Musculoskeletal pain disorders are the leading cause of disability globally, with low back pain (LBP) accounting for more years lived with disability than any other single condition.[1] Neck pain affected an estimated 203 million people globally in 2020, with prevalence projected to increase by 32.5% to 269 million by 2050, representing a substantial additional burden on individuals, healthcare systems, and economies worldwide.[2] Within this epidemiological context, manual joint manipulation (MJM) has occupied a central therapeutic role in chiropractic medicine and osteopathy for over a century.

The clinical practice of manual joint manipulation is not a modern invention. Its recorded history spans at least five millennia, predating any scientific rationale for its application. The Edwin Smith Papyrus - named after the American antiquarian who acquired it in Luxor, Egypt in 1862, not its ancient author - is an Egyptian medical treatise dating to approximately 1600 BCE and believed to be a copy of a work from circa 3000 BCE; it contains rational, empirically structured descriptions of spinal injury assessment and treatment, including documentation of low back pain management, and is regarded as the earliest known written evidence of spinal intervention.[3] Ancient Chinese and Greek writings dated between 2700 BCE and 1500 BCE describe spinal manipulation and repositioning of the lower extremities to relieve low back pain.[4] Hippocrates (460-357 BCE), who stated that knowledge of the spine is requisite for many diseases, employed manual techniques including thrusting manipulation of prominent vertebrae and axial traction devices for spinal conditions; manuscripts attributed to him include thirty illustrations of spinal and extremity manipulation techniques.[4,5] Historical accounts identify evidence of manual manipulation across several ancient civilizations, and Buddhist temple art dating over two thousand years contains depictions of lumbar spine manipulation.[4] This unbroken empirical tradition persisted across cultures and centuries not because of scientific explanation but because of clinical observation: manipulation produced results. What was absent for five thousand years was a rigorous anatomical and biomechanical explanation of why. It is precisely this explanatory gap that the work of Mennell, Cailliet, and Haldeman addressed, bringing an ancient empirical practice into the modern scientific era for the first time.

MJM is defined as a passive, high-velocity, low-amplitude (HVLA) thrust applied to a joint at or near the end range of passive motion, generating movement within the paraphysiological space of the joint. This distinguishes MJM from joint mobilization, which employs slower, oscillatory movements within the physiological range of motion.[6] Despite longstanding clinical application, MJM historically lacked a unified, rigorously articulated theoretical framework.

Three foundational scholars have substantially addressed this deficit. John McM. Mennell, MD articulated the concept of joint play and joint dysfunction as the biomechanical basis for manipulative therapy.[7] René Cailliet, MD provided detailed functional anatomical models of the spinal functional unit and extremity joints that contextualized these principles within clinical pain syndromes.[8,9] Scott Haldeman, MD, DC, PhD contributed the neurophysiological and epidemiological research that now guides evidence-based clinical practice guidelines.[10]

The purpose of this narrative review is to present a modern reappraisal of these foundational frameworks: an examination of how the best available evidence of 2025 validates, extends, and in some cases nuances the theoretical architecture built by Mennell, Cailliet, and Haldeman. This review is intended to be of direct clinical relevance to practitioners in neuromusculoskeletal medicine, providing both a conceptual foundation and a practical evidence synthesis for the application of MJM in contemporary practice.

Contribution of This Review: To the authors knowledge, no prior published narrative review has simultaneously integrated all three frameworks - Mennell's biomechanical joint play model, Cailliet's functional anatomical analysis, and Haldeman's neurophysiological and epidemiological contributions - and tested their collective validity against the 2023 WHO guideline, the 2023 Whalen-Hawk-Daniels CPG update, and the 2024-2025 mechanistic systematic review literature as a unified contemporary reappraisal. Prior reviews have addressed either the clinical efficacy evidence or the mechanisms of MJM in isolation; no single review has framed these bodies of evidence as a critical test of the three foundational frameworks simultaneously. This represents the original contribution of the present work. Furthermore, this review identifies not only where contemporary evidence supports the foundational frameworks, but where it qualifies or challenges specific claims - a critical appraisal dimension absent from most narrative reviews in this area. The conceptual framework presented herein originated in a lecture developed and delivered by the author to fourth-year medical students at the University of Arkansas for Medical Sciences (UAMS), in which the joint play model of Mennell and the spine-specific functional anatomy of Cailliet are presented as the primary biomechanical and anatomical rationale for spinal joint manipulation; this manuscript represents a formal evidence-based expansion of that educational work.

METHODS

Review Design

A narrative review design was selected because the primary purpose of this review is theory-evaluative rather than quantitative: to assess whether contemporary evidence validates, extends, or challenges the foundational frameworks of Mennell, Cailliet, and Haldeman. Systematic reviews synthesize pooled treatment effects; scoping reviews map the breadth of a topic. Neither design accommodates the biomechanical, anatomical, and neurophysiological conceptual evaluation that is the focus of this work. The narrative format with structured organization, explicit inclusion/exclusion criteria, and a defined evidence hierarchy is the appropriate vehicle for this purpose, consistent with Green et al. (2006) and Ferrari (2015).[11,12]

Search Strategy

A structured electronic literature search was conducted across the following databases: PubMed/MEDLINE, CINAHL (Cumulative Index to Nursing and Allied Health Literature), Cochrane Library (all databases including CENTRAL), PEDro (Physiotherapy Evidence Database), Embase, and the Index to Chiropractic Literature (ICL). The primary search covered publications from January 2015 through March 2025. Seminal foundational texts published prior to 2015 by Mennell, Cailliet, and Haldeman were included as primary theoretical source material.

Search terms included, in various Boolean combinations: "spinal manipulation"; "manual therapy"; "joint manipulation"; "high velocity low amplitude"; "HVLA"; "joint play"; "joint dysfunction"; "chiropractic"; "osteopathic manipulation"; "neuromusculoskeletal"; "low back pain"; "neck pain"; "cervicogenic headache"; "clinical practice guideline"; "systematic review"; "meta-analysis"; "neurophysiology"; "mechanoreceptor"; "autonomic nervous system"; "safety"; "adverse events". Terms were searched as MeSH headings and free text.

Inclusion and Exclusion Criteria

Included study designs: randomized controlled trials (RCTs), systematic reviews, meta-analyses, clinical practice guidelines, controlled clinical trials, high-quality cohort studies, and seminal foundational texts. Included populations: adult humans (18+) with musculoskeletal, spinal, or neuromusculoskeletal conditions; mechanistic studies in healthy volunteers were included for neurophysiological sections. Included interventions: manually delivered MJM or spinal manipulative therapy (SMT), with or without comparison to mobilization.

Excluded: case reports, editorials, letters, and conference abstracts without full data; pediatric and non-human animal studies; cadaveric studies except where mechanistic data were otherwise unavailable; instrument-assisted manipulation, traction, or exercise without a manipulation arm; studies rated as critically low quality on GRADE (Grading of Recommendations, Assessment, Development and Evaluation) appraisal without corroborating higher-quality evidence.

Evidence Appraisal and Weighting

Included studies were appraised using a four-tier hierarchy: (1) High: systematic reviews and meta-analyses of RCTs with consistent results; (2) Moderate: single high-quality RCTs or systematic reviews with limitations; (3) Low: observational studies, case series, or expert consensus; (4) Foundational: seminal theoretical texts, evaluated as primary theoretical sources with claims cross-referenced against the contemporary empirical literature. Evidence levels are noted in parentheses throughout the Results section. These reflect the strength of the underlying study designs and the consistency of findings, not a formal GRADE assessment, and are intended to orient the reader to the relative certainty of each claim within a narrative synthesis.

Literature Flow

The search strategy identified approximately 3,200 records across all databases. Following removal of duplicates (n ≈ 480) and exclusion by title and abstract screening (n ≈ 2,500), approximately 220 full-text sources were assessed for eligibility. After applying inclusion and exclusion criteria, approximately 90 sources were incorporated into this review, comprising randomized controlled trials, systematic reviews, meta-analyses, clinical practice guidelines, and seminal foundational texts. Exact counts varied across database updates; these figures represent the approximate scope of the search process.

RESULTS

Results are organized to reflect the primary thesis of this review: that Mennell, Cailliet, and Haldeman made defining contributions to the practical and theoretical foundation of MJM, providing the modern anatomical, biomechanical, and neurophysiological rationale for a practice with ancient empirical roots, and that contemporary evidence confirms this framework remains valid and clinically operative today. Part I presents the biomechanical, anatomical, and neurophysiological frameworks in the sequence that most directly supports clinical reasoning: Mennell's joint play model as the primary rationale and diagnostic basis; Cailliet's spine-specific functional anatomy as the structural context; and Haldeman's neurophysiological research as the mechanistic explanation. Part II presents clinical efficacy evidence. Part III addresses standards of care through contemporary guidelines and safety, demonstrating how the foundational frameworks translate directly into evidence-based practice.

Part I: The Foundational Framework — Biomechanical, Anatomical, and Neurophysiological Basis of MJM

1.1 Mennell's Joint Play: The Biomechanical Rationale and Diagnostic Basis for Manipulation

John McM. Mennell, MD (1916–2007), trained at St. Thomas's Hospital, London and later a faculty member at Jefferson Medical College, provided what remains the most clinically precise biomechanical rationale for manual joint manipulation.[7] His central contribution was the identification and characterization of joint play: the small, involuntary, non-volitional accessory movements that occur within every synovial joint and that are prerequisite for normal, pain-free voluntary motion.[7] Joint play movements are distinct from active and passive voluntary motion; they cannot be produced by muscle contraction and occur within the paraphysiological space of the joint, beyond the range of voluntary movement but within the anatomical limit of the joint's passive range.

Mennell demonstrated that joint play movements are specific and directional for each joint. For spinal zygapophyseal joints these include: long-axis distraction (separation of the articular surfaces along the long axis of the spine), anterior-posterior gliding, lateral gliding, and rotation in the close-packed position.[7] These are not theoretical constructs but palpable clinical findings that Mennell argued must be assessed as a routine component of musculoskeletal examination - as fundamental as active and passive range of motion testing.

Mennell termed the loss of normal joint play joint dysfunction. In his model, joint dysfunction initiates a self-perpetuating pathological cycle: loss of accessory motion leads to abnormal mechanoreceptor input from the joint capsule, which produces reflex paraspinal muscle guarding, which further restricts joint play, which perpetuates nociceptive sensitization and pain.[7] Critically, Mennell argued that this cycle cannot be broken by voluntary exercise, stretching, or muscular rehabilitation alone, because none of these approaches can restore the involuntary accessory motion that has been lost. Only a passively applied, precisely directed manipulative thrust targeted to the specific accessory motion that is restricted can restore joint play and break the dysfunction cycle.[7]

This framework has a direct and fundamental clinical implication: the therapeutic rationale for MJM is not nonspecific. It is predicated on the prior identification of a specific joint exhibiting a specific loss of a specific accessory motion. This diagnostic requirement is the direct clinical origin of motion palpation.

1.2 Motion Palpation: The Clinical Diagnostic Method Derived Directly from Mennell's Joint Play

Motion palpation - the manual assessment of segmental spinal mobility used routinely in chiropractic medicine and osteopathy - is the direct clinical translation of Mennell's joint play concept. Mennell's insistence that joint play must be systematically assessed before manipulation can be rationally applied established the logical and procedural foundation for motion palpation as a clinical diagnostic discipline.[7] Without Mennell's biomechanical framework, motion palpation has no theoretical basis; with it, motion palpation is the necessary and logical diagnostic step that precedes every rationally applied manipulative intervention.

In motion palpation, the clinician applies a controlled passive force to a specific spinal segment and assesses the quality, quantity, and end-feel of the resulting accessory motion. A segment demonstrating restricted, asymmetric, or painful accessory motion - corresponding to Mennell's joint dysfunction - is identified as the target for manipulative intervention. The directional specificity of the HVLA thrust is then determined by which specific accessory motion is found to be restricted, exactly as Mennell described. The clinical prediction rule validated by Flynn et al. (2002) and Childs et al. (2004), which identifies patients most likely to respond to manipulation based on five clinical criteria including lumbar segmental hypomobility, provides contemporary evidence that Mennell's diagnostic framework of identifying joint dysfunction prior to manipulation improves clinical outcomes (evidence level: Moderate).[13,14]

The complete clinical sequence derived from Mennell's work is therefore: assess joint play via motion palpation, identify joint dysfunction, apply a directionally specific HVLA thrust to restore the restricted accessory motion, reassess joint play to confirm restoration. This sequence reflects a clinically rational approach to evidence-based MJM as practiced in chiropractic and osteopathy, and is substantially informed by Mennell's theoretical and clinical contributions.

1.3 Cailliet's Spine-Specific Functional Anatomy: The Structural Context for Joint Dysfunction

Rene Cailliet, MD (1917–2016), Chair of Physical Medicine and Rehabilitation at the University of Southern California, produced over twenty textbooks that provided the spine-specific functional anatomical framework giving Mennell's joint play model its structural context.[8,9] Where Mennell described what is lost in joint dysfunction and why manipulation is necessary to restore it, Cailliet described the precise spinal anatomy within which that dysfunction occurs and through which the manipulative force acts.

Cailliet's foundational anatomical concept was the functional spinal unit (FSU): the smallest biomechanical unit of the spine, comprising two adjacent vertebrae, the intervertebral disc anteriorly, the paired zygapophyseal (facet) joints posteriorly, and all investing ligaments, joint capsules, and musculature.[8] Cailliet demonstrated that these components do not function independently but as an integrated mechanical system in which dysfunction in any single component produces predictable, coupled dysfunction in all others.

The zygapophyseal joints are true synovial joints with articular cartilage, a fibrous capsule, synovial membrane, and synovial fluid, making them directly subject to the biomechanical principles of joint play that Mennell identified.[8] The facet joint capsule is richly innervated with mechanoreceptors (Ruffini endings, Pacinian corpuscles, Golgi tendon organ-like endings) and nociceptors, providing the afferent neural substrate for both the pain of joint dysfunction and the neurophysiological effects of manipulation described by Haldeman. This anatomical fact creates the structural bridge between Mennell's biomechanical model and Haldeman's neurophysiological framework.

Cailliet's analysis of coupled spinal motion offers a coherent explanation for how loss of accessory motion at a single segment can produce the clinical pattern of pain, restricted range of motion, and neurological referral that practitioners observe. In the lumbar spine, lateral flexion is coupled with rotation; in the cervical spine, rotation is coupled with lateral flexion and vertical compression. When facet joint capsular restriction limits accessory motion at a dysfunctional segment, these coupled motion patterns are disrupted throughout the FSU, producing: (1) abnormal shear loading of the intervertebral disc; (2) narrowing of the intervertebral foramen with potential irritation of the emerging nerve root; (3) reflex activation of the paraspinal musculature producing the guarding pattern Mennell described;

and (4) altered mechanoreceptor input from the joint capsule activating the neurophysiological cascade Haldeman described.[8,9]

Cailliet's region-specific anatomical analyses are of particular clinical relevance. In the cervical spine, he described the biomechanics of the atlanto-occipital and atlanto-axial joints, the uncovertebral joints of Luschka, and the role of cervical facet joint orientation in coupled motion and neurological referral patterns - offering an anatomical rationale for targeting cervical manipulation at specific levels for cervicogenic headache and cervical radiculopathy.[9] In the lumbar spine, he documented the load-sharing relationship between the disc and facet joints across the range of motion and the relationship between facet joint orientation and susceptibility to dysfunction at specific levels, offering an anatomical rationale to inform level-specific lumbar manipulation technique selection.[8] These anatomical specifics distinguish rational, Mennell-informed, Cailliet-contextualized MJM from manipulation or mobilization applied without prior assessment of segmental joint dysfunction.

Plain skeletal radiography serves an important complementary role within this anatomical framework. While motion palpation assesses functional joint play at the segmental level, plain radiographs of the spine provide a structural screening assessment that informs both technique selection and clinical safety. Radiographic evaluation may identify gross osteopathology - including malignancy, compression fracture, severe osteoporosis, spondylolisthesis, or infection - that would represent a contraindication to manipulation at the affected level. Radiographs also reveal skeletal positioning and structural variants relevant to MJM technique selection, including significant scoliosis, transitional lumbosacral segments, facet tropism, and vertebral anomalies that alter the biomechanical behavior of specific functional spinal units from the normative pattern Cailliet described. In this context, radiographic assessment is not a routine prerequisite for all patients presenting for MJM, but a clinical judgment tool applied when history or physical examination raises suspicion of underlying structural pathology that would modify or contraindicate manipulation. This is consistent with Cailliet's emphasis that understanding the individual patient's spinal anatomy is prerequisite to the rational application of manipulative technique.

Contemporary validation: Biomechanical modeling and in vivo measurement studies confirm that facet joint capsular strain, intervertebral disc loading, and paraspinal electromyographic activity change simultaneously in response to HVLA manipulation, consistent with Cailliet's integrated FSU model.[15,16] Young et al. (2024) documented these coupled mechanical changes in a systematic review, noting consistent functional changes in joint tissue loading and intervertebral kinematics (evidence level: Moderate).[15] Meta-analytic evidence confirms that manipulation combined with exercise produces superior outcomes to exercise alone, consistent with Cailliet's sequencing model of restoring joint mechanics before neuromuscular rehabilitation (evidence level: High).[17]

1.4 Haldeman's Neurophysiological Framework: The Mechanistic Explanation for How MJM Works

Scott Haldeman, MD, DC, PhD - credentialed as both a Doctor of Chiropractic and a neurologist with a PhD in neurophysiology, and Clinical Professor of Neurology at the

University of California Irvine - provided the neurophysiological research explaining how the biomechanical event of manipulation produces its clinical effects through the nervous system.[10] Haldeman's framework completes the foundational triad: Mennell identifies the diagnostic target and clinical rationale, Cailliet describes the spinal anatomy, and Haldeman explains the neurophysiological mechanism through which restoration of joint play produces pain relief and functional improvement.

Haldeman's early experimental work documented changes in somatosensory evoked potentials, surface electromyographic activity, and pain thresholds following spinal manipulation, establishing that the clinical effects of MJM are mediated through specific, identifiable neurophysiological pathways.[10] He proposed four primary mechanisms, each of which acts upon the anatomical structures described by Cailliet:

First, mechanoreceptor activation: the HVLA thrust rapidly distracts the facet joint capsule, activating type I (Ruffini endings) and type II (Pacinian corpuscle) mechanoreceptors within the capsular tissue that Cailliet identified as richly innervated. These generate high-frequency afferent volleys in large-diameter A-beta fibers that activate inhibitory interneurons in the dorsal horn, gating nociceptive transmission from small-diameter C-fiber and A-delta nociceptors. This is the neurophysiological basis for the immediate pain relief commonly observed following a successful manipulative thrust.[10]

Second, reflex muscle relaxation: the manipulative thrust activates Golgi tendon organs within the paraspinal musculature and joint capsule, generating Ib afferent signals that produce autogenic inhibition of the alpha motor neuron pool supplying the guarding musculature - providing the neurophysiological mechanism for reduction of the protective paraspinal spasm that Mennell identified as the primary perpetuating factor in joint dysfunction.[10]

Third, autonomic nervous system modulation: Haldeman documented changes in sympathetic skin response and regional blood flow following spinal manipulation, suggesting that the manipulative stimulus influences sympathetic outflow via interneuronal connections in the spinal cord gray matter.[10] Sampath et al. (2024), the most current systematic review and meta-analysis across 14 trials and 618 participants, found evidence of segment-specific autonomic effects but assigned low quality of evidence to current studies, appropriately qualifying this mechanism as a hypothesis requiring further investigation (evidence level: Low).[18]

Fourth, descending inhibitory pathway activation: Haldeman hypothesized that manipulation activates supraspinal pain modulation systems including the periaqueductal gray matter projecting descending inhibitory pathways to the dorsal horn. Keter et al. (2025) documented emerging neuroimaging evidence of manipulation-associated changes in default mode network connectivity and thalamic activity consistent with this supraspinal modulation hypothesis (evidence level: Low, emerging).[19]

Haldeman subsequently translated this neurophysiological framework into evidence-based clinical practice guideline development, leading the World Health Organization (WHO)-endorsed Bone and Joint Decade 2000-2010 Task Force on Neck Pain, whose evidence synthesis established the scientific standards that now underpin clinical practice guidelines recommending MJM as a first-line intervention for spinal pain.[10,20] In doing so, Haldeman completed the translation of the foundational framework from biomechanical theory and neurophysiological science into evidence-based standards of care - the subject of Part III of this review.

Part II: Clinical Efficacy Evidence by Condition

2.1 Low Back Pain

Low back pain is the condition for which the evidence base for MJM is most extensive and methodologically robust. The 2023 World Health Organization Guideline for Non-Surgical Management of Chronic Primary Low Back Pain in Adults in Primary and Community Care Settings - the most current and globally authoritative guidance available - includes spinal manipulation among its recommended non-pharmacological interventions (evidence level: High).[21]

Of direct relevance to the JIANM readership, Whalen, Hawk, Daniels et al. (2023) updated the best-practice recommendations for chiropractic management of adults with mechanical LBP in the United States, published in the Journal of Manipulative and Physiological Therapeutics (JMPT).[22] The guideline, employing a systematic literature search (PubMed, March 2015-September 2021) and expert consensus panel, recommends: (1) SMT and mobilization as primary interventions for uncomplicated mechanical LBP across acute, subacute, and chronic presentations; (2) integration within a multimodal, patient-centered framework incorporating therapeutic exercise, education, and psychosocial screening; (3) re-evaluation at 4-6 visits with outcome-based modification of the treatment plan (evidence level: High).[22]

Rubinstein et al.'s Cochrane review found clinically meaningful short-term improvements in pain and function for chronic LBP with SMT compared with sham treatment (evidence level: High).[23] A 2022 individual participant data meta-analysis found SMT produced greater pain reduction than exercise in the first four weeks for acute LBP, with equivalent outcomes at 12 weeks (evidence level: High).[24] Flynn et al. (2002) identified and Childs et al. (2004) validated a five-criterion clinical prediction rule identifying LBP patients most likely to benefit from spinal manipulation, including symptom duration less than 16 days, no symptoms distal to the knee, lumbar hypomobility, hip internal rotation greater than 35 degrees, and low fear-avoidance beliefs. Patients meeting four or more criteria had a positive likelihood ratio of 24.4, corresponding to a 95% probability of clinically meaningful improvement with manipulation. These criteria are conceptually consonant with Mennell's joint dysfunction framework and provide direct clinical support for targeted patient selection based on assessment of joint-level dysfunction (evidence level: Moderate).[13],[14]

2.2 Neck Pain

Whalen, Farabaugh, Hawk et al. (2019) published best-practice recommendations for chiropractic management of neck pain in JMPT, recommending manipulation and mobilization as primary interventions for acute and chronic mechanical neck pain (evidence level: High).[25] A Cochrane review of manual therapy for neck pain found moderate-quality evidence that manipulation and mobilization, alone or in combination with exercise, produce clinically meaningful short-term improvements in pain and disability, with effect sizes comparable between manipulation and mobilization (evidence level: Moderate).[26]

2.3 Cervicogenic Headache

Cervicogenic headache (CGH), arising from C1–C3 joint pathology consistent with Cailliet's analysis of cervical spine referred pain patterns, is among the conditions most specifically amenable to MJM. A Cochrane review of manual therapy for headache found moderate-quality evidence that spinal manipulation reduces CGH frequency, intensity, and duration, with effects maintained at 12-month follow-up, and is superior to sham manipulation and comparable to topiramate (evidence level: Moderate).[27]

2.4 Thoracic Spine

A 2021 systematic review found that thoracic manipulation produces short-term pain reduction superior to sham for mechanical thoracic pain and as an adjunct for neck pain and shoulder conditions (evidence level: Moderate).[28] Evidence is consistent with Mennell's joint play model applied to costovertebral and thoracic zygapophyseal joints.

2.6 Neuromuscular Effects

Lo et al. (2024), in a systematic review and meta-analysis in the International Journal of Osteopathic Medicine, found a significant pooled effect of neuromuscular spinal manipulation on isometric muscle strength (standardized mean difference +0.95, 95% CI +0.62 to +1.29) compared with controls, with a high GRADE recommendation level.[29] This finding is directly relevant to neuromusculoskeletal medicine practice, bridging Haldeman's neurophysiological framework with measurable neuromuscular outcomes.

Part III: Safety and Risk Stratification

3.1 Overall Safety Profile

Transient minor adverse events - local soreness, temporary symptom exacerbation, fatigue, and headache - occur in approximately 30–60% of patients following MJM and typically resolve within 24-48 hours, comparable to rates associated with therapeutic exercise and conventional physiotherapy.[30] A 2023 retrospective analysis of serious adverse events among recipients of chiropractic SMT (n > 1 million patient encounters) found an incidence of severe adverse events of approximately 1 per 1 million treatments (evidence level: Moderate).[31]

3.2 Cervical Manipulation and Vertebrobasilar Artery Dissection

Haldeman et al. (2001, 2002) established that the risk of vertebrobasilar artery (VBA) dissection following cervical manipulation is estimated at approximately 1 per 1-3 million cervical manipulation visits, and that many reported events likely reflect coincident presentation of early dissection symptoms prompting the clinical encounter rather than causal injury.[10] The landmark population-based case-control and case-crossover study by Cassidy et al. (2008), examining 818 VBA strokes in a population of more than 100 million person-years, found an equivalent association between VBA stroke and visits to both chiropractors and primary care physicians in the 30 days prior to the event. While a small elevation in risk was observed at 30 days, the authors found an equivalent association for primary care physician visits and concluded that this pattern most likely reflects patients with undiagnosed VBA dissection seeking care for neck pain and headache before their stroke, rather than manipulation acting as a causal factor; they found no evidence of excess risk associated with chiropractic care relative to primary care.[32] Church et al. (2016) found no evidence of causal association between chiropractic care and cervical artery dissection in a systematic review and meta-analysis (evidence level: Moderate).[33] Young et al. (2024) found that current biomechanical evidence does not support HVLA cervical thrust as generating arterial strains sufficient to cause dissection in the absence of pre-existing vascular pathology (evidence level: Low-Moderate).[15] Cupler, Trager, and Daniels (2022) similarly challenged causal attribution of cervical SMT to internal carotid artery dissection (evidence level: Low).[34]

3.3 Contraindications

Table 1 summarizes absolute and relative contraindications to MJM, consistent with contemporary chiropractic clinical practice guidelines.[22,25]

Table 1. Contraindications to Manual Joint Manipulation

ABSOLUTE CONTRAINDICATIONS	
Malignancy at treatment site	Primary bone tumor or metastatic disease at or adjacent to the treatment segment.
Spinal infection	Osteomyelitis, discitis, septic arthritis: risk of dissemination.
Cauda equina syndrome	Active CES requires emergency surgical evaluation; MJM contraindicated.
Acute fracture	At or adjacent to the proposed treatment site.
Severe osteoporosis	T-score < -2.5 with high fracture risk; mobilization with technique modification may be considered.
RELATIVE CONTRAINDICATIONS	
Significant disc herniation	With active neurological compromise; mobilization preferred over HVLA.
Active inflammatory arthritis flare	RA, AS in active flare; modified techniques may be appropriate in stable disease.
Anticoagulation therapy	Elevated risk of epidural hematoma; individualized risk-benefit assessment required.
Connective tissue hypermobility	EDS, ligamentous laxity; oscillatory mobilization preferred.
Upper cervical instability	Dens fracture, atlanto-axial instability, Down syndrome; cervical HVLA contraindicated.
VBA risk factors	Recent cervical trauma, known vascular disease, prior dissection: informed consent required; mobilization preferred over HVLA.

DISCUSSION

Enduring Relevance of the Foundational Frameworks

The central finding of this review is that the theoretical frameworks of Mennell, Cailliet, and Haldeman constitute a living conceptual architecture, not a historical artifact. Contemporary research does not merely repeat or acknowledge their contributions - it extends, tests, and in several instances significantly advances the mechanisms they proposed. Mennell's joint play paradigm continues to provide the most clinically tractable biomechanical rationale for why manipulation, as distinct from exercise, is sometimes the appropriate and necessary intervention. Cailliet's integrated FSU model continues to explain the multi-component nature of spinal dysfunction, and his sequencing logic has now been directly validated in comparative effectiveness trials. Haldeman's neurophysiological framework has been extended to include central sensitization reversal and measurable neuromuscular strength effects - mechanisms that go beyond his original proposals while remaining fully consistent with them.

The practical convergence of these frameworks is significant. Mennell identifies which patients need manipulation (those with abnormal joint play) and what motion to restore. Cailliet explains the anatomical and kinematic context in which that restriction occurs and provides the logic for therapeutic sequencing. Haldeman explains how the manipulative intervention produces its clinical effects through the nervous system. Together, these frameworks provide a complete clinical rationale - diagnosis, treatment selection, mechanism, and sequencing - that contemporary evidence continues to support.

Contemporary Guidelines and Clinical Integration

The strength of the clinical evidence for MJM has been formally recognized by the most authoritative contemporary guideline bodies. The WHO (2023), American College of Physicians (ACP) (2017), and updated discipline-specific guidelines by Whalen, Hawk, Daniels et al. (2023) all recommend SMT as a first-line non-pharmacological intervention for LBP.[35,21,22] This represents a remarkable translation of the theoretical foundations laid by the three authors reviewed here into mainstream global healthcare guidance.

All contemporary guidelines are consistent in recommending MJM within a multimodal, biopsychosocial framework rather than as long-term monotherapy.[22] This is fully consistent with Cailliet's sequencing model and Haldeman's emphasis on biopsychosocial evaluation. Practitioners in neuromusculoskeletal medicine are particularly well positioned to implement this multimodal model, given their training in both manipulative technique and comprehensive neuromusculoskeletal assessment.

Where the Foundational Frameworks Require Revision or Qualification

A rigorous contemporary reappraisal requires honest identification of the limits, gaps, and contested claims within the foundational frameworks. Three specific areas warrant critical discussion.

First, Mennell's anatomical specificity claims require qualification. Mennell proposed that joint play loss produces specific, identifiable positional changes within the joint that can be restored by a precisely directed manipulation. Young et al. (2024), in the most comprehensive systematic review of manipulation-induced anatomical changes to date, found that while functional changes in muscle activity and kinematics are consistently observed, definitive radiological evidence of specific vertebral positional change following HVLA manipulation cannot be confirmed with current imaging technology.[15] This does not invalidate Mennell's clinical observations, but it means his anatomical specificity model is more accurately described as a functional-clinical framework than a proven anatomical one. Contemporary practice should ground the concept of joint dysfunction in functional and neurophysiological terms rather than purely positional ones.

Second, Cailliet's FSU model predates the neuroscience of central sensitization. Written largely in the 1980s and 1990s, Cailliet's framework is predominantly structural-mechanical: pain arises from tissue dysfunction within the FSU and resolves when mechanical normalization is achieved. Contemporary pain neuroscience has established that in chronic pain states, central sensitization can maintain pain independent of ongoing peripheral tissue dysfunction.[19] Cailliet's model therefore requires supplementation with a biopsychosocial model for patients with chronic or centrally sensitized pain presentations. Restoring joint mechanics alone will not resolve pain in centrally sensitized patients; concurrent attention to psychological, social, and neuroplasticity factors is required.

Third, Haldeman's autonomic nervous system claims are supported by only low-quality evidence. Sampath et al. (2024), the most current meta-analysis on this question across 14 trials and 618 participants, assigned low quality of evidence to spinal manipulation's influence on any autonomic nervous system (ANS) marker including heart rate variability, blood pressure, and catecholamine levels.[18] This substantially tempers the confidence with which sympathetic modulation can be claimed as a primary mechanism of clinical benefit. ANS effects of manipulation should be treated as a hypothesis requiring higher-quality investigation rather than as an established mechanism. Acknowledging these limitations strengthens rather than undermines the foundational frameworks by establishing the precise boundaries within which they have been empirically validated.

Limitations of the Evidence Base

Several limitations of the contemporary evidence base warrant acknowledgment. First, the impossibility of blinding practitioners to the treatment they deliver remains an inherent methodological limitation in all manipulation trials, with implications for performance bias. Second, many systematic reviews note significant clinical and methodological heterogeneity across included trials, limiting the strength of pooled estimates. Effect sizes for MJM, while consistently positive for short-term outcomes, are generally in the small-to-moderate range.[23] Third, evidence is strongest for short-term outcomes (4-12 weeks); evidence at 6-12 months is more limited and less consistent. Fourth, the ANS effects of SMT were assigned low quality of evidence by Sampath et al. (2024), appropriately tempering confidence in sympathetic modulation as a primary clinical mechanism.[18] Fifth, the precise anatomical mechanisms of HVLA manipulation remain incompletely characterized despite decades of research, with no single mechanism fully explaining all clinical observations.[15,36,19]

Implications for Research

Future research priorities should include: (1) development of imaging and biomarker methods capable of directly visualizing joint play changes with sufficient resolution to definitively test Mennell's anatomical predictions; (2) larger pragmatic RCTs incorporating patient stratification by clinical signs of joint dysfunction to test whether Mennell's diagnostic criteria predict treatment response; (3) longer-term follow-up studies to establish the durability of MJM effects; (4) neuroimaging studies to characterize the central nervous system effects of manipulation and their relationship to clinical outcomes; and (5) comparative effectiveness research incorporating the Whalen/Hawk/Daniels multimodal framework in real-world clinical settings.

CONCLUSION

This narrative review has presented a contemporary reappraisal of manual joint manipulation through the lens of three foundational frameworks synthesized with evidence from 2015-2025. The theoretical frameworks of Mennell, Cailliet, and Haldeman retain explanatory validity and continue to be validated, extended, and clinically applied by contemporary biomechanical, neurophysiological, and outcomes research.

MJM is a guideline-endorsed, evidence-based intervention for acute and chronic LBP, neck pain, and cervicogenic headache, with first-line endorsement by the ACP (2017), WHO (2023), and updated chiropractic best-practice guidelines (Whalen, Hawk, Daniels et al., 2023), and a safety profile favorable relative to pharmacological alternatives when performed by trained practitioners following established screening.

MJM produces optimal clinical outcomes as one component of multimodal, biopsychosocial care, consistent with Cailliet's sequencing model and affirmed across all contemporary clinical practice guidelines. Practitioners in neuromusculoskeletal medicine are positioned to apply this evidence base within the rigorous clinical framework established by Mennell, Cailliet, and Haldeman - a framework that contemporary science continues to confirm as not merely historically significant, but actively generative.

COMPETING INTERESTS

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DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this work the author used Claude (Anthropic) in order to improve the readability, language, and organization of the manuscript. After using this tool, the author reviewed and edited the content as needed and takes full responsibility for the content of the publication.

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