Biomechanical considerations of the cervical spine are extremely important due to the common occurrence of acceleration/deceleration injuries in this region. This chapter covers the cervical spine from the C2 vertebra through the C7-T1 motion segment. The cervical spine has been divided into two sections because of the uniqueness of both the upper and lower regions.

**CLINICAL ANATOMY AND BIOMECHANICS**

**Posture**

The cervical lordosis is formed primarily by the wedge shape of the intervertebral discs (1,2) (Fig. 10.1). There are several anatomic factors that determine the degree of lordosis. Hyperplastic articular pillars (3), small facet angles (4), and short pedicles (4) are important structural features that can lead to a cervical hypolordosis. Patients with hypolordotic cervical spines are more likely to develop symptoms (i.e., pain) than those without straightening (5).

The lateral radiograph of the cervical spine is appropriate for assessing the degree of curvature. During the exposure, the patient’s head should be held erect in what the patient considers to be normal upright posture. Slight flexion or extension of the head will have little effect on the cervical curve because this motion is confined primarily to the C0-C1 motion segment. Weir (6), however, found that lowering the chin one inch will create a postural hypolordosis in many patients. Patient positioning is especially critical if comparative radiography is performed (Fig. 10.2A-H). It is important that the doctor understands that the sagittal curves of the spinal column are all interdependent (7). Treatment directed at only the cervical spine will usually provide incomplete spinal care. Compensation reactions of the neck may even result from dysfunction of the lumbar spine or pelvis.

Besides specific adjustments, the doctor may wish to consider the incorporation of postural exercises as an additional therapeutic modality. These exercises usually consist of moving the head and neck into a lordotic configuration. The first step involves asking the patient to translate the head posteriorward along the Z axis. This maneuver counters the usual anterior carriage of the head which is present in patients with a kyphotic or hypolordotic cervical curve. The \(-Z\) translation should be followed with hyperextension of the head and neck. This maneuver is contraindicated if it provokes symptomatology. Patients with posterior and inferior subluxations may have difficulty with performing this exercise.

The use of a cervical pillow also may facilitate return of the lordosis (5). Ergonomic factors have a strong influence on cervical mechanics and symptomatology. Often, the work environment will require the head and neck to remain in a forward bent position for long time periods. The neck extensors will be under higher muscular loads and may fatigue in the forward bent position (8). This factor alone can create tension at the origins and insertions of the posterior neck muscles (e.g., trapezius), which then may lead to trigger points and ultimately neck pain or referred syndromes such as headache.

**Zygapophyseal Joints**

The three-joint complex comprises the two zygapophyseal joints of the functional spinal unit and the central intervertebral disc articulation. In contrast with the lumbar spine, the facet joints provide a greater contribution to the overall stability of this region. An example of the

*Figure 10.1. Normal cervical lordosis. This is a posttreatment radiograph.*
importance of the facets may be found in the work of White and Panjabi (9), who showed that after disc resection of the cervical spine, the motion segment increased its motion in flexion and extension by 33%. In contrast, the motion increased by 140% after posterior element resection.

The capsular ligaments are less taut in the cervical region when compared with the thoracic or lumbar areas. This relative laxity is a reflection of the large ranges of motion permitted in this region.

### Pattern of Motion

The *pattern of motion* can be defined as the path of movement of a vertebra while moving through its range of motion. The pattern of motion of a cervical motion segment is due to in large part to the orientation of the zygapophyseal joints. The facets are oriented at approximately a 45° angle to the horizontal (Fig. 10.3). This angle increases as one moves caudal. At C7-T1 the angle is approximately 60°. At the C2-C3 joint the angle is closer to 30°. The more horizontal the facet facings are, the more Z axis translation (anterior-posterior shear) is possible. The pattern of motion, therefore, is different at C2 compared with C7. The acuity of the arc of motion is increased in the lower cervical segments (Fig. 10.4) (See Chapter 2). Disc degeneration leads to flattening of the arc (9,10).

During flexion, the vertebra moves anterior and superior. With extension, the segment glides posterior and inferior (10). The pattern of motion illustrates biomechanical factors influencing adjustments applied to the lower cervical segments in the sagittal plane. When adjusting a subluxation involving an articulation fixed in extension, it is necessary to accentuate the component of “lift” of the spinous process (+θX) to move the segment toward a flexed position. The cervical adjustment has often been characterized as an “extension” adjustment. This type of adjustment is, in fact, a flexion adjustment,

![Figure 10.3. Facet planes of a midcervical vertebra.](image)

![Figure 10.4. Pattern of motion of C2, C4 and C7 during flexion/extension motion. Notice the increased arc at C7, which must be taken into account during an adjustment at this level.](image)
with the primary vectors applied in the $+\theta X$ and $+Z$ directions.

When movements are analyzed with stress radiography, it is important to consider the intraregional differences of movement of the lower cervical spine. Normally coupled with $+\theta X$ motion during flexion is a very slight $+Z$ translation (See Chapter 5). This movement amounts to 1 or 2 mm when using a film focal distance of 72 inches. Similarly, a slight $-Z$ translation accompanies extension or $-\theta X$ motion. Normal translation varies from individual to individual. However, an isolated posteriorward translation of C5 during extension in the presence of surrounding motion segments displaying no translation may be considered abnormal.

The angle of the facet joints necessitates coupled axial rotation (Y axis) and slight flexion (X axis) during lateral bending. Because the facet joints resemble those of the thoracic spine at C7-T1 (coronal plane), very little coupled axial rotation is present. At the C2-C3 level there is normally $2^\circ$ of axial rotation for every $3^\circ$ of lateral flexion (9). This coupling gradually decreases as one moves caudally. At the C7-T1 articulation there is only 1 degree of axial rotation for 7.5° of lateral bend. It is important to know these regional variations to assess fixation dysfunction or hypermobility of the cervical spine accurately during lateral flexion stress radiography.

**Intervertebral Disc**

In contrast with the lumbar spine, where the intervertebral disc resists most of the compressive load, the cervical intervertebral discs form a tripod arrangement with the facet joints in resisting compressive loads. Approximately one-third of the compressive load is resisted by each zygapophyseal articulation and the central joint.

As a portion of vertebra height, the cervical disc is relatively tall, much like the lumbar disc and quite different from the thoracic disc. The nucleus pulposus comprises a large portion of the cross-sectional area (30–50%), therefore predisposing the total disc to swelling after trauma (9).

**INNERVATION**

The cervical disc can be an intrinsic source of pain. Branches of the vertebral and sinuvertebral nerves primarily innervate the outer one-third of the annulus fibrosis of the cervical discs (11).

**Range of Motion**

The range of motion is defined as the angular change between the two physiologic extremes of movement. Through a literature review, White and Panjabi (9) have established the intersegmental ranges of motion of the cervical motion segments. These values represent the total range of the motion segment. The analysis of flexion versus extension ranges would, therefore, have to take into account the neutral position from which the motions begin. Flexion-extension motion or rotation around the x axis, has the greatest angular range of the three possible degrees of freedom (See Chapter 2) concerned with rotations. The C5-C6 joint is the most mobile, having a total range of motion in the sagittal plane of 17°. The amount of intersegmental movement decreases to 9° at the C7-T1 and 8° at the C2-C3 motion segments. The representative angles for the total range of $\pm \theta X$ motion are as follows (9):

- C2-C3: 8°
- C3-C4: 13°
- C4-C5: 12°
- C5-C6: 17°
- C6-C7: 16°
- C7-T1: 9°

Lateral bending, or rotation around the Z axis is greatest at the cervical segments C3-C4 and C4-C5 with approximately 5.5° to each side. The representative angles to each side are as follows (9):

- C2-C3: 5°
- C3-C4: 5.5°
- C4-C5: 5.5°
- C5-C6: 4°
- C6-C7: 3.5°
- C7-T1: 2°

Rotation around the Y axis, or axial rotation, is greatest at the C4-C5 joint for cervical segments C2-C7. The representative angles for axial rotation in each direction are as follows (9):

- C2-C3: 4.5°
- C3-C4: 5.5°
- C4-C5: 6°
- C5-C6: 5°
- C6-C7: 4.5°
- C7-T1: 4°

Global range of motion of the cervical spine can be accurately assessed with simple goniometric methods (12). Cervical lateral flexion asymmetries have been studied by Nansel et al. (13). These asymmetries were found to be a relatively stable phenomenon and could be ameliorated with a single Gonstead-type lower cervical adjustment (14).

**CERVICAL DISC DISEASE**

Haley and Perry (15) studied disc injury in the cervical spine. In 53 of 99 cadavers, there was evidence of cervical disc protrusion. Twenty-seven had lumbar disc protrusions. It must be kept in mind, however, that a lumbar disc protrusion tends to be reduced when the lumbar spine has been unloaded, as in the recumbent position. Seven cases had protrusions in the thoracic spine. Two of
these cases were associated with a marked thoracic scoliosis. Approximately 33% of cervical disc protrusions occur at C5 (15–17). Larger protrusions (4–6 mm) occur more frequently at C6. Most protrusions are central or posterolateral although lateral rupture and lateral protrusion form the most common combination. Although anterior migration of the nucleus does occur (15), it is more rare. The intervertebral foraminae of the cervical spine are elliptical and tightly enclose the neurovascular contents. Enroachment on the intervertebral foramen occurs frequently, especially when a disc protrusion is present. The prognosis of patients with disc protrusion is generally not good (15). Bony exostosis surrounding the disc material adds to the stenotic effect of the protrusion. Multiple levels (three to five) are often involved, which then can lead to spinal cord degeneration (15) (Fig. 10.5A-B). Ischemic degeneration of the cord and sensory portion of the nerve roots was the most common neurologic finding in the specimens studied with disc protrusion.

Management

The use of advanced imaging such as magnetic resonance to ascertain the extent of herniation more precisely makes conservative management of disc cases less difficult (Fig. 10.6A-D). MRI is also useful in differentially diagnosing other neurologic disorders such as tumors or multiple sclerosis (Fig. 10.7). Acute pain originating from disc protrusion or herniation most often presents itself as an acute aggravation of a preexisting condition. Protrusion or herniation is usually the result of cumulative and gradual disc degeneration (See Chapter 3). The condition often becomes clinically significant after a sudden movement or accident. Whether the patient relates a history of a gradual or sudden onset of pain, the acute cervical pain patient is often a challenging case. Disc derangement of a magnitude capable of producing severe pain is to be managed carefully. Chiropractic care, when indicated, must be administered to patient tolerance. The more experienced the clinician, the more likely the skill level of the practitioner will allow for a comfortable, early mobilization in the form of a spinal adjustment.

The symptomatic level(s) must be determined. The history and “hands-on” examination procedures are usually more useful than radiology in assessing the cause of the pain as well as determining patient tolerance to movement. Treatment by manual techniques in cases of mechanically induced acute neck pain depends mainly on patient tolerance. The decision as to whether or not mobilization is indicated depends on the doctor’s ability to position the patient for treatment and apply the manual forces required to reduce the restriction of motion when present.

Hypermobile articulations are commonly encountered at the C4 to C6 spinal segments, which are also the most common sites of disc protrusion in the cervical spine. If the patient can move the neck enough to assess the ranges of motion of the cervical articulations, func-
Figure 10.6. A, Sagittal view. Herniated nucleus pulposus at C5-C6 with cord compression. B, Axial view of Figure 10.6A. There is a central disc herniation at C5-C6. C, Sagittal view. There are disc herniations at C5-C6 and C6-C7 with subsequent cord compression. D, Axial view of C. There is a large broad based central herniation at the C5-C6 motion segment.

Figure 10.7. Image demonstrating white patchy areas in the superior portion of the spinal cord. These findings are characteristic of multiple sclerosis.

Conventional radiographs may be indicated. The patient is precisely adjusted at the fixated level like any other case (Fig. 10.8A-E). If the herniation occurs at a hypermobile and unstable motion segment, then attention should be focused on stabilization of those unstable levels. The patient’s neurologic status is carefully monitored during the course of treatment. Important signs include muscle strength, reflexes and sensation (Fig. 10.9A-C). If, after following careful adjustment, the patient does not respond favorably or deteriorates in their condition with progressive root or cord symptoms (e.g., spasticity, gait abnormalities, bladder incontinence), then neurosurgical referral is indicated (18).

Disc Degeneration

Narrowing and degeneration of the cervical discs occurs most often at the C5-C6 and C6-C7 disc spaces (19) (Fig. 10.10A-E). These findings correlate with the generally observed greatest range of motion in the sagittal plane at these levels. Most likely internal disc disruption leads to joint hypermobility and eventual disc resorption. The hypermobility may occur as a result of direct factors such as trauma to the joint as is often seen in acceleration/deceleration injuries. Compensation reaction to lower cervical immobility can also lead to gradual disc degeneration.

WHIPLASH INJURIES

Acceleration-deceleration injuries are commonly encountered in chiropractic practice. This subject is vast and diverse. For a more complete dissertation on these types of injuries, the authors advise seeking other sources (20).
Figure 10.8. A. Flexion radiograph. Notice the decreased flexion at the C6 level. Much of the patient's limitation of movement is due to pain. There is a −9X positional dyskinesia of C6. B, MRI demonstrating a disc protrusion at the C6-C7 level. C, Posttreatment (6 weeks) flexion radiograph demonstrating increased flexion movement. D, Pretreatment radiograph of right lateral bending. There is normal movement at C6-C7. E, Pretreatment radiograph of left lateral bending. Notice the decreased left lateral flexion (−θZ) at C6-C7.

If there is question as to the legitimacy of this disorder due to the often legal ramifications, the reader is referred to the review by Macnab (21). He poses the question as to why patients who have their head thrown backwards tend to become more “neurotic” than those who have it thrown forwards. Approximately 45% of patients still have symptoms two years or more after settlement of the legal dispute (21).

The patient suffering an acceleration-deceleration injury may present with a wide range of symptoms, the
only constant one being neck pain. The total clinical picture may take several days or weeks to climax. Dizziness is a common symptom relating to whiplash type injuries. The onset is usually seven to ten days after the trauma (22). Low back pain is a common sequela of soft tissue injury of the cervical spine (23). It is important, therefore, that a full spinal assessment be performed for anyone involved in an apparently regionally specific injury such as cervical whiplash (Fig. 10.11).

Figure 10.10. A, Lateral radiograph demonstrating a swollen (D1) disc at C6-C7. (See Chapter 2 for disc degeneration classification.) B, D2 disc at C5. Notice the hyperextension positional dyskinesia of C5. C, D3 disc at C3. There is a slight decrease in the anterior and posterior heights of the intervertebral disc. D, D4 disc at C5. There is a pronounced decrease in the anterior and posterior dimensions of the disc. E, D5 disc at C5. The disc is approximately one-third of its original height.

Pathomechanics

After a vehicle collision from the rear, the lateral cervical radiograph will commonly show a patient with a reduced or completely reversed cervical lordotic curve. Extension malposition (Fig. 10.12) after hyperextension of the neck is usually the most detrimental positional dyskinesia, because the possibility of injury to the nerve roots in the lateral recess is more likely. The hyperextension posture
Figure 10.11. Diagnostic algorithm for an acute traumatic neck injury. 

A. Rule out complicating factors suggestive of severe head trauma. Is the patient conscious? Is the patient paraplegic or quadriplegic? Both of these findings necessitate transport to hospital for advanced imaging. Are any lesions (e.g., bleeding) present which necessitate referral to an emergency room? 

B. Sectional radiographs are generally preferred for ruling out fracture. The doctor must exercise judgment in determining the extent of the radiologic examination. Those patients who have had severe trauma should have a comprehensive neurologic examination. Patients with little likelihood of fracture or dislocation are evaluated accordingly. A comprehensive examination of the cervical spine includes an APOM, neutral lateral, APLC, right and left obliques, and AP pillar radiographs. 

C. Stress radiographs should only be performed for positions in which adequate motion can be obtained. At least 25% of motion in the plane under evaluation is considered a minimum. Flexion, extension, and right and left lateral bending are the preferred postures for evaluation. Cineradiographic procedures can also be used. This technique is especially helpful in diagnosing ligamentous injury of the upper cervical spine, where movements are more complex. 

D. The technician should avoid aggravating the patient’s condition while performing the stress x-ray examination. If the patient’s tolerance for the procedure is minimal, then the examination should be postponed. E. Is instability present? See Chapter 5 for the radiologic determination of instability of the cervical spine. Hypermobility at a motion segment is not considered an unstable situation. Severe antero-or retrolisthesis on flexion or extension may necessitate surgical stabilization. Transverse ligament rupture with anterior subluxation of the atlas is considered an unstable situation. If spinal cord compression occurs when the patient moves within his or her physiologic range, the patient is considered unstable and requires a cervical collar and referral. 

F. The comprehensive chiropractic examination includes a full spine evaluation for the presence of signs and symptoms of the VSC, vital signs, and an orthopedic and neurologic battery of tests (See Chapter 4). Related areas, such as the cranial nerves can be examined as indicated. Are any signs of concussion present? Any signs suggestive spinal cord hematoma, such as dysphagia? Is ear or nose bleeding present (suggestive of brain injury)? 

G. Are postural abnormalities present (e.g., leg length inequality) which would impact on the management of the patient? Are spinal abnormalities (i.e., VSC) present in other areas, such as the thoracic or lumbar spine? 

H. If multiple levels of the spine are involved, then an AP and lateral full spine radiologic examination is indicated. Stress radiographs of related areas, if needed, can also be performed at this time (See Chapter 5). I. Additional diagnostic evaluations, if needed, include, but are not limited to, MRI, CT, nerve conduction studies, and thermography.
tends to be more injurious because the loads are usually greater and the spinal cord and nerve roots are more susceptible to this type of loading (24). The hyperextension injury from muscular reflexive contraction that usually follows the hyperextension is less forceful. The patient's head can also be thrown into hyperextension by secondarily striking the vehicle in front. The most frequent and reproducible whiplash injuries are ruptures of the anterior longitudinal ligament and separation of the annulus fibrosis from the associated vertebrae. Experimental injuries can range from minor tears of the sternocleidomastoid to partial avulsion of the longus colli. If the longus colli muscle is torn, a retropharyngeal hematoma may develop. If the patient reports dysphagia, hematoma should be considered (See Chapter 5).

Clark et al. (25) have reported eleven significant radiologic signs of cervical spine trauma. In their review of 400 cases they categorized the significant findings as follows:

I. Abnormal soft tissues
   A. Widened retropharyngeal space
   B. Widened retrotracheal space
   C. Displacement of prevertebral fat stripe

II. Abnormal vertebral alignment
   A. Loss of lordosis
   B. Acute kyphotic angulation
   C. Torticollis
   D. Widened interspinous space
   E. Rotation of vertebral bodies

III. Abnormal joints
   A. Widened middle atlanto-axial joint
   B. Abnormal intervertebral disc
   C. Widening of the apophyseal joints

Macnab's (21) findings were that extension-acceleration injuries of the neck are more likely to produce soft tissue disruption than either lateral flexion or forward flexion traumas. If disc injury occurs, healing of the injured tissue is less likely to be complete. These early disc lesions do not routinely show changes on plain film radiography.

Concussion

It is known that electroencephalographic (EEG) alterations after whiplash injuries are common (9). These changes may be partly responsible for the wide ranging bizarre clinical picture often reported by patients. These symptoms may be due to the stretch of the spinal cord and nerve roots and/or concussion of the brain.

Ommaya and Hirsch (26), using scaling techniques and extrapolating information from experiments on monkeys and chimpanzees, have concluded that head rotation (X axis) of 1800 Rad./sec² would result in a 50% probability of cerebral concussion. An angular acceleration of the head of 1800 Rad./sec² is reached when a car is hit from behind, producing a 5-g horizontal acceleration of the vehicle. (A “g” is equal to the amount of acceleration of gravitational force (9.8 m/sec²).) Five g’s of acceleration occurs when an automobile is accelerated to 18 kmh (11 mph) within 0.1 second. Severy (27), using anthropometric dummies and human volunteers at slow speeds, showed that a 13 kmh (8 mph) rear-end collision produces a 2-g acceleration of the vehicle and a 5-g acceleration of the head after a lapse of 0.25 second.

Seats

A stiffer seat produces less acceleration of the head than a soft one. The soft seat causes a delay before the vehicular speed reaches the back of the occupant. This delay results in a greater impact velocity between the seat and the occupant and, therefore, greater acceleration of the occupant after impact (9).

The use of headrests is important in lessening the severity of whiplash injuries. Placement is critical, however, because a low headrest will act as a fulcrum and accentuate the trauma. The headrest should be placed at the top-most portion of the head. Because of the "launching effect," the occupants will tend to rise slightly in the seat after a rear-end collision. Airbags will also lessen the severity of injuries caused by head-on collisions (28).

Treatment

The specific adjustment is the chiropractor’s primary treatment modality. With the acute patient, this specificity cannot be emphasized enough. The stabilization of normal and hypermobile articulations is especially important because an abrupt stretch of a painful muscle spasm during an adjustment is likely to cause an exacerbation. Making contact on the involved vertebra can be eased if cryotherapy is applied over the contact point before the adjustment. The adjustment should be made with the patient in as much of a neutral position as possible. A rapid and low amplitude thrust followed by a careful "holding" with both hands is important. The doctor may only have one chance to make an adjustment,
because unsuccessful attempts are likely to cause patient discomfort and lessen the patient’s ability to relax for a future attempt.

TRACTION

The use of strong, intermittent traction can easily be challenged on the basis that it is irrational, counterproductive, nonphysiologic, and traumatic (29). It is astonishing that the claims for intermittent traction have gone so long uncontested. The passive stretch of already sprained ligamentous elements and reduction of the cervical lordosis are two of the more common arguments against cervical traction.

Mild, manual traction applied carefully, when indicated, may be accomplished with a specific segmental contact. A gradual force is applied at the level of subluxation. The supine position is preferred to lessen the load on the spine. The doctor should contact the patient similarly to the actual adjustment. A traction force is applied to the spine with the stabilization hand while a sustained pressure is applied with the segmental contact hand. Attention must be paid to patient tolerance. The segment should gradually “give-way” as creep deformation of the ligamentous elements occurs. The segmental pressure is applied in the direction of fixation dysfunction.

IMMOBILIZATION

The use of rigid or soft collars is usually not indicated in the management of whiplash-type injuries. If the patient is unable to hold the head in an upright position or if gross instability or fracture is present, then a cervical support will be required. Mealy et al. (30) compared immobilization (soft collar and bed rest) with early mobilization (Maitland technique) for patients who suffered whiplash injuries. In a randomized study, the results showed that at eight weeks after the accident, the degree of improvement seen in the actively treated group compared with the immobilized group was significantly greater for both cervical movement and the intensity of pain.

Prognosis

Greenfield and Ilfield (31) evaluated short-term prognostic factors in patients who sustained whiplash injuries from automobile accidents. The presence of interscapular and upper back pain appeared to correlate with a less favorable prognosis. Those patients who underwent a course of traction therapy also had a poorer prognosis.

The presence of neurologic signs in the upper extremities, such as paresthesia, or referred pain should reflect a relatively worse prognosis (32). Simple neurologic testing of dermatomes (See Chapter 4) can be performed or more objective testing methods may be used to aid assessment of these patients. Thermography is a useful modality for imaging these types of disorders (33). The presence of persistent thermographic abnormalities would also adversely affect the prognosis of the patient.

A poorer outcome is expected if there are preexisting degenerative changes (32). A hypolordotic or kyphotic cervical curve is more common in patients with persistent pain (34). Patients with restricted motion demonstrated on flexion/extension roentgenograms also tend to have a poorer prognosis for recovery (34).

STATIC RADIOGRAPHY

Plain film radiography in the neutral position is used essentially to rule out possible contraindications for manipulative therapy and as an aid in determining the site for treatment. The lateral projection is useful for determining which segments are in a hyperextended or flexed position. There appears to be a high correlation with extension malposition and the level of involvement (35) (Fig. 10.13A-B). This positional dyskinesia may be
motion palpation assessment of the joint appears to contraindicate the static listing, then radiographs taken at the extremes of lateral bending should be performed to obtain a more accurate diagnosis.

**STRESS RADIOGRAPHY**

Analysis of the spine in lateral bending as well as the extremes of flexion and extension is relatively common (Fig. 10.15–10.17). If more detailed information is necessary, the spine can be x-rayed in intermediate positions between the extremes of maximal flexion and extension (36). Dvorak et al. (37) found that analysis of the cervical spine in flexion/extension was more sensitive when passive movements were used. In their study of 59 adults, 19 hypermobile segments could be diagnosed during the active examination, whereas 31 hypermobile segments were found during the passive examination. It is important that the examiner wear a whole lead coat with long sleeves and lead gloves, as well as lead glasses during the passive radiologic assessment. Slight and marked restrictions in extension motion appear to be significant findings that indicate an abnormality of the joint (38). Paradoxical motion may be present as well. In this situation, the segment appears to flex when the neck is extended and vice versa. During flexion, excessive anterior glide or increased flexion indicates hypermobility secondary to ligamentous sprain or rupture. Fixation dysfunction is usually more easily detected in the flexed posture. The segment will remain in an extended position with head and neck flexion.

Cineradiography or videofluoroscopy of the cervical spine may be useful in identifying dysfunction that is not present on roentgenograms in the neutral or stressed positions (39–41). Videofluoroscopy appears to be able to detect midcervical (i.e., C4-C5) fixation dysfunction with a high degree of reliability (42). Videofluoroscopy has also been advocated for the evaluation of cervical spine instability (43).

**COMPENSATION REACTIONS**

**Postural**

The most common postural reaction to cervical trauma is a hypolordotic or kyphotic cervical curve. If an extension positional dyskinesia (−Z, −θX) is present, the vertebra above usually compensates by flexion. Hyperextension subluxations of the upper cervical spine (e.g., AS occiput or AS atlas) will usually result in a kyphotic deformation of the midcervical spine below.

Hyperkyphosis and compression fractures of the thoracic spine, as commonly occurs in patients with osteoporosis, may cause a compensatory hyperlordosis of the cervical spine. In general, hyperlordotic compensations of
the cervical spine are less common than reversals of the cervical lordosis.

Dynamic

Dynamic reactions to vertebral injury include hypo- and hypermobility. Fixation dysfunction can be a result of direct injury (See Chapter 3) through adhesion formation or edema, or due to long-term effects of impaired postural movements. Hypermobility above the level of fixation dysfunction is quite common. The midcervical spine is a likely site for hypermobility to occur. The highest incidence of disc protrusion and degeneration in the cervical spine occurs in the midcervical area. Traction osteo-

Figure 10.15. A, Left lateral bending. There is no coupling of the spinous process at C7 toward the convexity of bend. B, Right lateral bending. There is decreased lateral flexion (+θZ) at C7 and T1. Notice the compensatory hypermobility at C6.

Figure 10.16. A, Left lateral bending. There is decreased lateral flexion (−θZ) at T1 and T2. B, Right lateral bending. There is decreased right lateral flexion (+θZ) and coupling motion (−θY) at C7. Notice the hypermobility at C6.
phytes are an early sign of hypermobility/instability. Treatment (i.e., adjustments) should not be directed at these hypermobile (and often painful) areas. The fixed level is usually below the site of hypermobility. Stress radiography is an important tool for identifying levels of hyper- or hypomobility.

ACQUIRED TORTICOLLIS

Torticollis is defined as a twisting or tilting of the cervical spine. For a summary of pediatric torticollis, especially those encountered in the newborn, please consult Chapter 14. A variety of different therapies show little documented clinical efficacy (44). The older the patient or the more constant the symptoms, the worse the prognosis. The two major types of torticollis encountered in general practice are spasmodic and nonspasmodic.

Spasmodic Torticollis

Spasmodic torticollis is characterized by spasm of one or more cervical muscles. Commonly, the sternocleidomastoid is involved. The contracture of the muscles pulls the neck and head to one side. The spasms are usually caused by reflexive muscular contraction after irritation to the spinal accessory nerve or upper cervical plexus. When the doctor attempts to passively straighten the head and neck, the patient will experience increased pain on the side of the neck being leaned away from. The etiology is often a subluxation of the lower cervical or upper thoracic area. Upper thoracic disc lesions are a common cause. A more caudal thoracic, such as a mid dorsal motion segment may be a contributing or primary factor. In the management of this condition, the lower segment, if two are involved, should be adjusted first, followed by the upper level during the adjustment session. Because of the substantial derangement of the intervertebral disc often encountered in nonspasmodic cases, the patient may require a more repetitive series of adjustments than with the spasmodic variety. Nonspasmodic conditions are usually a chronic problem presenting as an acute exacerbation. If the patient is prone to recurrent postural torticollis, ergonomic factors, such as sleep positions, must be evaluated (45).

Wood (46) has advocated not adjusting the spinal segment toward a central location (i.e., three-dimensionally
toward center, opposite the components of the listing) in patients with torticollis. This “approach” is not advised by the authors, because moving the segment into the direction of ligamentous stretch is more likely to cause further injury.

THORACIC OUTLET SYNDROME

Thoracic outlet syndrome (TOS) refers to a group of disorders in which the neurovascular structures that run through the thoracic outlet are compromised by structures in and around it. It is helpful to further classify thoracic outlet syndrome based on etiology; scalenus anticus syndrome, costoclavicular syndrome, etc.

Symptoms of Thoracic Outlet Syndrome

The symptoms of TOS are associated with brachial plexopathy. The most common symptom is pain radiating down the medially aspect of the arm to the fifth digit. In many patients, headache may be the leading symptom of TOS (47). Other symptoms include the following:

1. A dull ache in the entire arm
2. Numbness and paresthesias in the arms
3. Grip weakness
4. Pain at night
5. Arm edema, rubor, coldness, cyanosis. Reynaud’s phenomenon, and symptoms associated with vascular insufficiency.

Costoclavicular Syndrome

The costoclavicular area is the space between the first rib and the clavicle. Individuals with forward-drooping or rounded shoulders may develop symptoms when the clavicle is pressed down against the neurovascular bundle and the first rib. Postural exercises, as a supplement to spinal adjutant therapy, should provide relief for most patients. Less chronic postural dysfunctions will have a more favorable prognosis.

Scalenus Anticus Syndrome

The scalenes are often involved in TOS. This involvement can occur as a result of overdeveloped musculature such as may occur in bodybuilders or other athletes. There are often characteristic referred pain patterns due to trigger points in the scalenes. Pain may be referred from the lower part of the scalenus medius or scalenus posterior muscle to the anterior pectoral region about the nipple. The pain is aching and persistent.

The adjunctive treatment of scalenus anticus syndrome should begin with determining if a subluxation is present in the cervical spine. Because the scalene muscles attach to the transverse processes of C2 through C6, nerve impingement may cause a reflex hypertonicity or spasm of the associated muscular elements. Trigger points in the scalene muscles may need to be addressed to break the pain-spasm-pain cycle.

Cervical Rib Syndrome

Cervical ribs occur in 0.5% of the population with 80% of these occurring bilaterally. Ten percent of patients with cervical ribs may have related symptomatology. Because the cervical rib has been present in the patient throughout life, the question must be asked as to why it is symptomatic now. It is most likely that the presence of a cervical rib will complicate the clinical picture rather than cause the disorder. Cervical ribs narrow the thoracic inlet and can compress the brachial plexus and the subclavian artery between it and the clavicle. This is most apparent when the arm is hyperabducted. A hasty decision to refer for surgery might prevent the patient from getting the best treatment. The patient with thoracic outlet syndrome who also has a cervical rib might present with neurovascular symptoms that are difficult to differentiate from costoclavicular, or scalenus anticus syndrome. Wright’s and Adson’s test may be positive. Subluxations of the lower cervical and upper thoracic spine should be ruled out. Other factors to consider are abnormal fibrous bands extending from the tip of an incomplete cervical rib to the first rib, an abnormally long transverse process of the C7 vertebra, an abnormal insertion of the scalene muscle(s) on to the first rib (48), or pseudoarthrosis of the clavicle and malunion of the clavicle with exuberant callus formation (49).

Vascular Thoracic Outlet Syndrome

Vascular TOS is rare (5–10% of all TOS) (49). Arterial dysfunction may be created by a long complete cervical rib which causes compression or kinking of the subclavian artery. This can lead to injury to the tunica intima and later aneurysm and mural thrombosis (49).

Venous TOS is even less common than the arterial variety (49). The subclavian vein lies outside the scalene triangle so the etiology has been perplexing. Factors to consider would be metastatic tumors (e.g., pancreatic tumor).

Diagnostic Tests For Thoracic Outlet Syndrome

The diagnostic dilemma of TOS is differentiating it from C8-T1 radiculopathy (50). Foraminal compression tests, stress tests, electrodiagnostic studies and plain film radiography are useful tools for making the differentiation.

90° ABDUCTION EXTERNAL ROTATION TEST

The Abduction External Rotation (AER) Test is likely the most reliable test for assessing a narrow thoracic outlet (51,52). The arm is abducted to a right angle and exter-
nally rotated. The forearm should be flexed to 90° and the head turned to the opposite side of symptomatology. Pulse changes or increased symptomatology should be noted. If both the artery and the lower plexus are compressed, the patient will usually experience pain and paresthesia first in the ulnar distribution, followed by tingling into the entire hand (50). The early component is neurogenic and the late component is due to ischemia. Pure neurogenic TOS is suspected if paresthesia and pain persist without pulse diminution. If the patient’s symptoms are not provoked with this maneuver, then they should be asked to open and close their fist slowly for three minutes. The test is diagnostic if crescendo fatigue, numbness, or aching pain develops in the hand and forearm. If the symptoms are relieved when the arm is dropped, the diagnosis is further strengthened (50).

EXaggerated MILITARY MANEUVER

This postural maneuver narrows the costoclavicular space by approximating the clavicle to the first rib (50). The patient is asked to brace the shoulders downward and backward forcefully while the chest is thrust forward. The chin should be slightly elevated.

ADSON’S AND WRIGHT’S TESTS

Patients with true neurogenic TOS may have a negative Adson test: Even if a positive finding is present, this test has no localizing value as to the exact site of compression (50). Many normal subjects show pulse obliteration with the Adson maneuver (51,53).

Wright’s or the hyperabduction test may be positive in patients with TOS (50). This test compresses both the subcoracoid and the costoclavicular space, making localization of the site of entrapment more difficult.

SPINAL CANAL STENOSIS

The spinal canal can become stenotic due to congenital and acquired factors. Parke (54) has demonstrated that the spinal canal is funnel shaped and wider at the top. This configuration can be problematic if degenerative spondylophytic ridges narrow the dimensions of the canal (Fig. 10.18). There is an enlargement in the cervical spinal cord where the brachial plexus originates. This enlargement combined with a narrowed canal can lead to cord compression. Thus, the most common levels of involvement for cervical spondylotic myelopathy (CSM) are at the vertebral segments C4-C7 (55).

Degeneration of the motion segment occurs at the disc, the zygapophyseal joints, the vertebral body, and the surrounding ligaments. If the ligament flavum has been stretched or there is reduced disc space height, the ligament can infold into the posterior aspect of the canal. The ligament tends to thicken with repeated trauma. During extension movements, symptoms may be exaggerated due to compression from the ligament flavum. Flexion movements may also aggravate symptoms, because the spinal cord is stretched with this posture (See Chapter 2). The tension developed can lead to neural compromise. The cord can also become compressed against the posterior aspects of the disc and vertebral body (55).

ADJUSTMENT

Cervical Chair

The seated position is preferred for adjusting the cervical spine. In this position, the surrounding segments can be effectively stabilized and an inferior to superior pattern of thrust can be accomplished (35). Tension is developed usually through primarily lateral flexion movements. The doctor should avoid postures that compromise the vertebral arteries (i.e., rotation or rotation combined with extension) during the adjustment (See Chapter 11). The cervical chair has an adjustable back to accommodate most patients (Fig. 10.19). It is generally preferred to keep the seat-back in the most upright position.

The stabilization strap is used to prevent forward movement of the patient during the thrust. For right-sided contacts (e.g., PR, PL-La) the strap is placed over the left shoulder and vice versa.

The patient should be seated in an upright position with hands on the lap and legs extended in front. The patient should not clench the hands or press against the
floor with the soles of the feet. Both of these actions will create tension, thus making the adjustment more difficult.

The doctor’s contact point for the adjustment is the distal, lateral and palmar aspect of the first digit (Fig. 10.20). The other fingers then back-up the first digit. If the listing demands a lamina contact (i.e., PRI-La or PLI-La), then the finger contacts the most medial portion of the lamina. For spinous listings (e.g., PR, PL, PLS, PRS, P, etc.), the doctor contacts the distal inferior border of the spinous process (Fig. 10.21). If the spinous is rotated to the left, then the doctor should slightly favor the left side and vice versa. A tissue pull is made with the stabilization hand in the line of correction. For example a PL listing would require a left to right and inferior to superior tissue pull (Fig. 10.22). The inferior to superior tissue pull is to accommodate the $+\theta X$ pattern of thrust of most lower cervical adjustments.

The thrust hand is stabilized by placing the thumb against the ramus of the mandible. Depending on the size of the doctor’s hands and the size of the patient’s neck, the thumb may be placed over or behind the ear. No pressure should be applied with the thumb during the thrust. It should simply move forward across the skin when the thrust is made from posterior to anterior. There should be a clear arch formed between the thumb and first finger (Fig. 10.23). This opening is sometimes referred to as a “rat hole.” Maintenance of the arch appears to strengthen the hand for the thrust so that it remains rigid during the maneuver.
The palmar surface of the stabilization hand is placed over the cervical spine on the opposite side of the thrusting hand. The hand and fingers should stabilize the segments above and below the vertebra being adjusted (Fig. 10.24). No thrust is made with the stabilization hand. A slight inferiorward pressure can be applied by the fingers of the stabilization hand contacting the vertebra just beneath the segment being adjusted. This is done to stabilize the foundation that the vertebra is becoming "set-upon." The patient's head can rest against the doctor (Fig. 10.25), or can be maintained in the upright position solely with the doctor's hands. The set-up for the adjustment proceeds as follows:

1. The patient's head is flexed and a tissue pull is made in the line of correction.
2. The distal, lateral, palmar aspect of the first finger should contact the inferior and lateral border of the spinous or the medial portion of the lamina.
3. With the stabilization hand, the head is brought into an upright position and translated posteriorward.
4. The head is laterally flexed toward the side of contact (10–15°).
5. The stabilization hand covers the cervical segments from the opposite side.
6. The thrust is made with a very quick movement of the hand and forearm in the line of correction. No thrust is made with the stabilization hand.
7. The segment being contacted should be held for a moment after the thrust in order that the viscoelastic elements of the motion segment are maximally affected.

Indications: Retrolisthesis of C5 with decreased +Z and +θX motion.

Contraindications: All other listings, normal FSU, hypermobility, instability, destruction or fracture of the neural arch or spinous process, infection of the contact vertebra.

Patient position: Seated in the cervical chair as upright as possible with both lower extremities extended and the dorsal aspect of the patient's hands resting on the anterior thighs.

Doctor's position: Standing behind the patient and slightly to the right. The listing demonstrated could be adjusted with either the right or left hand.

Contact point: Palmar and lateral surface of the (R) distal phalanx of the index finger placed on the inferior lateral aspect of the C5 spinous process. The middle finger should be directly

Name of technique: Gonstead

Name of technique procedure: P (-Z, -θX) C5 Cervical Chair Adjustment (Fig. 10.25).

Figure 10.23. Maintenance of an arch between the thumb and first digit is critical to the performance of a cervical adjustment.

Figure 10.24. Stabilization hand for a T1 adjustment. Notice the line of drive for the thrusting hand along the plane line of the T1 disc.

Figure 10.25. C5 P adjustment from the right side.
Adjacent to the index finger to give the index finger stability. The contact hand (R) is stabilized by placing the thumb on the ramus of the mandible, below the temporomandibular joint so that no pressure is applied to the head of the mandible. When the contact hand is properly placed, an arch is formed by the lateral portion of the thumb and index finger. Figure 10.25 demonstrates the thumb resting lightly over the patient’s ear.

Supporting hand: The left hand is placed so that the palmar surface supports the lateral area of the cervical spine at the C5-C6 level. This will bring the thenar eminence below the ear and the thumb along the angle of the jaw.

Set Up: With the stabilization hand (L) on top of the patient’s head, the head should be flexed slightly to separate the spinous processes. The palmar surface of the left distal phalanx of the index finger is then placed on the inferior aspect of the C5 spinous process. The thumb of the contact hand (R) should be placed on the ramus of the jaw facing anteriorward so that the arch is formed between the thumb and the index finger. The head is brought back into a more relaxed position by the stabilization hand, and it is placed along the posterior and lateral portion of the cervical spine. The chin is elevated slightly so that the posterior musculature is relaxed. The cervical spine is laterally flexed (+θ2) to the right approximately 10–15°. The slack is then reduced by applying a (+Z) pressure on the C5 spinous process with the (R) contact finger. The stabilization hand restricts head motion as the thrust is given. There is no pulling with the stabilization hand.

Pattern of thrust: An arcing motion through the vertebral body posterior to anterior (+Z) and inferior to superior (+θX) through the plane line of the intervertebral disc and facet articulations.

Category by algorithm: Short lever specific contact procedure.

Name of technique: Gonsteac

Name of technique procedure: PL (−Z, −θY) C7 Cervical Chair Adjustment (Fig. 10.26A-B).

Indications: Retrolisthesis of C7 with decreased +Z, +θY and +θX motion.

Contraindications: All other listings, normal FSU, hypermobility, instability, destruction or fracture of the neural arch or spinous process, infection of the contact vertebra.

Patient position: Seated in the cervical chair as upright as possible with both lower extremities extended and the dorsal aspect of the patient’s hands resting on their anterior thighs.
Doctor's position: Standing behind the patient and slightly to the left.

Contact point: Palmar and lateral surface of the (L) distal phalanx of the index finger placed on the inferior lateral aspect of the C7 spinous process. The middle finger should be directly adjacent to the index finger to give the index finger stability. The contact hand (L) is stabilized by placing the thumb on the ramus of the mandible, below the temporomandibular joint so that no pressure is applied to the head of the mandible. When the contact hand is properly placed, an arch is formed by the lateral portion of the thumb and index finger.

Supporting hand: The right hand is placed so that the palmar surface supports the lateral area of the cervical spine at the C7-T1 level. This will bring the thenar eminence below the ear and the thumb along the angle of the jaw.

Set Up: With the stabilization hand (R) on top of the patient’s head, the head should be flexed slightly so as to separate the spinous processes. The palmar surface of the left distal phalanx of the index finger is then placed on the inferior lateral aspect of the C7 spinous process. The thumb of the contact hand (L) should be placed on the ramus of the jaw facing anteroinward so that the arch is formed between the thumb and the index finger. The head is brought back into a more relaxed position by the stabilization hand, and it is placed along the posterior and lateral portion of the cervical spine. The chin is elevated slightly so that the posterior musculature is relaxed. The cervical spine is laterally flexed (−θz) to the left approximately 10°-15°. The head is rotated slightly towards the left. The slack is then reduced by applying a (+z) pressure on the C7 spinous process with the (L) contact finger. The stabilization hand restricts head motion as the thrust is given. There is no pulling with the stabilization hand.

Pattern of thrust: An arcing motion through the vertebral body posterior to anterior (+z) and inferior to superior (+θx) with a slight +θy rotation (10% of the thrust) through the plane line of the intervertebral disc and facet articulations.

Category by algorithm: Short lever specific contact procedure.

Name of technique: Gonstead

Name of technique procedure: PRS (−z, +θy, −θz) C2 Cervical Chair Adjustment (Fig. 10.27A).

Indications: Retrolisthesis of C7 with decreased +z, −θy, and, +θx motion. Right spinous rotation and left lateral flexion positional dyskinesia (Fig. 10.27B).

Contraindications: All other listings, normal FSU, hypermobility, instability, destruction or fracture of the neural arch or spinous process, infection of the contact vertebra.

Patient position: Seated in the cervical chair as upright as possible with both lower extremities extended and the dorsal aspect of the patient’s hands resting on the anterior thighs.

Doctor’s position: Standing behind the patient and slightly to the right.

Contact point: Palmar and lateral surface of the (R) distal phalanx of the index finger placed on the inferior lateral aspect of the C2 spinous process. The middle finger should be directly adjacent to the index finger to give the index finger stability. The contact hand (R) is stabilized by placing the thumb on the ramus of the mandible, below the temporomandibular joint so that no pressure is applied to the head of the mandible. When the con...

Figure 10.27. A, C2 PRS adjustment. B, AP radiograph demonstrating right spinous rotation (+θy) and left lateral flexion (−θz) positional dyskinesia of C2. C, C2 PRS adjustment. If the segment is also hyperextended (−θx), then the contact hand should be lowered slightly to accentuate the “lift” of the spinous process. Compare with A.
tact hand is properly placed, an arch is formed by the lateral portion of the thumb and index finger.

Supporting hand: The left hand is placed so that the palmar surface supports the lateral aspect of the cervical spine. This will bring the thenar eminence below the ear and the thumb along the angle of the jaw.

Set Up: With the stabilization hand (L) on top of the patient’s head, the head should be flexed slightly so as to separate the spinous processes. The palmar and lateral surface of the right distal phalanx of the index finger is then placed on the inferior lateral aspect of the C2 spinous process. The thumb of the contact hand (R) should be placed on the ramus of the jaw facing anteriorward so that the arch is formed between the thumb and the index finger. The head is brought back into a more relaxed position by the stabilization hand, and it is placed along the posterior and lateral portion of the cervical spine. The chin is elevated slightly so that the posterior musculature is relaxed. The cervical spine is laterally flexed (+θZ) to the right approximately 10–15°. The slack is then reduced by applying a (+Z) pressure on the C2 spinous process with the (R) contact finger. The stabilization hand restricts head motion as the thrust is given. There is no pulling with the stabilization hand.

Pattern of thrust: An arcing motion through the vertebral body posterior to anterior (+Z) and inferior to superior (+θX) with a slight −θY movement (10% of the thrust) through the plane line of the intervertebral disc and facet articulations. Toward the end of the thrust, a vector is applied through the center of mass of the segment that causes right lateral flexion of the vertebra. If a large amount of hyperextension (−θX) positional dyskinesia is present, then the contact hand should be lowered slightly to accentuate the lift of the spinous process (Fig. 10.27C).

Category by algorithm: Short lever specific contact procedure.

Name of technique: Gonstead

Name of technique procedure: P (−Z) C7 Knee Chest Table Adjustment (Fig. 10.28).

Indications: Retrolisthesis of C7 with decreased +Z and +θX motion.

Contraindications: All other listings, normal FSU, hypermobility, instability, destruction or fracture of the neural arch or spinous process infection of the contact vertebra.

Patient position: The knee chest position with a stabilization strap placed over the cranium.

Doctor’s position: Standing on either side of the patient. If spinous rotation is present (e.g., PR or PL), then the doctor should stand on the side of spinous laterality.

Figure 10.28. C7 P knee chest table adjustment.

Contact point: The posterior inferior aspect of the C7 spinous process with a double-thumb contact.

Supporting hand: None

Set Up: The slack is reduced gradually and lightly with equal pressure from both thumbs, until a slight resistance is felt. A quick, high velocity, short amplitude thrust is given and held for 1–2 seconds to affect the soft tissue components and to prevent a whiplash effect.

Pattern of thrust: An arcing motion through the vertebral body. Posterior to anterior (+Z) and inferior to superior (+θX), through the plane lines of the intervertebral disc and facet articulations.

Category by algorithm: Short lever specific contact procedure.

Name of technique: Gonstead

Name of technique procedure: P (−Z) C5 Knee Chest Table Adjustment (Fig. 10.29).

Indications: Retrolisthesis of C5 with decreased +Z and +θX motion.

Contraindications: All other listings, normal FSU, hypermobility, instability, destruction or fracture of the neural arch or spinous process, infection of the contact vertebra.

Patient position: The knee chest position with a stabilization strap placed over the cranium.

Doctor’s position: Standing on either side of the patient. If spinous rotation is present (e.g., PR or PL), then the doctor should stand on the side of spinous laterality.
Contact point: The posterior inferior aspect of the C5 spinous process with a double-thumb contact.

Supporting hand: None

Set Up: The slack is reduced gradually and lightly with equal pressure from both thumbs, until a slight resistance is met. A quick, high velocity, short amplitude thrust is given and held for 1–2 seconds to affect the soft tissue elements and to prevent any whiplash effect.

Pattern of thrust: An arcing motion through the vertebral body. Posterior to anterior (+Z) and inferior to superior, through the plane line of the intervertebral disc and facet articulations.

Category by algorithm: Short lever specific contact procedure.

Name of technique: Gonstead

Name of technique procedure: PL (Z,−Y) C2 Knee Chest Table Adjustment (Fig. 10.30).

Indications: Retrolisthesis and left spinous rotation of C2 with decreased +Z, +θX and +θY motions.

Contraindications: All other listings, normal FSU, hypermobility, instability, destruction or fracture of the neural arch or spinous process, infection of the contact vertebra.

Patient position: The knee chest position with a stabilization strap placed over the cranium.

Doctor's position: Standing on the left side.

Contact point: The posterior inferior and left lateral aspect of the C2 spinous process with the right pisiform.

Supporting hand: The left hand is placed over the right.

Set Up: The pisiform of the contact hand (R) is placed on the lateral inferior aspect of the spinous process, and the stabilization (L) hand is placed over the contact hand (R). The slack is then reduced gradually and lightly with equal pressure from both arms, until a slight resistance is met. A quick, high velocity, short amplitude thrust is given and held for 1–2 seconds to affect the soft tissue elements and to prevent any whiplash effect.

Pattern of thrust: An arcing motion through the vertebral body. Posterior to anterior (+Z), inferior to superior (+θX) and left to right (+θY), through the plane line of the intervertebral disc and facet articulations.

Category by algorithm: Short lever specific contact procedure.

REFERENCES

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