Joint Manipulation: Toward a General Theory of High-Velocity, Low-Amplitude Thrust Techniques

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ABSTRACT

Objective: The objective of this study was to describe the initial stage of a generalized theory of high-velocity, low-amplitude thrust (HVLAT) techniques for joint manipulation.
Methods: This study examined the movements described by authors from the fields of osteopathy, chiropractic, and physical therapy to produce joint cavitation in both the metacarpophalangeal (MCP) joint and the cervical spine apophysial joint. This study qualitatively compared the kinetics, the similarities, and the differences between MCP cavitation and cervical facet joint cavitation. A qualitative vector analysis of forces and movements was undertaken by constructing computer-generated, simplified graphical models of the MCP joint and a typical cervical apophysial joint and imposing the motions dictated by the clinical technique.
Results: Comparing the path to cavitation of 2 modes of HVLAT for the MCP joint, namely, distraction and hyperflexion, it was found that the hyperflexion method requires an axis of rotation, the hinge axis, which is also required for cervical HVLAT. These results show that there is an analogue of cervical HVLAT in one of the MCP joint HVLATs.
Conclusions: The study demonstrated that in a theoretical model, the path to joint cavitation is the same for asymmetric separation of the joint surfaces in the cervical spine and the MCP joints. (J Chiropr Humanit 2017;xx:0-9)
Key Indexing Terms: *Manipulation, Chiropractic; Manipulation, Osteopathic; Biomechanical Phenomena*

INTRODUCTION

High-velocity, low-amplitude thrust (HVLAT) techniques are widely used in manual therapies and nearly always produce a "cracking" noise. This is considered a cavitation event[1,2] for the metacarpophalangeal (MCP) joint and is produced by the sudden separation, or "gapping," of the joint surfaces. In clinical practice, the force to do this is applied manually. It is assumed that the event is the same mechanism in both spinal and peripheral joints, as it involves the same types of structures. For example, similar characteristics were found for joint noises (ie, "cracks") in both the MCP joint and the cervical apophysial joint.[3] In addition, it was found that gapping occurred in lumbar adjusting procedures.[4] Various terms have been used for the lesion that is treated with HVLAT.[5] In this paper, the term "joint dysfunction" will be used.

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One way to try to better understand the joint dysfunction that is treated with HVLAT is to analyze in detail the kinematics of the thrust procedure used in clinical practice that produces joint gapping. Following the reverse path of those kinematics should then reveal the path to the lesioned state.

There appear to be problems with describing the manipulative technique unambiguously: one description of the spinal manipulative thrust technique[6] focused on "end feel" for what has been called the *preload phase* of the maneuver produced by combinations of applied movements.[7] However, these combinations are only hypothesized, and the numerous variations of the positioning prior to delivery of the thrust (eg, it is not agreed whether the target joint should be in flexion or extension) are based on a prescriptive rationale that has not been verified by proper testing. For example, the direction of the thrust on a target joint would appear to depend on the therapist's desire to either increase or decrease tension on unspecified joint structures. Hing et al.[8] stated that HVLAT can be performed on the same joint in at least 3 directions following the methods described in the literature.[9] The authors failed to explain how the target joint is gapped in 2 of these directions (ie, "upslope" and "downslope"), if that is an immediate aim of the manipulation, since the thrust is parallel to the joint plane.

Evans and Breen[10] used the chart attributed to Sandoz[11] to find the position of minimum energy to perform the HVLAT, although there is no particular requirement to do that. They decided that the neutral position is the appropriate position, but if the technique is not restricted to distraction HVLAT and causes a hinge separation on the MCP joint in adduction or abduction, the efficiency of the technique is doubled. By using a 2-dimensional example to which a symmetric gapping force is applied, the parallel with normal spinal manipulation is rendered false, whether or not other planes of movement are considered.

Klein et al.,[12] using a method of HVLAT to the cervical spine in which the patient is in the sitting position, showed that movement may be blocked at the contralateral joint to the one targeted by placing a finger over the joint. It is also not clear how cephalad axial traction can be easily and simultaneously applied by using this method.

In trying to assess the accuracy and specificity of lumbar and thoracic manipulation, Ross et al.[13] offer 4 different modes of manipulation of the lumbar spine. In 2 of these, “spinous push” and “spinous pull,” which are possibly opposite forces of axial rotation, are applied to the same target joint. It is not clear from their description whether this implies that gapping of the same zygapophysial joint can occur in several different ways. A quite different prescription for cervical HVLAT from that suggested by other therapists has also been given.[14] This method employs a contact point on the inferior vertebra, and the thrust is applied to the inferior vertebra in the same direction as recommended by other authors, keeping the patient’s head and cephalad spine still, but moving the inferior vertebra. Kinematically, it is not equivalent to the consensus method outlined in this paper.

There appears to be general agreement on the process of applying HVLAT techniques. This is to be expected from the long empirical tradition of using the HVLAT in clinical practice.[15] Nevertheless, as described here, there are variations and nuances of technique that are deemed necessary for success with the maneuver but that do not lead to a consistent view of either the pathophysiology or the therapeutic benefit of HVLAT techniques. However, without sufficiently detailed kinematics, it is impossible to describe the kinetics accurately, and the physiology of joints with lesions therefore remains unclear.

Except for the simplest case of distraction HVLAT of the MCP joint, the kinematics of HVLAT techniques have not yet been rigorously evaluated. Therefore, the objective of this study was to describe the initial stage of a generalized theory of HVLAT techniques for joint manipulation. This study examined the movements described by different authors to produce joint cavitation in both the MCP joint and the cervical apophysial joint, and the similarities and differences between MCP cavitation and cervical facet joint cavitation were investigated by comparing the kinetics qualitatively.

Methods

To visualize the motion segments, graphical models were drawn by using engineering drawing software (SmartSketch, Intergraph Corporation, Madison, AL). The bones with their articular surfaces are regarded as rigid bodies, but the joint capsule is elastic and deformable; the capsular attachments are fixed but are regarded as pin joints (when modeled as individual fibers). Only the relevant structures are shown. The topologic relationships between elements are emphasized over numerical measures, since the vector analysis is qualitative; therefore, the models are not to scale, and forces have direction but no given magnitude. Keeping 1 bone fixed, incremental movement is made on the other bone in accordance with the generally agreed prescription to produce articular gapping.

Using data on joint contour from Chao,[16] Minami,[17] and Unsworth,[2] a typical MCP joint was drawn in lateral view cross-section (Fig 1). This single view suffices, since nowhere in the literature has it been suggested that movement occurs out of this plane to produce the 2 methods of HVLAT to the joint, as discussed below. The proximal phalanx (PP) could then be moved, but the metacarpal (MC) bone was taken as fixed. The changes in capsule length (and hence tension) are illustrative, although we ensured that the relative changes were within acceptable parameters (ie, less than failure strain: ~100% at MCP, ~100% at C4-C5[18,19]). This was done by measuring differences in length after movement had been imposed on the model and normal rotations constrained by maintaining contact of articular surfaces until articular gapping occurred.

We did not find any reports providing a detailed description of hyperflexion HVLAT of the MCP joint. However, it is a widespread practice to crack the knuckle joints in this way. *Hyperflexion* is defined as flexion taken beyond the range possible through voluntary muscle contraction by an external force. The overall sequence is that the MCP joint is palmar flexed to a point of tension by an external force applied to the proximal phalanx and, similar to distraction HVLAT, a further impulse is given to the phalanx to produce the crack.

A similar construct was used to visualize a midcervical segment (Fig 2).

The positioning and movements for cervical HVLAT are listed in Table 1.[20-25] They are fairly consistent among several authors from different disciplines. The lower vertebra is fixed in space so that motion occurs at the

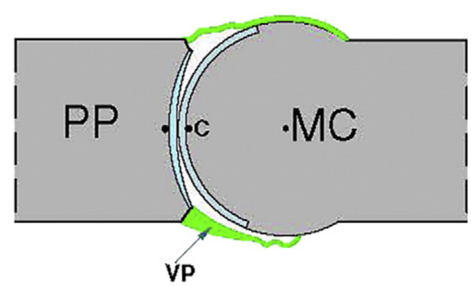

Fig 1. *The metacarpophalangeal joint in neutral position.*