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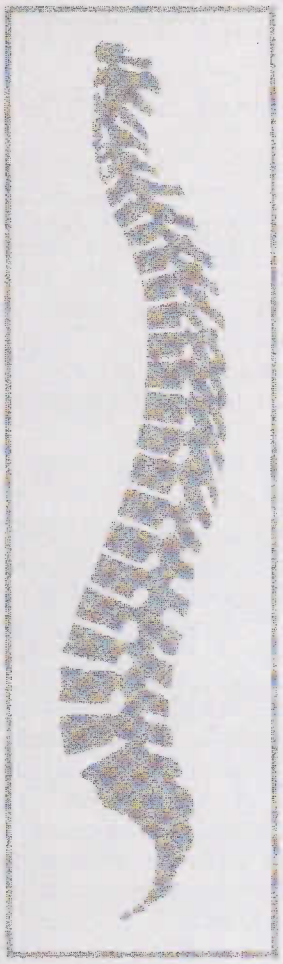

Professional Notes

Cerebral Artery Deficiency - A New Theory

'Cerebral Dysfunction: A Theory to Explain Some of the Effects of Chiropractic Manipulation', Terrett Allan GJ (1993), Chiropractic Technique 5(4):168-173.

There are case reports and much clinical experience of visual disabilities improving after chiropractic cervical adjustment. It is commonplace in practice to have patients reporting improvements in other sophisticated functions - such as improved powers of concentration or memory, mood alteration and a new sense of well-being.

What is the likely basis for these results? In a paper recently published in Chiropractic Technique Dr. Allan Terrett, an Australian chiropractor, gives thoughtful presentation of a new theory - that vertebral subluxation may create a decreased level of cerebral blood flow ('cerebral artery deficiency' or 'ischemic penumbra' or 'brain hibernation').

Terrett explains that this new theory was first presented in 1983 by two Australian medical practitioners, one a family physician with an interest in spinal manipulation and the other an ophthalmologist with an interest in migraine. Gorman, the ophthalmologist, reported on 12 patients who underwent spinal manipulation for

continued on page 6

The Biomechanical Basis of Whiplash Injuries

"Early reckonings of the mechanics of whiplash were intuitive and speculative. They provided a fairly simple model that described a rearward excursion of the head/neck complex followed by some degree of forward movement or flexion... (This) pioneering work led to more recent research which has greatly expanded our understanding of whiplash. Many misconceptions engendered by early work remain in our literature and continue to cloud the water. Therefore a new and more comprehensive model must now eclipse these vintage concepts."[1]

Arthur Croft DC, DABCO, Director, Spine Research Institute, San Diego.

A. Introduction

1. Extensive new research into the causes and management of whiplash injuries during the past few years makes it clear that hundreds of thousands of motor vehicle accident (MVA) victims who have suffered whiplash injuries have been unfairly accused of exaggerating their disabilities and symptoms - and poorly treated.

The medical, legal and insurance communities, vexed by patients who report years of neck and arm pain, headache, and vertigo following minor collisions and who have no apparent pathology, have often too readily jumped to the conclusion that there is no physical or organic basis for the symptoms. Because the symptoms have seemed to defy common sense patients have been accused of insincerity, and of 'compensation neurosis' or 'litigation neurosis'.

2. 'Common sense', not for the first time, has now been proven simplistic and wrong. The problem has been inadequate research and understanding of whiplash injuries. Much remains unknown, but these things are now clear:

Diagnosis

a) New high-resolution imaging technology, especially magnetic resonance imaging (MRI), is revealing extensive soft-tissue injuries that were formerly invisible on plain film x-ray and standard medical examination. The first detailed evaluation of the diagnostic accuracy of plain radiography for whiplash injuries, by Jonsson et al[2] from Sweden and published in *Spine* in 1991, produced dramatic conclusions.

Specimen cervical spines from 22 victims of fatal traffic accidents were first studied using state-of-the-art plain film x-rays (AP, lateral, 45 degree oblique views - an average of 10 films per specimen), backed up with CT scans where the radiographic findings were ambiguous in any way. The specimens were then sectioned and filmed in the sagittal plane, to discover what injuries had been missed on xray examination.

Conclusions included:

i) There was severe soft-tissue injury - extensive rupture of muscles, joint capsules, synovial folds, ligaments, etc.

ii) Virtually none of this extensive soft-tissue injury could be seen on state-of-the-art plain film.

iii)"... it is well known that emergency plain radiograms are usually negative after whiplash type injury even when the clinical findings are indicative of soft-tissue lesions... it would seem reasonable to assume that these injuries may be overlooked in clinical situations and that a negative radiographic examination does not exclude cervical spine injuries."

iv)Plain radiograms also failed to show many fractures.

If injuries causing death are invisible on standard medical examination, so are most moderate to severe neck sprains as in whiplash.

Management

b) It is still true that no treatment approach has convincing evidence of effectiveness.[3] However traditional medical management, based on rest and medication for pain control, is now known to be inappropriate and likely to prolong disability and recovery. Manual treatments, exercise and early return to function, which form the basis of tradi-

1995 Centennial Celebrations
Canada: May 31 to June 4, Toronto, Ontario. *United States:* July 5-9, 1995, Washington DC (incorporating the 1995 World Chiropractic Congress) and September 13-17, 1995, Davenport Iowa. Clear those dates now.

tional chiropractic management, are now preferred.

In the words of Nikolai Bogduk, MD, PhD, Professor of Anatomy and Director, Cervical Spine Research Unit, University of Newcastle, New South Wales, Australia:

"...Early manual therapy has been shown to be superior to rest and a collar in the management of acute whiplash... Of all the various therapies for neck pain only early manual therapy for whiplash has been vindicated in the literature...Collars and other passive measures are not justified if formal manual therapy is available for this particular problem."[4]

Biomechanics

c) In this context biomechanics refers to the precise forces applied to, and the physical movements of, the occupant of a motor vehicle in a collision. It is now known that the views of important pioneers in the field of whiplash injuries, such as the Canadian orthopedic surgeon Macnab, views that form the basis of much current thinking and practice, are inaccurate in many respects.[5]

An important fact now established is that the occupant of a vehicle in an accident is exposed to much greater forces than the vehicle itself. For example, with a rear impact at a speed of only 8 miles per hour:

i) The head of an occupant of the front vehicle is exposed to an acceleration/deceleration force 2.5 times greater than the vehicle in which he/she is sitting.[6]

ii) The force is about 5G (i.e. 5 times the acceleration caused by the earth's gravity, which is 5 x 32.2 ft/sec^2 or 9.81 meters/sec^2 - approximately 50 m/sec^2.)[7]

iii) This is a major traumatic force, sufficient to induce concussion 50% of the time in unrestrained primates unaware of the impending impact.[8]

Litigation Neurosis

d) The concept of compensation or litigation neurosis has now been researched quite exhaustively. The studies show that, for most patients, periods of disability/symptoms/treatment are not related to settlement of their claims and pursuit of compensation. In a recent review of the evidence titled *'The Case Against Litigation Neurosis'* Arthur Croft DC, a prominent clinician and researcher into whiplash injuries from the Spine Research Institute of San Diego, California, concludes that, while there are obviously individual cases of exaggeration and malingering linked to claim settlement:

"... the evidence is compelling and leaves little room to support an inorganic etiology for these conditions in the majority of cases... The terms *litigation neurosis* and *compensation neurosis* should probably be repudiated and relegated to the scrap heap of Byzantine medical terminology... the term *accident neurosis* may indeed describe a minority of patients".

"It seems likely that much of the foundation for the perceptions of the inorganic nature of (whiplash injuries) has emerged from a void in our general understanding about the biomechanical forces involved in certain types of trauma and the underlying neuronal and soft-tissue pathology which results from these forces."[9]

Croft concludes that, if whiplash injuries had made their debut today, in the current clinical and scientific environ-ment, "the medical and legal commu-nities would be somewhat less scep-tical and considerably more interested in discovering the real mechanics behind the subjective symptoms typi-cally seen in (cervical acceleration/
deceleration injuries)."[9]

3. A previous issue of this *Report* (September 1988 Vol 2 No 6) looked at whiplash in general, including the tissues injured, classification of injuries, chiropractic management, and systems of prognosis. This issue looks at current biomechanical principles - these are fundamental to understanding whiplash injuries and providing a sound explanation of the basis for chiropractic management.

B. The 'Gentle' Rear-ender

4. The various forces experienced by an MVA victim are more severe and complex than previously appreciated. The following analysis of events during the first half second after impact is based upon a rear-end collision. This is an appropriate example to choose because although the 'rear-ender' represents only 20% of motor vehicle accidents, it causes over 80% of injuries giving long-term and persistent symptoms.[10,11]

The analysis is based on research from various disciplines from automotive engineering to basic and clinical health sciences. It draws particularly from the work of Croft. He and Stephen Foreman DC are joint authors of the text *'Whiplash Injuries: The Cervical Acceleration/Deceleration Syndrome'*,[12] a text described by the leading medical author Ruth Jackson MD as "the most remarkable compilation of scientific and factual data thus far published concerning the many facets of the cervical spine".[13] (A second edition of this 1988 volume is to be published later this year.)

5. Figure 1, based on crash testing work by Severy et al[14,15,16] illustrates the acceleration forces generated in the first half second - actually the slightly shorter time of 300 milliseconds - when an automobile with a human volunteer is struck from the rear by another like-sized automobile at the modest speed of 8 miles per hour (approximately 13 km per hour). It can be seen that:

a) The front vehicle accelerates immediately and evenly to a peak acceleration at .15 seconds, then decelerates completely by .225 seconds.

b) The occupant of the struck car accelerates later (the dotted curve commencing at .1 seconds), accelerates more violently than the car (a steeper line to the curve), and reaches much higher levels of acceleration and speed than the car (2 to 3 times higher at the

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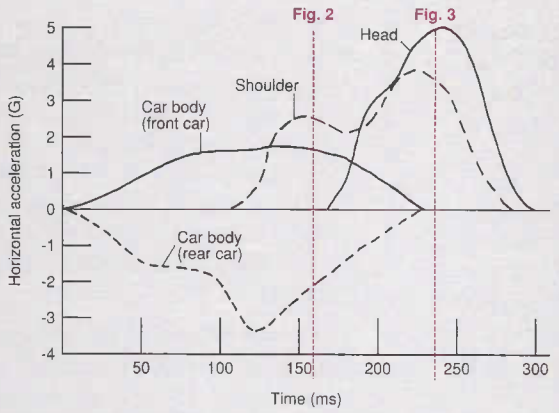
Figure 1
Acceleration Curves of Vehicles and Human Volunteer Exposed to 8 mph Rear Impact Motor Vehicle Collision.



After Severy et al (1955-1958). Reprinted with permission.

head and neck). The torso (shoulder) and head of the occupant experience different and conflicting rates of acceleration.

In real life all of this is subject to many other important vehicle and human variables discussed in para 10 below.

80 msec After Impact

6. At 80 msec after impact:

a) The struck vehicle, including the car seat, is accelerating.

b) The occupant, whether driver or passenger, is not but is moving backward into the seat cushion. The seat flexes backward also, more at the top than the bottom. The sum of these forces is that there is no net acceleration of the occupant's head and torso.

Understandably, compression into and flexion of the seat back ('loading of the seat back' or 'the diving board effect') will soon deliver a spring response that increases the accelerative forces on the occupant. In low-speed collisions this potential energy can be released, to quote Croft, "at precisely the worst possible time since it can occur at the moment the torso begins to accelerate".[17]

160 msec After Impact (Figure 2)

7. At 160 msec after impact:

a) **Torso.** The torso/shoulder has reached a first peak of forward motion. It began to accelerate at about .12 seconds and has accelerated more quickly and to a higher speed than the car. Loading of the seat back is not yet a factor.

b) **Head.** Notably, *the head is still not accelerating*. Since the car and torso are at a peak of acceleration the net effect is that the head is whipping backward - extending the neck or cervical spine and subjecting it "to tremendous axial stretch and shear forces".[18]

c) **Restraints.** Vehicle head restraints, if well-designed and appropriately positioned, can minimize the cervical spine extension at this point, reducing backward motion and the 'whipping forward' flexion forces that are soon to follow.

d) **Ramping.** Many head restraints, however, can aggravate the range of motion, peak force and injury by unintentionally providing a fulcrum - by restraining the neck as in Figure 2 rather than the head.

'Ramping', which allows this, is the vertical lift or rise of the occupant in the car seat following impact. A rear impact causes the rear of the struck vehicle to drop and the front to rise. It is not unusual for the driver's seat, which is flexing back also, to drop 2" or 3".[19] The driver, in relation to the seat, rises. This means that a head restraint that seems to be in position to limit injury may well, depending upon the precise mechanics of the accident, end up too low providing a fulcrum that aggravates the involuntary extension and the injury.

e) **Low-back.** Because the seat flexes backward more at the top, the pelvis and lumbar spine accelerate just before the torso. Croft explains that this is significant in two respects:

i) Providing a flexion force at the lumbosacral spine capable of causing soft-tissue injury at that level.

ii) In stationary vehicles that are rear-ended, causing brake release which allows the acceleration differential between the vehicle and occupant to be fully felt. How? The driver of a stationary vehicle generally applies only a light brake pressure - sufficient to keep the vehicle still. The low-back flexion results in an involuntary flexion of the hips and knees that lifts the foot from the pedal.

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Figure 2
Forces on Occupant 160 Milliseconds After Impact.

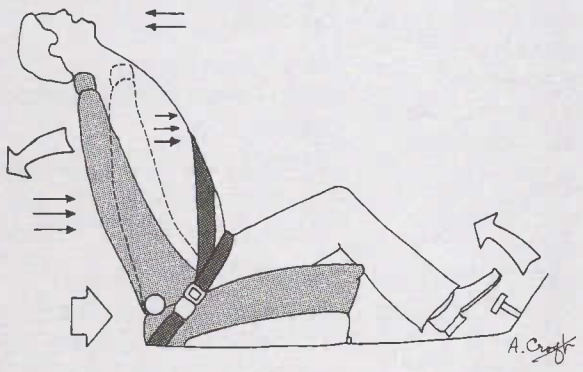
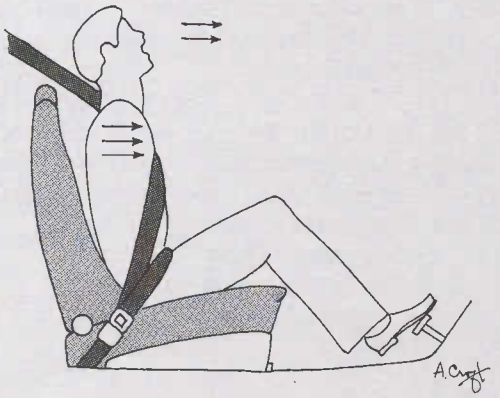


Figure 3
Forces on Occupant 240 Milliseconds After Impact.



f) **Jaw.** As the head moves backwards the mandible drops because of the musculature. However, unlike normal jaw movements, this is an involuntary, uncontrolled and frequently traumatic action.

While the relationship between whiplash and temporo-mandibular joint (TMJ) injuries is well known[20] the exact mechanism of injury is unclear. The standard dental model is torn ligamentous attachments. Croft believes "the normal translation of the disc/condyle complex, which occurs after the initial 25 mm of opening, may be precluded due to the suddenness of the opening and the release from muscular control. The result is a spraining of the joint and violent compression of the disc."[21]
(In voluntary mouth opening the external pterygoid muscle facilitates gliding of the disc/condyle complex).

240 msec After Impact (Figure 3)

8. At 240 msec after impact:

a) **Occupant.** The head and torso are both in peak acceleration and reaching highest speed at the same time. The torso, because of the diving board effect of the loaded seat back it is thought, has accelerated a second time. These factors may compound the injury:

i) The foot is involuntarily thrust back onto the brake pedal, which may make the deceleration of the vehicle and the occupant more sudden.

ii) A shoulder harness will restrain the torso abruptly yet will allow the head to continue to arc forward.

iii) The high chin position may result in greater flexion arcing and injury.

b) **Vehicle.** Review of the graph (Figure 1) shows that while the occupant is at peak acceleration the vehicle is not accelerating at all. Where the driver brakes, voluntarily or involuntarily, it may already be stationary.

A lap belt and shoulder harness, as in Figure 3, will restrain the occupant abruptly in the torso and pelvic areas, encouraging a concentrated stress to the neck as the occupant's head whips forward - producing maximum flexion and axial stretch of the neck and cervicothoracic spine.

Thereafter

9. All of the above mechanical and biomechanical forces are exerted in the first half second after impact. What happens next depends upon many things, including the force of the impact and whether or not the victim was prepared for it (see para 10). The head may go back and forth in additional but smaller arcs of motion and this is the basis for use of the term 'whiplash'.

C. Other Factors

10. The above principles also apply to a side collision, producing lateral whiplash. The shoulder provides no effective lateral restriction of neck movement, just as it is now known that the chin to chest provides no effective front restriction - especially with shoulder restraints. Many accidents will combine forward and lateral whiplash.

However the forces described in the above analysis are only one factor in assessing overall impact, injury and likely prognosis. Other vehicle and human factors include:

a) The relative speeds of the vehicles or other objects involved in the collision.

b) The relative sizes of the vehicles.

c) The exact types and positions of restraints.

- In a population of 327,354 patients with rear-end collision neck injuries Nygren found that *integral* restraints (fixed as part of the seat back - as in Figure 2) reduced injuries by an average of 24.5% while adjustable restraints reduced injury by an average of only 14.8%.[22] Other studies are consistent with this range of reduction.[23]

- Precise position of the restraint is important. As discussed a head restraint may, with low position and/or ramping, increase range of motion and injury. Mertz and Patrick report that the ability of a restraint to protect against injury is greatly reduced when it is more than 2 inches from the head.[24]

- Was there a lap belt, a shoulder belt? Did they work?

d) The design and condition of the seats. In 1987 Strother and James found that all production car seats would flex rearward with a sudden change of velocity of 15 miles per hour, and energy absorbing capacity would be exceeded with a change of 20-25 miles per hour.[25]

e) Whether and when brakes were applied. Firm braking will reduce acceleration, and therefore extension injuries - but may increase deceleration and flexion injuries. (If the road ahead is clear and you have a good head restraint don't brake if you are about to be hit from behind.)

f) Whether the occupant was forewarned and prepared for the accident. By bracing for impact the forces to the head are significantly reduced.[14] (Muscular reflexes, which take at least 120 msecs under ideal conditions, are too slow to reduce movement and injury, and will increase injury where reflex activation of flexors coincides with deceleration.[26])

g) Patient factors include sex, age, stature and pre-existing degeneration or other conditions.

h) Position at impact is significant - was the accident victim looking straight ahead or turning his/her head at 45° or 90°?

D. Practical Implications

11. Chiropractors and their patients will be confronted by third party payors and defense attorneys, supported by medical expert opinion, who still rely upon a simplistic biomechanical model of

Classification of Whiplash Injuries

It is clinically useful in chiropractic and medical practice to classify soft-tissue neck strains. The following three categories, commonly used in North America, are from Ameis A 'Cervical Whiplash: Considerations in the Rehabilitation of Cervical Myofascial Injury', Can Fam Physician 1986; 32:1871-1876).

Mild (first-degree spinal myofascial strain - uncomplicated). This describes injuries where there is rapid healing, minimal work loss, and the patient is symptom-free about 6 months after the injury. These are 'mild', but not 'slight' or 'trivial'.

Moderate (second-degree strain). Serious symptoms, substantial work loss, and patients generally recover normal lifestyle within 6 months to 2 years - 50% will have functional recovery within 12 months. 'Functional recovery' is defined as ability to perform all normal activities with a competence reasonable for the patient's age, skill and needs. However functional recovery may take some years longer, and the patient may never be entirely symptom free.

Severe (third-degree strain). Often accompanied by other significant injury such as fracture or concussion. Symptom onset certainly within 48 hours. Long-term or even permanent disability. Many patients, up to about 15%, will never achieve a functional recovery. 40- 70% of patients will permanently have intermittent continuing pain and stiffness which is unpleasant but not materially disabling.

injury. They will challenge a patient's injuries, substantial work loss and persistent symptoms on the 'common sense' basis that the vehicle impact was slight and no injury is apparent on xray.

This must be countered in two ways:

a) Familiarity with the relevant biomechanical principles and the evidence that supports them. The single most important principle is that the head and neck of an MVA victim may be subjected to accelerative forces that are more sudden and 2-3 times as high as the vehicle in which he/she is sitting.

b) The biomechanical facts of the case, documented in a detailed case history which records the various vehicle and human parameters relevant to biomechanical forces sustained. This will provide the foundation for an effective explanation of how an apparently slight impact has given rise to a moderate injury with prolonged functional recovery and symptoms.

As an example, Figure 4 gives an extract from an examination form used by Croft which allows for a full but efficient history.

E. Whiplash and TMJ Disorders

12. Finally, a note on jaw injuries. During the past five years there has been much greater awareness of:

a) The potential for injury of the temporomandibular joint (TMJ) in whiplash and other trauma. A new study from Braun et al at the University of Minnesota[27] reports that 50% of patients reporting symptoms following whiplash trauma have TMJ dysfunction.

b) A surprising and confusing similarity in symptoms from cervical disorders and TMJ disorders. Many patients with neck pain and headache, and no stiffness or pain in the TMJ, will be misdiagnosed as having a cervical spine disorder and managed unsuccessfully because a TMJ dysfunction is the primary problem and is ignored. Signs and symptoms in the TMJ itself may not appear for some months.

c) The effectiveness of multidisciplinary management - chiropractic (physical), dental (orthotic supports), surgical, and psychological

The leading text in this area is 'Whiplash and Temporomandibular Disorders, An Interdisciplinary Approach to Case Management'[20] edited by Dennis Steigerwald DC, a California chiropractor who has specialized in the management of TMJ disorders since the 1970s. Chapter authors include chiropractors, dentists, medical specialists and a psychologist.

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Figure 4: History Exam Form – Extract Relevant to Vehicle Collision Data

HX (auto) Pat. was ☐ Driver ☐ Pass. _____ ☐ Other _____ Driven by _____

Pat's. vehicle (yr, make, model) _____ ☐ Stopped Est. speed _____ MPH

Time ☐ Day ☐ Night ☐ Dawn ☐ Dusk Rd. cond. ☐ Dry ☐ Damp ☐ Wet

Head rest. ☐ None ☐ Integral ☐ Adj. in _____ Posit.

Seatbelt ☐ None ☐ Not wearing ☐ Wearing ☐ ? Other vehicle (yr, make, model) _____

Shldr. harn. ☐ None ☐ Not wearing ☐ Wearing ☐ ?

Head posit. ☐ Ahead ☐ Right ☐ Left Hands ☐ One one wheel ☐ Two on wheel ☐ ?

Brakes on ☐ Y ☐ N Trans. ☐ Manual ☐ Auto.

Aware of imp. collision ☐ Y ☐ N Felt body go ☐ Fwd. then back ☐ Back then fwd. ☐ ?

Description _____

_____

_____

From Croft AC 'Whiplash: The Masters' Certification Program. Reprinted with permission.

References: *continued from page 5*

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Professional Notes: *continued from page 1*

visual disorders and were then examined by four ophthalmologists independent of the author and each other. In all cases vision improved, as did non-visual disabilities. For example:

Case 1: (A 62-year old female). She could now see 6/6 in the right whereas previously she had only seen 6/12, and 6/5 in the left whereas she had only seen 6/9. Her visual field had certainly improved dramatically. The result is quite remarkable ... She told me that the headaches have gone since the manipulation and her arm movement had improved quite remarkably and her spine which had a hump in it has straightened out. It was quite clear on talking to her that her depression had lifted. The specialist wrote that she "has shown a response not seen in my clinical experience ... the proof of the pudding, however, is in the eating and this lady has my personal documentation of a substantial benefit which I do not think could be achieved by any traditional therapeutic modality."

Case 2. (A young boy). The visual acuity improved from 6/12 to 6/5. I tested his reading before and after. The reading prior to the manipulation was slow and after two minutes the eyes became sore and he found that the page was becoming glary and the writing moved. Following manipulation all these symptoms disappeared.

Terrett then gives examples from the general literature including a study by Zhang et al in China involving 114 patients with 'cervical visual disturbance' whose vision and cerebral blood flow was improved following spinal manipulation. Terrett concludes that "if spinal manipulation is a method of reactivating hibernating cerebral neurons, the implications are enormous to both patients and the future of chiropractic." There are implications in the fields of education/learning, psychology/psychiatry (many patients currently given a psychological label and medication may have a disability that is being ignored), and performance enhancement. Terrett invites communication from anyone with information relevant to this theory - Dr. Allan Terrett, Senior Lecturer, School of Chiropractic, Royal Melbourne Institute of Technology, Bundoora Campus, Plenty Road, Melbourne 3083, Victoria, Australia.

Patient Satisfaction

The Manga Report in Canada recently reviewed the international evidence on back pain and patient satisfaction, and found that comparable groups of patients were far more satisfied with chiropractic management than medical management.

This conclusion is confirmed by a new study (n 425) by Eric Hurwitz DC from the School of Public Health, University of California, Los Angeles. The new factor in this study was that all patients came from one multidisciplinary health care organization - they were referred to a staff medical doctor or staff chiropractor within the same network. (Hurwitz EL (1994) 'The Relative Impact of Chiropractic vs Medical Management of Low Back Pain on Health Status in a Multispecialty Group Practice'. JMPT 17(2):74-82).

Subluxation and Nerve Compression

An old chestnut that has been argued at many scientific - and political - meetings is whether or not the lumbar spinal nerve roots may be compromised by vertebral joint subluxation at the intervertebral foramen.

A sophisticated new study by Lynton Giles DC PhD appearing in the January issue of JMPT provides convincing evidence that they can - "neural and associated vascular structures may well be compromised due to vertebral joint subluxation within the important interpedicular zone of the intervertebral canal".

Giles criticizes the 1973 study by Crelin, which concluded that there was ample space and no restriction from subluxation in the intervertebral foramen, because Crelin examined only "the relatively insignificant lateral border" of the intervertebral canals and "failed completely to study the relationship between the nerve roots and the spinal ganglion within the important interpedicular zone". ('A Histological Investigation of Human Lower Lumbar Intervertebral Canal (Foramen) Dimensions', Giles LGF (1994), JMPT 17(1):4-14).