Successful chiropractic management of spinal fractures and dislocations is dependent on the proper pretreatment evaluation of the injury, treatment regimes which are biomechanically sound and referral when necessary.

Although up to 9% of presenting patients may have compression fractures (1), the protocols for management of both chronic and acute lesions remain ill-defined due to the fact that relatively little documentation exists regarding chiropractic management. However, the few reported cases (2) provide a promising foundation for future work in this area.

In the attempt to aid an injured individual, the doctor must take heed of the Hippocratic oath: “Primum non nocere” (above all do the patient no harm). It is with this perspective that the author will explore the existing body of knowledge of spinal fractures and dislocations, while developing a rationale for chiropractic care of these often disabling disorders. Given the risks of adjusting patients with fractures or dislocations, more extensive investigation is often required (e.g., MRI, CT, tomography) in managing these cases. Before beginning treatment, the doctor must always evaluate their skill and experience to determine if they are capable of managing these types of disorders.

Fractures have been organized in this chapter according to anatomical regions with an emphasis on their major injury vectors in an effort to encourage the chiropractor to think in mechanistic terms when analyzing traumatic injuries and in creating logical strategies for their treatment. Case studies, when available, have been provided to illustrate the chiropractic management of spinal fractures and dislocations. The practitioner must keep in mind that every patient should be evaluated individually and any treatment course dependent upon the specific findings and potential risks of that particular case.

The scarcity of published reports necessitates a more intensive professional participation in exploring and documenting the chiropractic options for the treatment of spinal fractures and dislocations. Through the accumulation of published reports of successes and failures, this small database can be expanded.

The foremost concern in evaluating the patient with a potentially devastating lesion is resolving the stability status of the injury, since that is the determining safety factor.

**SPINAL STABILITY**

According to White and Panjabi (3), spinal stability is defined as that situation where a spine placed under normal physiologic load is able to resist further positional deformation, neurologic damage and irritation.

The two column classification of spinal stability as suggested by Holdsworth (4,5), anatomically separates the spine into posterior and anterior columns as seen on a lateral view. The anterior column is comprised of all bony and ligamentous structures from the posterior longitudinal ligament forward, including the vertebral body, the great common ligament (disc) and the anterior longitudinal ligament. The posterior column is comprised of all structures behind the posterior longitudinal ligament, including the pedicles, articular pillars and facets, the lamina, spinous processes and all of the posterior supportive ligamentous tissues. Holdsworth, using his two column classification of the spine, suggested that spinal instability occurs only when the posterior column is damaged.

Denis (4,5) created the three column concept of spinal stability. He divided the spine into three columns, the anterior, the posterior which Holdsworth had identified and a middle column comprised of the posterior aspect of the annulus fibrosis and the posterior longitudinal ligament (Fig. 12.1). By evaluating biomechanical studies he determined that instability would not occur if only posterior ligamentous structures were damaged, as Holdsw-

![Figure 12.1](image)

Figure 12.1. Denis three column spine: posterior, middle and anterior. The middle column is highlighted.
worth had suggested. Rather, Denis found that instability occurred only when there was disruption of the middle column combined with the posterior column damage. Thus he recognized the independent importance of this middle column. In addition, he concluded that there must be damage to all three columns for dislocation to occur. Denis also suggests (5), though does not state, that spinal instability may occur when there is damage to two of the three columns, one of which has to be the middle column. Most spinal fractures can be correctly classified as stable or unstable according to Denis’ concept. However, there are some instances, such as an extensive teardrop injury with posterior ligamentum flavum damage, where the anterior and posterior columns are damaged and the middle column is intact, but the injury is still unstable. In light of this, the author will classify fractures as unstable if any two of the three columns are damaged to the degree that they could potentially lead to further mechanical deformity or to increased neurological damage or irritation when placed under normal physiological loading.

FRACTURES OF THE CERVICAL SPINE

Jefferson Fracture

The Jefferson fracture is a burst fracture of the atlas ring which breaks it into four parts (3). Automobile, diving, and other accidents in which a considerable blow is sustained to the vertex of the head in a −Y translational direction cause the occipital condyles to force the lateral masses of the atlas apart laterally. The term major injuring vector (MIV) is used to describe the directional mechanism of injury (3) (Fig. 12.2). This excessive compressive force causes a fracture at the junction of the lateral mass and the anterior arch in front, and the lateral mass and the posterior arch in back (Fig. 12.3).

The Jefferson fracture usually occurs bilaterally but may be unilateral if the downward force is exerted off-center to the vertex of the skull. In addition to compression, some degree of extension of the upper cervical spine is required to cause the break (3). This may cause additional injuries (e.g., occipitoatlantal subluxation) in the area (See Case Report). Due to the lateral forces exerted on the atlas lateral masses, a rupture in the transverse ligament often accompanies the fracture.

The Jefferson fracture is best visualized with an AP open mouth radiograph. A common finding will be a lateral displacement of the lateral masses of the atlas in relation to the superior articular processes of the axis. The CT scan will confirm the separation of the neural arches. The Jefferson fracture is most often stable and is usually not associated with neurological compromise (3). However, the fracture is potentially biomechanically unstable.

CASE REPORT

A 21-yr-old comatose male was brought to a chiropractic clinic for evaluation and treatment. The patient had been comatose for approximately fifteen months following a motor vehicle accident. After the accident, the patient was transported to a local hospital for evaluation. Plain films (now unavailable) taken at the time of hospital admission revealed a Jefferson fracture without major displacement. The patient’s condition was stabilized although he remained comatose. The patient was otherwise unresponsive to conventional medical treatment. At the parent’s request the patient was brought home. There, 24 hour nursing care was provided. During the next fifteen months the patient’s condition deteriorated. His weight dropped approximately 90 lbs.

Physical examination revealed a comatose emaciated individual. His vital signs were as follows: pulse rate was 42 beats/min., respiration was 8 and blood pressure was 60/27. Anteroposterior and lateral full spine x-rays were obtained in the supine and lateral recumbent position. Spinoigraphic analysis revealed an anterior superior (∆X) condyle subluxation (Fig. 12.4).

In the supine position, a closed reduction was attempted for the fracture at C1. The transverse process of C1 was contacted and a thrust was made from right to left (+X) and then from left to right (−X). This was repeated twice over the course of one day. The patient was unresponsive to the adjustments. The next day, closed

![Figure 12.2. Major injuring vector (MIV) for a Jefferson fracture.](image1)

![Figure 12.3. Jefferson fracture. Modified from White AA, Paréjabi MM. Clinical biomechanics of the spine. 2nd ed. Philadelphia: JB Lippincott, 1990:197.](image2)
reduction was performed on the anterosuperior condyle subluxation in the supine position (6). After the maneuver, a comparative radiograph in the lateral recumbent position was performed. This radiograph (Fig. 12.4B) demonstrates only minimal change in the osseous configuration of the C0-C1 motion segment. The patient continued to be unresponsive. The adjustment was repeated followed by another comparative radiograph. This radiograph (Fig. 12.4C) demonstrates a partial reduction in the displacement, however, the patient’s condition remained unchanged. Encouraged by an apparently successful closed reduction, the adjustment was performed a third time. After the maneuver, the patient became conscious. Another comparative radiograph was performed (Fig. 12.4D) which demonstrates a marked reduction when compared with the initial displacement. Vital signs were obtained after the patient regained consciousness. The pulse rate was 58 and the blood pressure elevated to 90/60. The patient was observed for three days with no treatment. Adjustments were performed later at the L5-S1 motion segment to reduce retrolisthesis at that level. Adjustments were also administered to the thoracic spine.

The patient was eventually able to ambulate with the aid of a walker.

**Atlas Posterior Arch Fracture**

A fracture at the junction of the posterior arch and lateral masses is the most common atlas fracture (3,7). A force exerted caudally (−Y) on the vertex of the head, as in a Jefferson fracture, but with a component of hyperextension (−θX) causes the posterior arch of the atlas to be forced between the posterior neural arch of the axis and the base of the occiput. This compressive force causes the posterior arch to move caudally while the lateral masses are held rigid, creating a fracture at the weakest point in the arch, the vertebral artery groove. The extension component of the mechanism of injury is further evidenced by the frequently accompanying hangman’s fracture of C2 (also a hyperextension injury). A posterior arch fracture can best be visualized with a lateral radiograph. When the fracture is present, it should always be scrutinized closely for evidence of an accompanying hangman’s fracture.

If no neurological signs are present, flexion and exten-
sion radiographs can further establish the fracture's stability status. Given that dynamic stress radiographs may recreate the mechanism of injury and further stress the damaged tissues, care should be taken with this procedure.

Like the Jefferson fracture, the posterior arch fracture is usually stable, but due to the presence of the delicate neurological structures and vertebral artery located in this area, extreme caution is advised (3,7).

Hangman's Fracture

The hangman's fracture, or traumatic spondylolisthesis of C2, is one of the most commonly occurring injuries of the cervical spine (7). The fracture is caused by forced hyperextension (−θX) (Fig. 12.5).

A rebound hyperextension action (7) following hyperflexion, from the head hitting the windshield or dashboard in rapid deceleration injuries (8), or hyperextension with compression, causes a separation at the pars interarticularis. The posterior arch of C2 remains in contact with C3 at the articular processes, but the body of C2 is displaced anteriorly, bringing with it the odontoid, atlas ring, and the skull. The lateral radiograph is the best view to evaluate the C2 anterolisthesis.

The hangman's fracture, is associated with anterior and middle column damage and although biomechanically unstable it is often times without neurological deficit because of the increased diameter of the spinal canal caused by the anterior slippage. Due to the location of delicate neurological structures, when nerve injury does occur, it can be devastating.

C2 Odontoid Fractures

Odontoid fractures have varied mechanisms of injury. Depending on the direction of force involved, each injury may have dramatically different neurological and mechanical manifestations.

Both +Z translational forces, as well as hyperflexion injuries, can lead to dens fractures by causing the atlas transverse ligament to forcibly sever the dens from its vertebral body. Negative Z forces, as well as hyperextension injuries, can create fractures through forces exerted by the posterior aspect of the anterior arch, posteriorly on the odontoid process (Fig. 12.6). The −Z and +Z translational injuries are usually caused by direct blows to the front or back of the head respectively.

The odontoid fracture can be visualized on the AP open mouth view as a jagged line through the dens, or on the lateral radiograph as an anterior or posterior displacement of the dens.

A dens fracture may be mistakenly interpreted on the AP open-mouth view due to the Mach effect (7). This is caused by a superimposition of the anterior and posterior arch of C1 appearing as a fracture line at the base of the odontoid. One helpful differentiating tool is that while the superimposition line is smooth and regular, the fracture line will be more jagged and irregular. Taking a lateral radiograph or altering the head position on the AP open mouth, should move the atlas ring enough to eliminate the superimposition. As with all suspected fractures, the doctor should exercise caution. If uncertainty exists, a flexion extension study should eliminate any remaining questions.

When determining if an odontoid fracture is present, the doctor must also rule out os odontoideum, a developmental nonunion of the dens to the body of C2. The gap between the dens and the body is much larger than occurs with most fractures and exhibits smooth sclerotic borders, as opposed to nonsclerotic jagged edges in the case of the fracture. The use of a bone scan and any pre-injury x-rays should clarify the situation (7).

Three main types of odontoid fractures occur, as classified by Anderson and D'Alonzo (7). Type I is an avulsion of the top of the odontoid. It does not usually pose any neurological deficit or stability problems even with nonfused healing. Type II is the most frequently occurring and most likely not to reattach (7). As many as 38% heal with nonunion (3). It occurs at the junction of the dens and the vertebral body of C2.

Type III is a fracture occurring deeper into the C2 body (7). This fracture usually heals with no complications.
Odontoid fractures do not usually cause neurological compromise because of the extra canal space in this area of the spine. But since some fractures have an accompanying related anterior or posterior slippage, spinal canal encroachment (i.e., instability) can occur (3,7).

Rupture of the Atlas Transverse Ligament

Traumatic C1 transverse ligament rupture unrelated to preexisting ligament weakness is rare. As with most ligament-osseous relationships, the bone normally fails in trauma before the ligament tears. Certain conditions (7,8) predispose the ligament to rupturing; rheumatoid arthritis, psoriasis, ankylosing spondylitis, Reiter’s syndrome, Down’s syndrome, tonsillitis, pharyngitis and cervical adenitis. Any of these conditions, combined with a severe blow at the posterior of the skull in a +Z direction, can cause the ligament to rupture, with or without a corresponding odontoid fracture. In cases where the dens does not fracture (Fig. 12.7A), the cord is pinched between the posterior arch and the odontoid causing much more neurological involvement and damage than in instances where the odontoid also breaks (Fig. 12.7B). The latter allows the cord to snake around the insulting osseous structures.

The rupture is best visualized with the lateral radiograph. A finding of anterior slippage of the atlas on the axis is demonstrated with an increased atlanto-dental interval (ADI). The normal ADI is 3 mm in adults and 5 mm in children (See Chapter 5). This injury is unstable and often requires surgical stabilization (3).

CASE REPORT

This 36-yr-old female presented to hospital following cervical trauma. Initial radiographs taken there showed no transverse ligament disruption. She underwent a course of cervical traction of several days before electing to undergo chiropractic evaluation and treatment. Radiographs taken at this time demonstrated anterior displacement of C1 on C2, indicative of transverse ligament rupture. The patient complained of severe neck pain. The chiropractor adjusted C6 four times and then referred her to an orthopedist for surgical consultation. An arthrodesis at C1-C2 was performed subsequently (Fig. 12.8A-B). Approximately five months after surgery, she returned for chiropractic care with a complaint of severe headaches. Initially, the patient was adjusted at C2 and C5 four times. At later dates the patient was adjusted at T5, C6 and the sacrum. Cervical adjustments were performed in the seated position. The patient was eventually adjusted at C1, which then provided symptomatic relief for her headaches. This is an extremely interesting case study in which thrusts were applied at the level of an arthrodesis, which in most instances (See Chapter 11), would be considered a contraindication for direct adjustments at that level.

Clay Shoveler’s Fracture

A clay shoveler’s fracture is an avulsion injury of the lower cervical or upper thoracic spinous processes. Due to their elongated spinous processes, C7 and C6 are the most frequently involved (3). The etiology is typically heavy lifting or forced flexion of the cervical spine, though direct trauma can also be a cause. The avulsion fracture is the result of extreme pulling from the muscles which are attached to the spinous processes, such as the upper trapezius or rhomboids.

The clay shoveler’s fracture is best viewed on a lateral cervico-thoracic radiograph. The avulsed spinous process is usually displaced inferiorly and is often difficult to see due to the thick musculature at the cervico-thoracic area. Pre-patient filtration of the cervical spine is often helpful in producing a clearer radiograph (See Chapter 5).

The AP lower cervical radiograph often reveals two separated spinous processes on the same vertebra since the tip of the fractured spinous is visualized caudally to the base of the attached spinous of that vertebra.

Due to the non-neurologic proximity of the tip of the spinous process, the clay shoveler’s fracture usually has no complications except when associated with other flexion injuries such as vertebral body compression or articular process misalignment. The spinous tip often does not reattach and will take on a smooth sclerotic edge as it heals (3,7,8).

Bilateral Interfacetal Dislocation

Bilateral interfacetal dislocation (BID) is caused by a severe hyperflexion injury to the cervical spine (Fig. 12.9). The mid cervical spine (C4-C7) is most commonly afflicted. Extreme hyperflexion brings the supporting soft
tissues beyond their limits leading to ligamentous tearing (Fig. 12.10). This allows the inferior articular surfaces of the superior vertebra to ride up and over the superior articular surface of the vertebra below. In this particular situation, soft tissues fail before the bony structure. Affected soft tissues include the posterior longitudinal ligament, the midline ligaments, the annular fibers of the disc, the capsular ligaments, the apophyseal joints and occasionally the anterior longitudinal ligament.

After the injury, the superior vertebra usually comes to rest anterior to the vertebra below, with the inferior articulating processes resting in the intervertebral foramen. The body of the dislocated segment is usually anteriorly displaced a distance of at least ½ the AP vertebral body length of the vertebra below (7). Although rare, spontaneous repositioning can occur. In this scenario the neutral lateral cervical radiograph may not show bony misalignment, but the patient can have severe signs of cord injury. A radiograph taken in flexion will demonstrate the mechanical instability. As with all motion x-rays which reproduce the mechanism of injury, extreme care must be taken. Small chip fractures of the articular process may be found accompanying this dislocation (7). Since all three columns are involved, this injury is always considered unstable. Neurosurgical referral is indicated.

The so called “perched facet” (Fig. 12.11A-B) has
been proposed by White and Panjabi (3) to be a true dislocation. The injury can be uni or bilateral. Treatment is through controlled traction combined with muscle relaxation and sedation.

Unilateral Interfacetal Dislocation

The direction of injury in a unilateral interfacetal dislocation is flexion coupled with rotation (7). The dislocation occurs at only one zygapophyseal joint and leaves the injured inferior articular surface resting in the intervertebral foramen of the vertebra below.

The lateral view will give several indications of this condition. The body of the dislocated vertebra will be misaligned anteriorly on the body of the vertebra below, although usually not as far as in bilateral dislocations (See Case Report). There is also a disruption in the alignment of the facets which often exhibit a “bow tie” or “bat wing” appearance (8). Since unilateral dislocations are potentially unstable, protocol requires obtaining advanced imaging, such as MRI or CT, to determine the extent of injury.

CASE REPORT

This 19-yr-old male suffered an injury to the cervical spine while diving head first into a shallow portion of the ocean. The patient was driven to a hospital where clinical and computerized tomographic examinations of the cervical spine were performed. The CT scan clearly shows a displaced fracture of the vertebral body of C6 with a hairline fracture of the pedicle (Fig. 12.12A-E). The transverse process is also fractured. The patient’s chief complaint was of moderate neck pain and numbness of the right upper arm and hand. The patient was placed in a Philadelphia collar and surgery was recommended. The patient then elected to travel out of state to seek chiropractic treatment. The patient presented to an outpatient facility with complaints of neck pain and numbness of the right arm and hand. This was twenty days after the initial trauma. Dynamometer evaluations revealed weakness of grip strength on the right side. Range of motion examination of the cervical spine demonstrated flexion limited to 80% of normal and extension limited to 60%. Right rotation of the cervical spine was limited to 50% of normal and left rotation was approximately 80% of normal. Radiologic examination disclosed the fracture dislocation of the C6 vertebra (Fig. 12.13A-B). Hyperextension of C7 on T1 was present. Interssegmental dysfunction was also present at the mid thoracic region (i.e., T5-T6) and at the lumbosacral junction. The patient was adjusted in the prone position on the hi-lo table using the spinous process of C7 as the contact point. A very light posterior to anterior and inferior to superior thrust was made in an attempt to reduce the hyperextension positional dyskinesia that was present at C7. The patient was treated sev-


eral times a month for two months and is currently seen on a periodic (maintenance) basis. He is completely asymptomatic and participates in sport activities (i.e., basketball, water-skiing).

Lamina Fractures

Lamina fractures can be caused from forward flexion (+θX) injury leading to avulsion of the lamina from the spinous process. Due to the strength of the ligamentous structures, the bone often fails before the ligament ruptures. The lamina fracture usually occurs in the mid cervical region. The lateral plain film radiograph is the best view to visualize this injury, which will appear as a radiolucent line through the lamina (7). Since the fracture is often difficult to detect with plain films, in some cases, a tomogram may be helpful in its identification. Lamina fractures can contraindicate spinal adjustments using the involved level as the contact vertebra (9).

Articular Pillar Fractures

Articular pillar fractures occur most commonly in the mid to lower cervical region, especially C6 (7). The most common mechanism of injury is hyperflexion with compression (7) coupled with lateral flexion (3,7,10). As the bony pillar fails and collapses, the body of the vertebra is often forced anteriorly.

This fracture may be seen on a lateral radiograph, but when suspected, it is best visualized with an articular pillar projection, taken in an AP direction with a caudal tube tilt of 20–30 degrees (7).

Vertebral Body Compression Type Fractures

Wedge Fractures

The MIV for the wedge fracture is forced hyperflexion (+θX) of the spine creating a compression on the anterior portion of the vertebral body. Most (%) wedge fractures occur at the fifth, sixth and seventh cervical segments (7). Supportive soft tissues are usually spared and no major ruptures occur to either the anterior longitudinal ligament, the disc structures, or the posterior ligamentous elements. Thus, the simple wedge compression fracture is a relatively stable injury.

The cervical wedge fracture is best seen on the lateral radiograph. The vertebral body is usually compressed anteriorly and the anterior vertebral body height measurement is generally at least 3 mm less than that of the posterior.

Prevertebral edema and hemorrhage can increase the retropharyngeal interspace (7). The measurement taken from the anterior margin of the vertebral bodies of the upper and mid cervical vertebra to the posterior aspect of the tracheal air shadow should not exceed 40% of the
anterior to posterior measurement of C4. An increase in this measurement suggests anterior vertebral trauma (Fig. 12.14). The normally radiolucent fat stripe which runs within the prevertebral soft tissue may be locally displaced at the level of the trauma (8).

The wedge fracture often shows a disruption in the normal smooth and regular contour of the vertebral body at the point of cortex break. The best view for visualizing a compression fracture is the lateral radiograph. The AP view does not typically give a clear indication of the injury since no fracture line can be visualized. Once a fracture has been identified, the doctor should search for concomitant injuries. Nontraumatic compression fractures can occur with severe bone weakening diseases such as advanced osteoporosis or lytic metastasis.

Seizure attacks can lead to fracture of the cervical spine in rare cases. This accounts for approximately 2.5% of all hospitalized “non-traumatic” fractures of the spine (11). It is generally not contraindicated to use the fracture segment as a contact vertebra for an adjustment. If an adjustment is indicated, it can be performed in the prone or seated position using the spinous process as the short lever arm.

CASE REPORT

This patient suffered a diving injury (6–22–79) which compressed the C5 and C6 vertebral bodies (2). The patient immediately became quadriplegic. After treatment with halo traction the patient’s condition improved and he regained control of the upper extremities but remained paraplegic. The patient subsequently underwent wire fixation arthrodosism from C4 to C6.

At the time of presentation to an outpatient chiropractic facility, the patient remained nonambulatory and paraplegic. This was approximately nine months after the accident. Physical and radiologic examinations were performed. The arthrodosis is visible on the lateral and anteroposterior radiographs (Fig. 12.15A-B).

The first thoracic vertebra was adjusted four times (PR-1). The patient did not improve. The C7 vertebra was then adjusted (PL). The spinous process was contacted with the distal lateral tip of the index finger. All adjustments were made with the patient seated in the

Figure 12.14. Cervical spine of a normal individual. Notice the tracheal air shadow.

Figure 12.15. A, Lateral radiograph. Notice the retrosthesiathesis and hyperextension positional dyskinesia of C6. B, Anteroposterior radiograph of a C4-C7 arthrodosism.
sign is usually present in the burst fracture and absent in the simple compression fracture, making it useful as a differentiating factor (7).

The burst fracture is often missed, due to its tendency to reposition back to a more normal shape and position after the injury. This is due to the centering effect of the ligaments of the motion segment. This may leave the practitioner uncertain as to the level of neurologic deficit if the radiograph shows no alterations (3). The CT scan is the best method of determining the level of comminution and fracture (7). Due to the fact that the burst fracture involves the anterior and middle columns, it is always biomechanically and often neurologically unstable.

**Lateral Bending Fractures**

Forced lateral flexion (± 6Z) of the cervical spine causes compression on the concavity of the curve and avulsive type forces on the convexity. The compressive forces, if severe enough, can cause vertebral body collapse on one side of an articular pillar. The fracture or dislocation can best be visualized with the AP radiograph (or with an AP pillar view) (3).

In severe cases, the transverse process on the convex side may fracture due to avulsion forces. The distal tip of the transverse process is forcibly pulled off by its attachment to strong ligaments and muscles. Due to its elongated processes, the C7 vertebra is the most common site of a transverse process fracture. The break is best visualized on an AP cervical view and will be differentiated from nonunion of the transverse process by the irregular edge in the fracture and the smooth sclerotic appearance of a nonunion process. Brachial plexus injury can occur on the convex side of bend, and worsens the prognosis. If the injury is isolated to the vertebral body, the segment is usually stable. When the posterior elements are also
involved, or avulsion is present, the segment is considered unstable (3).

**Teardrop Fractures**

A teardrop fracture of the cervical spine may be caused by either a hyperextension ($-\theta X$) or hyperflexion ($+\theta X$) injury. The hyperextension type injury creates an avulsion of a triangular piece of bone from the anterior inferior aspect of the vertebral body. The damaging force is often severe enough to also rupture the anterior longitudinal ligament. The motion segment may be unstable if the anterior damage is combined with posterior compression. Along with anterior ligament avulsion damage, the posterior supportive laminar ligaments (i.e., ligamentum flavum) are usually compressed to such a degree that they are driven anteriorly into the spinal canal, causing posterior cord compression (7, 8). This compression may cause central spinal cord syndrome which is characterized by loss of pain and temperature, but a sparing of sensation to touch (3).

Hyperflexion injuries can also cause teardrop type fractures as the anterior inferior aspect of one vertebra is compressively forced onto the anterior superior aspect of the vertebral body below. This may cause an often sizable chip of bone to break from the anterior inferior aspect of the vertebral body above. The posterior supportive ligaments can be torn, possibly allowing unilateral or bilateral facet dislocation to occur. There may also be associated acute anterior cervical cord syndrome (3, 7). When ligamentous damage is present, the segment is considered biomechanically unstable.

**FRACTURES OF THE THORACIC SPINE**

Study of this area has long been neglected since fractures of the thoracic spine constitute only a small percentage of spinal fractures (14). Fractures occur less often in the thoracic area than in other parts of the spine given the protection offered by the rib cage, the orientation of the facet planes and the fact that considerable force is required. Due to the architecture of the thoracic vertebrae, the neural canal is smallest in this area, thereby subjecting its contents (the spinal cord and nerve roots) to damage when a vertebra is either fractured or subluxated. The main causes of thoracic fractures are auto accidents, falls from excessive heights, and direct blows to the area.

Unstable fractures result in loss of anterior vertebral body height and progressive kyphotic deformity (Gibbus) (Figs. 12.19–12.21), subluxation of the superior vertebra and disruption of the soft tissues, usually causing pain. Stable compression fractures may also present a similar symptomatology and if not treated properly, instability can ensue when anterior column height exceeds 50% due to progressive stress at the posterior elements.

As the cancellous bone collapses, there may or may not be a loss in compressive strength (3). The mechanical properties of spongy bone are depicted in Figure 12.22.

A less common type of injury is the burst-dislocation, combining elements of the burst fracture and fracture dis-

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*Figure 12.19. A, Radiograph of a cadaveric specimen demonstrating multiple compression fractures of the thoracic spine with a kyphotic or Gibbus deformity. B, Cadaver specimen.*
location. In typical fracture-dislocations, the spinal cord is compromised with the superior fracture segment tethering the spinal cord contents across the relatively fixed inferior segment. In contrast, burst-dislocations shatter the inferior vertebral body and extensive posterior element fractures appear to add an element of decompression of the spinal canal at the time of injury. Without this decompression, a greater neurologic injury would be expected. Many unstable fractures of the thoracic spine occur from isolated direct blows.
CASE REPORT

This patient suffered an upper thoracic and left hand injury while involved in a high speed auto racing accident on 5–30–88. He remained in intensive care for two days. Injuries included a fractured ulna, median nerve damage, three fractured ribs, two fractured spinous processes, three fractured transverse processes, a brain concussion, and a compression fracture at T5 (Fig. 12.23). The attending orthopedic surgeons recommended Harrington rod surgery. The patient denied medical treatment and elected to undergo chiropractic evaluation and treatment for the spinal injuries. He was transported in a sling-type bed in a van and survived the 12 hour drive to a chiropractic care facility. After a thorough evaluation, treatment began. Since the patient was not ambulatory, several individuals had to logroll him so that the upper thoracic spine and neck remained in a neutral position when he was moved to the adjusting table. At first, treatments were rendered using the knee-chest table. After 1½ weeks the T5 segment was adjusted in the seated position. Four months after the accident, the patient, a chiropractor, was adjusting a limited number of patients. The patient was virtually pain-free approximately 18 months after the accident. He is regularly adjusted at two week intervals.

CASE REPORT

This 10-yr-old female was involved in an automobile accident on 11–12–89. On 11–24–89 she presented for chiropractic evaluation and treatment with complaints of difficulty in breathing, interscapular and lower thoracic pain, and left anterior costal pain. The radiograph (Fig. 12.24) demonstrates compression fractures at T7 and T8. The patient was adjusted 12 times over a five month period at the sacrum (8X), T9 (4X), T4 (4X), C7 (1X) and C1 (3X). Two weeks after beginning chiropractic care, the patient reported no symptomatology.

CASE REPORT

This 85-yr-old male presented for chiropractic evaluation and treatment one week after thoracic spine trauma. He suffered a compression fracture of T8 (Fig. 12.25). Following a comprehensive assessment, the patient was adjusted. Over the course of several months the patient was adjusted at T9 (9X), T8 (1X), T12 (1X) and T10 (1X). Initially, a double thumb lamina contact was used. Breathing and thoracic pain improved. The patient continues to experience intermittent pain when lifting.

THORACOLUMBAR COMPRESSION FRACTURES

Most thoracic and lumbar fractures occur at the thoracolumbar junction. Approximately 60% are found between T12 and L2 and as many as 90% occur between T11 and L4 (1). The first lumbar is the most common level of involvement (1).

Several anatomical and functional factors contribute to the high incidence of fractures in this area: 1) the transition of facet orientation from thoracic coronal to lumbar.
bar sagittal, 2) the change from the thoracic kyphosis to the lumbar lordosis, 3) absence of thoracic costal stabilization in the lumbar spine, 4) increased range of lumbar motion compared to thoracic motion which is limited by costal attachments, and 5) the presence of mortise type joints which may increase susceptibility to fracture in this region by increasing the stiffness of the motion segment (3,15).

Compression or wedge fractures account for 48% of all fractures in the thoracic and lumbar spine (15,16). The MIV is hyperflexion with the center of rotation occurring at the center of the disc (15). Combined $+\theta X$ and $-Y$ forces on the anterior of the vertebral body cause failure. Since the posterior vertebral body elements, as well as the posterior ligamentous structures are usually unaffected, the typical thoracolumbar compression fracture is stable and exhibits minimal to moderate neurologic injury.

The compression fracture is best visualized on the lateral view, its primary radiographic finding being the wedge deformity, which is a decrease in anterior vertebral body height while the posterior body height remains unchanged. This leaves the vertebral body with a triangular shape. The "step defect" is another radiograph finding of the compression fracture (7). This finding can be seen on the lateral view as a sharp disruption in the anterior superior aspect of the vertebral body. As $-Y$ forces compress the anterior surface of the vertebral body, a piece of bone is forced anteriorly leaving a step in the normally smooth bony contour. In minor fractures with less than 30% loss of body height, the step defect may be the only radiographic finding.

A white line may also be seen in the superior section of the vertebral body running parallel to the vertebral end-plate. This radiopaque line represents a recalcification healing of the fracture. As healing progresses past two months, this line decreases and eventually disappears (1,7). The healing process of recalcification also occurs in the step defect as time progresses. The step usually becomes smoother and less clearly delineated within two to three months (7). These two findings can help determine if the lesion is acute or healed, which can be very useful, especially in the geriatric patient, who may present with several fractures.

Forces that are predominantly $-Y$ in direction with little flexion ($+\theta X$), may lead to end-plate fractures (3). This fracture is often difficult to view on plain films but can be readily seen with tomography. End-plate fractures are the most common pathologic finding on lumbar dissection (17).

Although thoracolumbar compression fractures are not commonly associated with severe neurologic damage, some acute transient or chronic neurologic symptoms may occur. Abdominal ileus, or paralytic ileus is a loss of bowel function due to injury to the spine and irritation of the visceral (autonomic) nerve plexus and ganglia. This is
usually transient and self resolving. Abdominal ileus is seen radiographically as excessive amounts of gas pockets in a slightly extended gastric lumen.

Clinical signs and symptoms can alert the practitioner to the possible existence of a thoracolumbar fracture, especially if there is a history of hyperflexion injury. The patient often complains of pain referred by the cluneal nerve to the iliac crests. Palpation of the paraspinal musculature, as well as spinous percussion with a hammer, should elicit pain. The presence of a gibbus formation is a strong indication of a compression fracture.

Computed tomography is usually not helpful in evaluating compression fractures since the axial view parallels the fracture line. Sagittal reconstruction is needed to identify the lesion. Greater than 50% loss of anterior vertebral body height is considered unstable due to the fact that it is often associated with posterior column ligamentous damage.

If the compressive forces (−Y) are of sufficient magnitude and there is less of a flexion bending moment, a burst fracture can occur (Fig. 12.26). With this injury, bony elements may be forced into the spinal canal causing cord compression.

CASE REPORT

This 57-year-old male presented to a chiropractic office with complaints after a lifting injury. The patient stated that he was lifting heavy pipes (approx. 100 lbs) when a sharp pain developed in the right lower portion of the back. After the injury, the patient was referred by his employer to a hospital where plain radiographs were performed. The patient was diagnosed as having a lumbar sprain and was prescribed muscle relaxant medication. The radiographs taken at this time (Fig. 12.27) clearly indicate a compression fracture at T12 which was not present on radiographs performed one year previously (Fig. 12.28). Clinically, thoracolumbar compression fractures may be missed, if a thorough examination is not performed. The patient then chose to seek chiropractic evaluation from the same physician who had successfully treated him for a cervical condition approximately one

Figure 12.26. A, Burst fracture of T12. B, CT scan of patient in A.
year previous. Three days after the lifting injury the patient underwent examination. He presented with an antalgic forward lean. Anteroposterior and lateral full spine radiographs and clinical examinations were performed. A diagnosis was made of an acute compression fracture of T12 with associated neuritis and muscle spasm (Fig. 12.29). The patient was treated with an adjustment at the involved spinal level (T12). A double thenar contact was made on both transverse processes, very close to the spinous process. Because of the acute pain present on the spinous process, this contact point was avoided for the first few treatments. A hi-lo table was used for the adjustment and a very light pressure was made with attention to the patient’s tolerance for the procedure. Over the next 10 days the patient was treated seven times. Gradually the force of the adjustment was increased and audible releases were heard after each treatment. The patient maintained employment during the treatment regimen and made moderate symptomatic improvement over the first week of care. Follow-up examinations were not obtained because the patient moved out of state.

**ANTEROLATERAL COMPRESSION FRACTURES OF THE THORACOLUMBAR SPINE**

Four patients involved in front-end collision auto accidents exhibited the same thoracolumbar wedge compression fracture accompanied by distraction trauma (18). All four were wearing a lap seat belt with shoulder harness and they sustained the wedge fracture in the anterior column on the side of the unrestrained shoulder, and the accompanying distraction injury occurred at the contralateral posterior column.

Biomechanical studies with cadavers using flexion-rotation about a shoulder harness exhibited the exact same fracture with distraction, leading to the conclusion.
that flexion-rotation is the mechanism of injury (18) (Fig. 12.30). Although none of the four patients in the study by Miniacci experienced any associated major injuries, due to the fact that both the anterior column and the contralateral posterior column were damaged, this injury must be considered unstable (18). In all four cases there was no neurologic deficit and all four fractures had healed at two years follow-up.

Figure 12.30. MIV for anterolateral compression fractures.

CASE REPORT

This patient suffered a compression fracture of the eleventh thoracic vertebra during a snowmobile accident (2) (Fig. 12.31A-B). No surgery was performed at this time. Upon presentation to an outpatient chiropractic facility, approximately three months after the initial trauma, the patient was paraplegic and confined to a wheelchair.

The right transverse process of T11 was contacted for the adjustment. The patient was prone for the maneuver (hi-lo table). The adjustment incorporated both +Z and +θZ patterns of thrust. During the course of treatment an L5 retrolisthesis was also adjusted. This maneuver was performed in the side posture position while avoiding axial rotation of the thoracolumbar junction. During this adjustment it was necessary to have an assistant stabilize the legs. The patient was periodically adjusted (1x/month) over the next two years. During this time the patient underwent extensive physical therapy. He was eventually able to ambulate, although with some difficulty.

THORACOLUMBAR FRACTURE-DISLOCATIONS

Most fracture-dislocations of the lumbar spine occur at the thoracolumbar junction area (7). A forced hyperflex-
ion $\theta X$ injury is usually the MIV, but forced rotation $\pm \theta Y$ and forced lateral flexion $\pm \theta Z$ are often associated (3). Due to the high strength of both bony and supportive soft tissues in the thoracic and lumbar spine, extreme multidirectional forces, from high speed auto accidents, high falls, or direct blows, are usually needed to produce the injury (3).

Anterior motion segment injuries include compression fractures, teardrop fractures and disk injuries. They are often coupled with posterior column distraction fractures, soft tissue tears, and dislocations. Middle column fracture and ligamentous injury can also occur.

Neurologic damage from compression of both the spinal cord and nerve roots may lead to permanent paralysis. These fracture dislocations can be well visualized on both AP and lateral radiographs. If there is a history of a hyperflexion injury which demonstrates vertebral body compression on the lateral view, the posterior bony elements should always be closely scrutinized to evaluate for fracture or dislocation which can complicate the treatment and final outcome of this injury. Since a fracture dislocation always involves damage to all three columns, the injury is considered unstable.

CASE REPORT

This 45-yr-old female suffered a fracture dislocation injury at L1 in October, 1977 (Fig. 12.32A-B). At the time of chiropractic evaluation (several months later), she had lower body paralysis and no bowel or bladder control. The patient was adjusted three times per week for three months, twice weekly for two months and once weekly for six months. After this, the patient was adjusted on an as needed basis for approximately one year. She was fitted with a back support (warm & form) after the first three months of care. The primary segment adjusted was L2 (hi-lo table), although C1, C6, T4, L5 and the right ilium were treated at various times. She regained bowel and bladder function after the fourth month of care. Her lower limb paralysis continues.

FRACTURES OF THE LUMBAR SPINE

Burst Fractures of the Fifth Lumbar Vertebra

There is an extremely low number of reported cases of burst fractures of the fifth lumbar vertebra. Court-Brown and Gertzbein (19) report a three case study of this fracture. In each of their examples there was a reduction in the original height of L5 by at least 60%. All three cases exhibited a loss of lordosis between L4 and the sacrum, and spinal compromise ranging from 70–85%. Two of the examples demonstrated posterior displacement of fracture fragments. One of the fractures was treated surgically with internal spinal instrumentation, and the other two were treated more conservatively with spinal bracing and bed rest. The surgical patient experienced complications of pseudarthrosis and persistent low back pain necessitating a second surgical procedure in which the instrumentation was removed. Despite two operations, only the surgical patient continued to suffer pain at two years follow-up. He also experienced the greatest loss of lordosis between L4 and the sacrum. Court-Brown and Gertzbein suggest conservative treatment of lumbar support and bed rest for many of these patients.

LAP SEAT BELT FRACTURES

The lap seat belt fracture, also called a Chance fracture, is a hyperflexion (+$\theta X$) injury with the center of rotation anterior to the body of the vertebra (15) (Fig. 12.33). Since the center of rotation is anterior to that of a pure compression fracture, there is much greater tension put on the
posterior bony elements. As the spinous processes separate to their physiologic limits, the bone often fails before the posterior ligamentous structures, creating longitudinal fractures through the spinous process, posterior arch, the pedicles and often into the posterior aspects of the vertebral body itself (Fig. 12.34). The anterior portion of the vertebral body may suffer mild compression type fractures as well. Although bone usually fails before the ligamentous structures, severe soft tissue injuries of the posterior ligaments, the posterior longitudinal ligament, and the disc itself are often associated with this injury due to the extreme tensile forces involved.

Standard plain film lateral radiographs may show fractures in the spinous, lamina, pedicles, and posterior portion of the vertebral body. Since there is often soft tissue injury as well as spaying of spinous processes, an abnormally increased posterior disc height is often visualized (7).

AP and lateral tomography can clearly demonstrate the fracture lines in a Chance fracture which are often poorly visualized in the axial view of CT. However, the reconstructed sagittal view of the CT scan can be quite helpful in visualizing and evaluating these horizontal fracture lines (15). The CT scan can also be useful in evaluating an associated burst fracture. In a group of Chance fractures described by Gertzbein (20), 70% had an accompanying vertebral body compression fracture. Fifteen percent had burst fractures and 15% had no vertebral body fracture. High force deceleration can cause the burst fracture due to increased \(-Y\) forces, while low velocity can lead to the posterior distraction \(+(\theta X)\) injury. Because the center of rotation is more anterior, it causes posterior element soft tissue damage combined with posterior body fracture.

Flexion distraction type injuries are extremely uncommon in children due to their greater flexibility. However, with the use of lap seat belts, the major focus of flexion with posterior element distraction is placed on the lumbar vertebrae at the level of the seat belt. With the belt functioning like a fulcrum, the forced flexion is concentrated in one spinal area as opposed to being dissipated over a greater area, thereby increasing the likelihood of damage (21).

Since the introduction of the lap seat belt, in the 1950s and 60s, the Chance fracture has occurred much more frequently (7). Approximately 50% of Chance fracture cases have associated intra-abdominal injuries (20).

The Chance fracture may or may not heal and return to being a stable motion segment. This is dependent on the tissues that are injured. A purely bony injury is most likely to heal. An injury with posterior supportive ligament or disc damage may never return to a stable situation. Regarding associated vertebral body fracture, the compression injury is much more likely to regain stability than the burst fracture (20). Neurologic deficit occurs in 15% of all Chance fracture cases and the upper lumbar spine, especially L1-L3, is the most frequent site of occurrence (7).

**CASE REPORT**

This 29-yr-old female presented on 3–21–88, one day after a motor vehicle accident. A full spine radiologic examination disclosed a traumatic spondylolisthesis at L4 (Fig. 12.35). The MIV for this injury is \(+\theta X\) with the center of rotation anterior to the vertebral body.

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**Figure 12.33.** MIV for the Chance fracture. Modified from Kaye JJ, Nance EP. Thoracic and lumbar spine trauma. Radiol Clin North Am 1990;28:375.


**Figure 12.35.** Traumatic spondylolisthesis of L4.
She was treated twenty-four times over a thirteen month course. Adjustments were performed at L5 (5X), sacrum (9X), the left ASIn (3X), T7 (5X), C7 (3X) and C2 (15X), in the prone, side posture, and cervical chair positions, without complication.

Initial symptoms included low back pain which radiated down the right leg, neck pain and headache. At one year follow-up, the patient reported no low back or leg pain. Psychological stress provoked occasional headaches. Since the injury, she has had two uncomplicated pregnancies.

TRANSVERSE PROCESS FRACTURES

Transverse process fractures of the lumbar spine usually occur from excessive lateral flexion coupled with a hyperextension injury. The break usually occurs at L2 and L3 and is the second most frequently occurring lumbar fracture (7). It is often found at more than one level. Fifth lumbar transverse process fractures commonly accompany pelvic fractures, such as the vertical sacral type.

Radiographically, transverse fractures appear as radiolucent lines that usually run vertically or obliquely (Fig. 12.36A-B). When, on occasion, they traverse horizontally, a Chance fracture should be suspected. The transverse fracture can be differentiated from developmental nonunion by evidence of the fracture’s jagged irregular border and fracture line. A urinalysis and kidney exam should be performed since renal damage may be found concurrently with transverse process fractures (7). Transverse process fractures are usually stable unless accompanied by other fractures or ligamentous damage.

LATERAL WEDGE FRACTURES

The lateral wedge fracture is very similar to the compression fracture but the \(-Y\) force is directed lateral to the center, creating a \(\pm 0Z\) bending moment along with the \(+\theta X\) injury vector (Fig. 12.37). The \(Z\) axis bending injury with vertebral body collapse to one side, can also create damage to the articular pillar and facet, the pedicle and lamina on the concavity of bend, as well as an avulsion fracture of the transverse process on the convexity (3).

Since the lateral wedge injury creates a greater amount of avulsion force to the soft tissue than does the simple anterior wedge fracture, the degree of permanent pain is also greater. Nicoll (22) states that in comparing the two injuries, there was total recovery in only 21% of lateral wedge fractures, while 40% of those with anterior wedge fractures completely recovered.

LUMBAR COMPRESSION FRACTURES

Lumbar compression fractures involve primarily a \(-Y\) translational vector combined with flexion \((+\theta X)\). Most of these injuries are stable since only the anterior column is involved. As with other compression fractures, they are best visualized with the lateral radiograph.

CASE REPORT

This male patient was asleep in the back seat, when the vehicle he was traveling in was involved in a head-on col-
lision (2). Of the five passengers in the vehicle, he was the sole survivor. He sustained a compression fracture of the fourth lumbar vertebra (Fig. 12.38A-B). The patient had a course of medical treatment (medication) and physical therapy for his complaints at the time. He then presented for chiropractic evaluation with a complaint of severe low back pain and difficulty in ambulation, nearly six years following the initial trauma.

After examination, he was adjusted in the side posture position to reduce the retrolisthesis at L4 (PR-m). Two adjustments were given over the course of two days and one adjustment was administered four months later. The patient’s lower back pain resolved and he subsequently became employed as an airline pilot.

CASE REPORT

This 18-yr-old female patient suffered a car accident in 1973 in which the third lumbar vertebra compressed (2) (Fig. 12.39A-B). She subsequently developed secondary

![Figure 12.38](image)


![Figure 12.39](image)

A, Lateral radiograph demonstrating a L3 compression fracture with retrolisthesis. B, AP radiograph depicting a wedge deformity at the fracture site.
amenorrhea. In 1984 she presented for chiropractic evaluation after a fall from a horse. Her symptoms consisted primarily of low back pain and secondary amenorrhea of eleven years duration. Adjustments of the L5, C7, and T3 vertebrae were performed nine times over the next eight months. The lumbar spine was adjusted in the side posture position by using a push move which emphasized reduction of the retrolisthesis. The seventh cervical was adjusted in the seated position and T3 was adjusted in the prone position. In February of 1985 she returned to the same clinic with a complaint of headaches. The third lumbar, T3 and C7 vertebrae were adjusted four times over the next month. The patient began menstruating during this time and became pregnant after three regular menses.

CASE REPORT

This 69-yr-old farmer fell from a roof on 11–28–89 and suffered a burst fracture of L3 and a compression fracture of L2 with cauda equina injury. Internal fixation was performed on 12–11–89. The patient presented for chiropractic evaluation on 4–29–91. Radiologic examination disclosed positional dyskinesia of the left ilium (PIIn) and L5 (PR-m). The internal fixation is demonstrated in Figure 12.40A-B. The patient received fourteen treatments. Initial symptoms of right foot numbness did not completely resolve. The patient reported improvement in bowel and bladder function (near normal). Intermittent rectal pain still occurs after riding farm equipment for long periods.

LUMBAR NEURAL ARCH FRACTURE

Lumbar neural arch fractures occur posterior to the posterior longitudinal ligament (3). These fractures can be caused by hyperextension $-\theta X$ or from flexion $+\theta X$ coupled with axial rotation $\pm \theta Y$. Due to the sagittal position of lumbar facets, rotation is very limited. If they are forced beyond normal physiologic limits (less than 3 degrees at one segment), the facets will be damaged and the posterior elements such as the pars interarticularis or lamina will fracture (3).

Pars interarticularis fractures can also be caused by severe hyperextension. Although uncommon, when they

Figure 12.40. A, Lateral radiograph demonstrating the internal fixation. B, AP radiograph demonstrating the bilateral internal instrumentation.
do occur, these fractures are usually at L4 or L5 and are most often unilateral. This acute traumatic fracture is not the same as the stress fracture associated with isthmic spondylolisthesis (7). The latter, which is usually bilateral, remains persistently displaced and does not typically undergo bony union (23). The unilateral acute pars interarticularis fracture often reunites (7).

**PELVIC RING INJURIES**

The pelvic ring is comprised of the sacrum and ischium in the posterior, the iliums laterally, and the pubic bones at the anterior. In cases of high force trauma with a magnitude great enough to cause a fracture, the pelvic ring usually breaks in more than one place. When a fracture is
suspected or visualized on a radiograph, the entire pelvis should be scrutinized closely to rule out other fractures or dislocations in the sacroiliac joints or symphysis pubis.

Soft tissue injuries occur with pelvic injuries and can create an even more traumatic situation. Patients with pelvic injuries should be evaluated for the following complications: rupture of the diaphragm as evidenced by a chest x-ray, laceration or obstruction of the rectum, laceration or complete rupture of the urethra, bladder and ureters signaled by bruising in the perineum, retention of urine and fresh blood at the tip of the urethra, and laceration of the blood vessels causing hemorrhage. This is indicated by ecchymosis of the scrotum, inguinal area and buttocks (7). Acute injuries of the pelvic ring should undergo computed tomographic examination (24).

Classification

Many attempts at a logical and helpful classification of pelvic fractures have met with little success. Since most classifications are not based on mechanisms of injury, they provide the practitioner with little information regarding proper treatment protocols, accompanying soft tissue injury and prognosis.

Pennal and associates (25) developed a classification system that provides the necessary mechanistic perspective, hence aiding in treatment protocol and prognosis. Three common MIVs for pelvic fractures have been identified. They include lateral compressive (LC), anterior-posterior compressive (APC) and vertical shear (VS) forces. These mechanisms of injury are found alone or in combinations. The mechanisms are further classified according to severity (I–III), based in large part on radiographic findings (26).

LC

Lateral compressive forces (LC) cause the ipsilateral side of the pelvis to implode. This causes injury to both the anterior and posterior aspects of the pelvic ring. Anterior damage to the pubic ramus is pathognomonic of this injury and may be seen with or without symphysis pubis injury. One or both rami are fractured in a transverse direction. These fractures are best visualized with the inlet view and although the anterior component does not directly determine weight bearing capability, radiographic findings of injury here, are of help in determining mechanism(s) of injury, treatment protocol and prognosis.

LC-I

This is the most common and stable injury of the LC group. It is characterized by vertical sacral compaction (posterior injury) and a transverse rami fracture. The inlet view will often reveal a discontinuity of the sacral fora-
Figure 12.42. A, Pretreatment AP radiograph (5–7–84). Notice the separation of the symphysis pubis and widening of the left sacroiliac joint. The patient had difficulty bearing weight for this radiograph. B, Pretreatment lateral radiograph demonstrating a sacral fracture. C, Posttreatment radiograph (5–31–84) in which the patient is able to bear weight. Note that a 9-mm leg length inequality is now apparent.

due to the knees impacting the dashboard of the automobile. At the time of chiropractic evaluation the patient could not bear weight and used crutches to aid ambulation. The patient’s medical doctor did not advise surgery and stated that she would require crutches for ambulation indefinitely. The patient was adjusted in the side posture position (left ASIn) three times over a three week period. After the first adjustment, the patient was able to ambulate unaided (Fig. 12.42C).

APC-II

This injury is characterized by damage to the anterior sacroiliac ligaments with widening of the joint space and symphysis pubis diastasis. The inlet view is used to diagnose the displacement. The sacrotuberous and sacrospinous ligaments are usually torn or there is an avulsion at their bony insertions on the ischial spine or sacral border. This class of injury may be seen bilaterally, depending on the specific injury contact and MIV. The pelvic ring is unstable in certain directions. Internal rotation of the ASIS will be excessively mobile and external rotation may be mobile if the fracture has spontaneously reduced. The severe force needed to create the open-book injury of an APC-II usually causes significant neural and vascular injury.

APC-III

APC-III injuries are the most unstable and severe of the pelvic fractures. A large force is needed to tear the anterior sacroiliac ligaments as seen in the APC-II. This injury causes further internal rotation of the PSIS to the point where the posterior sacroiliac ligaments are also compro-
mised, leaving the hemipelvis totally disconnected from the sacrum. The injury is associated with the greatest amount of vascular damage, blood loss, and mortality.

VS

Vertical shear forces (VS) from above (−Y) and more commonly from below (+Y), cause the hemipelvis to separate at the symphysis pubis anteriorly and the SI joint, iliac wing or sacrum, posteriorly. This leaves the hemipelvis in a superior or inferiorly displaced position according to the direction of impact. The sacrospinous and sacrotuberous ligaments are usually severed. Common injury scenarios include landing on the feet from high falls and motor vehicle or cycling accidents. The −Y displacements are often caused by crushing injuries from building and tunnel cave-ins. Due to the associated neurovascular damage, VS injuries can be life threatening. These fractures are best visualized with the AP or outlet views.

CM

Combined mechanical (CM) groups of injuries are due to obliquely directed forces or from multiple impacts from varying directions. After separating the components of the MIV, the practitioner must determine appropriate treatment for the soft tissue injuries and arrive at a prognosis.

AVULSION FRACTURES OF THE ILIUM

Avulsion fractures of the ilium involve separation of a fragment from the bone. They are common in young ath-
letes who have yet to experience fusion of the involved growth center. Sprinters, long jumpers, gymnasts, hurdlers and cheerleaders are particularly prone to the fractures, due to the frequent and stressful flexing motion required (7).

There are two types of avulsion fractures of the ilium, anteroinferior iliac spine (AIIS) and anterosuperior iliac spine (ASIS). The former is avulsion by the sartorius muscle and can be ameliorated with hip flexion. The latter is avulsion by the rectus femoris muscle. Hip flexion usually causes great pain (7).

SACRAL CLASSIFICATION

Denis et al. (27) have devised a new classification for sacral fractures. Three zones are identified according to the level, location, and direction of the sacral fracture. Zone I involves the region of the ala, the area of the sacrum lateral to the foramina line. These alar fractures may include lateral compression fractures which cause minimal displacements, or open-book fractures where the displacement is severe. Neurologic damage is rare in a zone one injury except when the L5 root or the sciatic nerve is compromised.

Zone 2 fractures must include one or more foramina. Neurologic involvement is more frequently seen in fractures of this area. Sciatica is the most common complication, with bowel and bladder dysfunction occurring rarely.

Zone III fractures involve the region of the central sacral canal and are most often associated with neurologic deficits. Bowel, bladder, and sexual functions are most frequently compromised by Zone III fractures. Computed tomography scans are essential in evaluating the nature and extent of fractures of the pelvic ring (27).

SACRAL FRACTURES

Fractures in the sacrum occur in one of two ways, either horizontally or vertically. Horizontal sacral fractures are usually a result of a fall on the buttocks from great heights, as in suicide attempts. This fracture is sometimes referred to as the “suicidal jumper’s” fracture. This is the most common type of sacral fracture and usually affects the third and fourth sacral tubercle toward the end of the sacroiliac joint.

Horizontal fractures are best visualized on the lateral radiograph although they may be difficult to detect if air or fecal matter blocks the fracture site. A displacement or angling forward of the lower segment of the sacrum is often seen. This is the best radiographic indication of the injury. All horizontal fractures are considered zone three, since they pass through this zone.

Vertical sacral fractures can be visualized on an AP radiograph. The fracture lines generally run the entire length of the sacrum. As sacral fractures do not usually occur in isolation, the doctor should search carefully for associated fractures or dislocations of the pelvic ring or symphysis pubis (7).

LUMBOPELVIC FRACTURES

Generally, a combination of both anterior and posterior fractures constitute a pelvic ring injury (24). The anterior component could manifest as a pubic ramus fracture or pubic symphysis dislocation. The posterior lesion most frequently involves a fracture of the sacrum. These sacral fractures range from minimal compression fractures that remain stable to displaced fractures that may be extremely unstable. The first and second sacral foramina are the areas most commonly involved in pelvic ring fractures. The boundaries of the fracture include the articular process of the sacroiliac joint as a proximal landmark, through the free border of the sacrum as the distal landmark.

The lumbosacral junction is not jeopardized if the fracture boundary is lateral to the articular process of the sacroiliac joint. However, if the fracture is medial to the articular process of the sacrum, the lumbosacral junction will be damaged.

In a study of pelvic ring fractures and lumbosacral injuries, in which there was only partial posterior instability, Isler (24) found it very difficult to evaluate using routine radiologic examination. The author suggests that computerized tomography would considerably increase the number of diagnosed lumbosacral fractures. While unstable fractures can be easily diagnosed by conventional radiographs of the pelvis, computerized tomography provides detailed information concerning the range of soft and hard tissue injury. Since a locked L5/S1 facet joint dislocation prevents the reduction of a displaced sacral fracture, it is particularly important to properly visualize and diagnose lumbosacral injuries. Also, lumbosacral pain that remains chronic after pelvic ring injuries have healed can be traced to degeneration of the lumbar sacral facet joints due to trauma from the original injury. It is estimated that 6% of the population in this study had a lumbosacral lesion in conjunction with the pelvic ring injury.

There are three major types of lumbosacral injuries associated with pelvic ring injuries: 1) articular lumbosacral injuries which may manifest as joint subluxation, fractures, dislocations, and complete locked dislocations; 2) extra-articular fractures where the lumbosacral posterior articulation remains intact, but there is a fracture either at the base of the L5 laminar pillar junction, or at the base of the L5 or S1 articular pillar; 3) complex injuries with multiple fractures of L5.

CHIROPRACTIC TREATMENT PROTOCOLS

Although the evaluation and treatment protocol for spinal fractures and dislocations is necessarily vague and
extremely case dependent, certain basic practice guidelines must be followed to ensure the patient receives the most appropriate care (e.g., medical, chiropractic). A comprehensive investigation including a careful history, physical examination, plain film and any necessary advanced imaging examination, should be undertaken to arrive at an accurate assessment of the patient’s condition. The clinician must then make certain clinical judgments based on this information. Many factors influence the clinician’s decisions, including past experience with similar cases and knowledge of the clinical biomechanics and associated soft tissue injuries. The risks of the procedure should always be discussed with the patient and informed consent obtained. Extreme care should be taken in determining whether a patient is a candidate for chiropractic care. A cautious approach is advised since little data on clinical outcomes have been reported with closed reduction methods. Denying appropriate surgical treatment is not in the patient’s best interest (28).

Whereas fixation dysfunction is the primary biomechanical factor for deciding the locus of an adjustment in nonfracture cases, misalignment of the segment or fracture displacement are the determining variables for fracture patients.

Examination

The patient must first be evaluated to determine if there are any abnormal vital signs which would necessitate immediate emergency room referral. This is true for the initial presentation as well as anytime during the course of care. If the vital signs are determined to be stable, then an evaluation is necessary to determine neurologic stability. Any neurologic instability (e.g., cauda equina) requires emergency room referral. Deterioration in neurologic status at anytime necessitates reevaluation and/or expert consultation and possible referral.

Classification

Patients may present at anytime during the course of recovery. The doctor should be familiar with acute, subacute and chronic presentations to manage the case effectively.

ACUTE

Emphasis should be on determining vital signs and indications for emergency room referral. Acute injuries require a comprehensive assessment to determine the patient’s condition accurately. In many cases, advanced imaging such as MRI or CT and electrodiagnostic evaluation will be beneficial. All neurologically unstable patients require further evaluation and possibly referral. The patient will require stabilization when transport is made to the emergency room. Although there are reported cases of successful management of acute patients (2) no clear protocols have appeared in the literature.

SUBACUTE

The major determination should be to determine the stability of the vital signs, and the vascular and neurologic systems. The examination must be comprehensive (i.e., plain films (neutral and dynamic), and CT or MRI, if necessary). As in all cases of spinal fractures and dislocations, care must be case specific. Unstable injuries will often require surgical referral.

CHRONIC

These patients will usually have stable vital signs. Determination should be made if the fracture is biomechanically or neurologically unstable. If earlier plain films are available, then these should be obtained to compare with the most recent evaluations. This assessment is often helpful to determine if a progressive biomechanical instability is present.

PREVENTION

Since spinal fractures and dislocations are often devastating to an individual and costly to society, all efforts must be made to not only effectively treat them but to maximize efforts to prevent their occurrence and minimize their damaging effects. It has been estimated that the approximate cost to society for each new cervical spine injury with spinal cord involvement is $400,000 (10). There are approximately 10,000 new cases of spinal cord injury each year in the U.S. The total cost to society, therefore, is approximately $4 billion annually (10).

Spinal injuries may occur from so many different (unusual) situations (i.e., freak falls, being struck by falling objects and other accidents), that their prevention may be difficult or impossible to affect, but efforts can be made to minimize the frequency and damage of some more commonly occurring causes of spinal fractures and dislocations.

Public education aimed at both the prevention and emergency care of spinal injury victims can reduce the incidence of mortality and morbidity. Early instruction of the importance of spinal hygiene promotes increased spinal awareness and if properly applied, will increase both spinal strength and the ability of the spine to adapt under extreme loading conditions. The sagittal curves, symmetrical weight-bearing, normal mobility and proper postural positioning (29), increase the ability of the spine to yield, within normal physiologic boundaries, under high stresses and therefore limit residual effects.

During an impact injury, the body’s position will determine the type and extent of tissue damage. In most instances, the anatomical position provides the highest degree of protection.
Motor vehicle accidents have greatly increased the occurrence and severity of many types of spinal fractures. Before the use of seat belts, unrestrained movements in the vehicle were common. Lap seat belts are responsible for reducing the instances of mortality in auto accidents which might otherwise occur from collisions with the dashboard, windshield, or other part of the interior (18). Lap seat belts provide some degree of body restraint, however, since this restraint is focused at one region of the body, a wide range of other injuries may occur (See Lap Seat Belt Fractures). These injuries include acceleration/deceleration injuries of the head and neck, head impacts with the steering wheel or dashboard or Chance fractures.

In an effort to decrease head impact, whiplash, Chance fractures and other spinal flexion injuries, shoulder harness restraints have been developed. These provide further support for the torso, but they can cause other injuries as a result of the forces pushing against the restraint. While one shoulder is restrained on impact, the other is thrown forward. In what is known as the “roll-out phenomenon,” the upper trunk, neck and head “roll-out” from behind the restraint causing severe axial rotational stresses (18). To avoid damage from the roll-out phenomenon, a double shoulder harness seatbelt is currently in use in race cars. This type of restraint should be a standard feature in conventional automobiles.

The development of the air bag is one effort to decrease the bodily damage caused by automobile collisions. There are also other devices which can further decrease the likelihood of spinal injuries.

The properly positioned headrest decreases hyperextension injuries to the cervical spine. Headrests that are too short, provide a fulcrum for the cervical spine to hyperextend over, thus increasing injury to the soft and hard tissues (3).

Seats that provide support, while not reversing the lumbar lordosis nor exaggerating pressures onto the lumbar spine, help to keep the spine at its maximal strength position. This increases stability and decreases spinal injuries (3). Unfortunately the head and neck remain unprotected from many impacts, especially those from the side or front. Since these safety innovations are effective in reducing spinal injuries during motor vehicle accidents, it is imperative that manufacturers incorporate them and continue to develop new safety devices. It is equally critical that consumer education be advanced to increase utilization.

Many spinal fractures occur during athletics and recreation. Contact sports such as football and hockey create enough body impact for spinal injuries to occur. Proper protective gear must be used to minimize severe injuries. In football, the use of neck rolls, college style shoulder pads, and face masks that extend to or below the chin, can limit the amount of cervical motion and therefore decrease hyperflexion, extension and lateral flexion injuries. However, many athletes attempt to increase their mobility and thus opt for one or two bar masks, no neck rolls or less padding. As participants in contact sports become younger and younger, it is critical that they be maximally protected. This is especially important, since the young usually have increased spinal flexibility, thus risking injury to the spinal cord and nerve roots.

Diving, snowmobile riding, bicycling, horseback riding, skiing and other sports where high speeds or physical inertia is a factor, increase the potential for spinal fractures. The risks should be evaluated before participation is considered.

Only slight variations in postural position can dramatically affect stability and the occurrence, degree and type of fracture which occurs. Since biomechanical abnormalities will decrease spinal strength and increase the chance of injury, all competitive athletes, especially those in scholastic settings, should be properly screened for potential instability syndromes by professionals who specialize in spinal biomechanics.

Continued development of safety technology, accident prevention and educational programs, along with advances in the management of spinal fractures and dislocations when they do occur, should provide promising options for reducing the devastation caused by these injuries. The philosophical and political chasm between chiropractic and medicine has been ongoing. Cooperation between these two branches of the health care delivery system, in the area of spinal trauma, may greatly benefit society and ultimately the patients they both serve.

References

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Statistics on the percentage of visceral disorders (Type O) managed by chiropractors indicate a decline in the number of patients presenting to clinics with these complaints. In 1979, the number of patients presenting with a Type O disorder was 14%. For 1989 this number had declined to approximately 8% (1). Should this trend continue, by 1995 there will be few patients with these disorders being treated by chiropractors. This trend may be a result of a declining emphasis on visceral management by many chiropractic colleges. Recently, however, material on visceral disorders related to the spine has surfaced in the literature (2,3). If the chiropractic approach to low back pain had been abandoned early on due to the lack of research data, we would have never known its superiority to other conservative measures (4).

For the confident practitioner familiar with the management of visceral disorders, each case represents a chance to become reacquainted with the neuroanatomy and neurophysiology of the particular disease. The tasks of determining the primary levels of involvement, of adjusting them in a specific manner, and of monitoring the patient during resolution of the dysfunction become daily occurrences. The practitioner—with little clinical experience or one without a systematic approach—will find patient management to be an awkward exercise. Confidence is replaced with uncertainty and treatment becomes referral. For those who wish to take on this aspect of chiropractic practice, both challenges and rewards are plentiful.

CLINICAL OBSERVATIONS

Gonstead’s empirical work with numerous patients during 55 years in practice are the foundation of our approach to a given condition. (Doctors who followed Gonstead’s career found that he treated personally between 150 and 200 patients six and a half days per week. Gonstead worked at least 18 hours a day, usually not going to bed on the same day that he awoke. An 8-hour shift was considered half a Norwegian workday. The reception area at the Gonstead Clinic in Mt. Horeb, Wisconsin has seating for 106 patients (5).) Many have attempted to manage clinical conditions by using a theoretical approach. A treatment strategy that seems reasonable from an anatomic or physiologic standpoint may not necessarily produce favorable patient outcomes. Improvement is more likely if treatment and management are based on clinical experience or observation rather than theoretical protocols. Ultimately, the best approach will be through the accumulation of data from controlled clinical trials and descriptive case reports. Clinical trials provide more information for the practitioner, because they reveal useful or useless treatment for well-defined circumstances. The case report is important because it provides detailed information about how the patient was treated and monitored. The physiologic mechanisms involved in visceral disorders and how they may be remedied through chiropractic treatment will likely evolve as more basic science information becomes available.

HEALTH CARE TEAM

There are many disorders for which chiropractic treatment alone is not adequate. In these instances, the doctor should know with which health care professional to cooperate. If a spinal subluxation exists, then chiropractic care is indicated, provided no contraindications to treatment are present.

PROBLEM SOLVING

For each disorder there may be a variety of spinal levels which are related. The management approach should be systematic, insofar as the most likely related areas of spinal involvement are adjusted first. Adequate time for the healing process of the particular disorder is mandatory before determining the success or failure of the prescribed treatment. For example, a patient who has accumulated 40 years of dysfunction and degeneration may take years to heal or may not completely recover at all. In these situations, the practitioner must be patient and must realize his or her limitations with respect to the management of spinal related conditions. This perspective towards vi-