Orthopedic Physiotherapy Sheet

Introduction

The common approach used in physiotherapy is the patient-centered and problem-solving approach. This means that therapist individualize their treatment program in order to provide a comprehensive rehabilitation that help patient to resume normal function as normal as possible.

In order to provide individualized program, therapist needs to collect all relevant information through the standard physical assessment procedures. This assessment includes; history taking, Assessment, problem listing, goals setting, treatment methods, discharge note and follow-up notes.

It is quite important that therapist report all initial assessment findings as well as all follow-up findings in order to be able to judge patient's progress and to plan any rehabilitation program modification.

1. History and physical Assessment

Patient's History

1- Personal History:

Name: to get familiar with the patient and for recoding/reporting purposes.

Age: some orthopedic conditions are age related such as fracture neck of femur which is common in old age and rickets and other congenital anomalies commonly seen in young children.

Sex: gender may be a risk factor for the development/progression of orthopedic conditions such as congenital dislocation of the hip that is commonly seen in new borne females and more car accidents that commonly affects males than females.

Address: residential address may have an impact on the physical rehabilitation of the patients. For example, certain habitual positions may be common in some residential areas such squatting and sitting on floors which predispose individuals to osteoarthritis. Also, during rehabilitation therapist will need to know these information in order to plan for "returning to activity" rehabilitation phase. For example, when therapist recognizes the number of floors the patient has to ascend/descend daily, he will be able to plan for cardiopulmonary conditions and endurance training of his patient.

Telephone number: for filing purposes and to be able to contact patient for treatment plan changes and follow-up purposes.

Occupation: the job of the patient will dictate the rehabilitation goals and exercise specificity. For example, if a patient, who is a computer terminal operator, is complaining of hand and wrist pain (e.g. carpal tunnel syndrome), symptomatic physiotherapy will not be enough to help patient to return to his activity. Ergonomic analysis and work-station modification will be needed for long term relief of symptoms.

Marital status: Diseases has social & psychological impacts on patients and their families that is why therapist should be able to understand patient's environmental circumstances in order to be able to develop a comprehensive rehabilitation program. For example, it has been found that single women who have advanced osteoarhritic joints refrain from seeking medical advice. This was attributed to their need for self-dependency and their fear of losing their independence.

Special habits: special habits that might influence the function of the neuromusculoskeletal system are quite important to realize and analyze. This is because such habits may dispose patients to diseases or can be used to attract patient and encourage his/her participation in rehabilitation program. For example, running may predispose patient to painful knee a condition known as runner's knee. It also could be incorporated into rehabilitation program to regain -general body conditioning and cardio pulmonary fitness. There are a few habits
that are not physical yet they adversely affect the health of the musculoskeltal system such as alcoholism and cigarette smoking, it has been proven that Nicotine reduces the blood supply to different

body tissue and hence predisposes to delayed fracture healing. Another example is reduced exposure to sun light which may predisposes to Vit D deficiency and hence may predisposes patients to diseases such as rickets or osteoporosis.

Handedness: the direction of handedness may be of great value in the planning of upper limb rehabilitation such as tendons injuries and amputation. It may also be important for thoracic and neck examination. For example, handedness may influence the direction of scoliotic curve of the thoracic spine.

2-Present history

For traumatic or orthopedic conditions, the history of current illness needs to be taken in detail. This includes:

a. *Mechanism of trauma:*

Therapist needs to get a full description of the trauma from the patient or his family. This will help the therapist to focus the examination on areas that might got contused or injured during the impact. Briefly, trauma may be (1) a simple minor trauma such as stumbling on carpet or falling down or (2) major such as hit and run or run over Motor Car Accident *(MCA) or Road Traffic Accident (RTA).

b. ***Date and Type of trauma (disease):***

For a traumatic conditions

Direct Trauma: site of trauma is the site of injury like falling of a hammer on the thigh.

Indirect Trauma: site of trauma away from the site of injury; e.g. falling on out stretched hand (shoulder flexed and elbow and wrist are extended to absorb the impact) which might lead to a fracture anywhere in the upper limb from the wrist up to the clavicle.

Stress Fracture: micro cracks propagate into a fracture because of repeated **the** minor traumas. Stress fractures commonly occur at the 5 Metatarsal bones as a consequence of prolonged standing (merchant soldier fracture), shaft of fibula and tibia, and the neck of femur.

C. ***Date of admission:***

Knowing when patient was admitted will help the therapist to plan his examination. For example, a patient that was admitted after a MCA one day before examination is expected to have greater pain that interferes with moving the limbs and almost normal joint mobility (unless has a previous relevant history), whereas a patient with the same trauma that was admitted 3 month before the examination might be present with restriction of joint mobility, atrophy and complications related to bed recumbency.

D. Date and type of reduction:

Reduction aims at restoring the alignment or position of fractured bones or dislocated joints. Generally, reduction is done to move the segment in opposite direction of its abnormal displacement. It is important to realize that sometimes a fracture might not need a reduction if not displaced (impacted) or minimally displaced and is not expected to alter nearby joint mechanics. Reduction could be done by two methods:

Closed: axial traction with manipulation of the distal fracture segment to restores *nearly* anatomical position under fluoroscope (real time digital X- ray) guidance.

Open: a surgery is performed and the fracture segment is realigned directly.

This achieves an anatomical reduction and is usually done when internal fixation is indicated or when there is an associated soft tissue injury.

e. ***Type of fracture: (classifications of fracture)***

1. Fractures could be classified based on the shape of the fracture line.
2. Fracture could also be classified based o the displacement of the fragment distal to the fracture line e.g. varus or valgus deviation
3. Fracture could also be classified based on the integrity of the skin and the communication with the exterior. It could be closed (no skin opening) or opened (skin is opened). Open fracture could be open from within (by the sharp edge of the fractured segment) or from without (the trauma that caused the fracture also injured and opened the skin)

Date and type of fixation:

Fixation could be extemal (cast, traction or extemal fixators) or internal. Details on the type of fixation will be given later.

Date and types of operation:

Reduction and fixation may not be done on the same day. Also, correction may be done over a series of operations. It is important to identify the date of operation to expect which complications may exist. For example, you expect patient to have pain and swelling immediately after an operation, whereas, a few weeks after operation, stiffness of an immobile joint is expected to occur.

Also the operative approach :(whether skin incision is done in the anterior, lateral, posterior, or medial aspect). This will help therapist to determine the muscle that are potential risk of complications. For example, in a patient who had a lateral incision at the hip joint, therapist needs to assess hip abductors for possible muscle weakness.

It is also important to check whether the patient had only bones operated on or soft tissue procedures were involved (e.g. repair/release)

H. Date of first physical therapy session:

If patient already received previous physiotherapy for the same condition or for other causes, therapist should check patient's file and plan accordingly. This will ensure consistent delivery of physiotherapy intervention, and thereby patient's confidence and cooperation

Current morbidity or health problems:

Any current diseases should be recognized and reported. For example, diabetes, hypertension, bone weakening diseases such as osteoporosis. This will influence treatment planning and application. For example, a diabetic patient with peripheral neuropathy is not allowed to have any source of heat applied. Also, a hypertensive patient is expected to have increased blood pressure with exercise. Therefore, frequent rest and ensuring regular breathing is important.

Orthopedic diseases:

In orthopedic diseases, instead of taking the trauma history, The therapist needs to gather information concerning the onset (how the disease started) and course (how it behaves since the onset)

The onset could be:

- **Acute or Sudden onset:** A disease that starts all of a sudden such as pyogenic arthritis (due to infection)
- **Chronic or gradual onset:** The disease symptom starts gradually such as degenerative arthritis
- **Acute on the top of chronic:** in many chronic diseases, patient may ior may not complaint of symptoms all time, however, during certain periods, the symptoms flares up and signs of the acute disease (such as swelling or inflammation) may be seen. This could be seen in diseases such as rheumatoid arthritis The course could be:
- **Progressive course: the severity of the disease increases over time, such as in degenerative joint diseases**
- **Regressive course: The disease improves over time such as in inflammatory diseases e.g. tennis elbow**
- **Intermittent course (ON/Off): in some diseases, patients experience episodes of increased disease activities, in between; patient is almost normal. For example, auto-immune diseases such as rheumatoid arthritis**

3-Past history:

Any past problems related to present injury or disease (e.g. habitual; dislocation, or previous soft tissue injury or deformity) is important to know in order to plan treatment program comprehensively.

4. Family history

It includes hereditary or familial diseases that may have an effect on the musculoskeletal system such as malignancy, CEDD, deformities or fragile bone (osteogenesis imperfecta).

2. <u>Chief complaint</u>

Chief complain means the biggest problem that challenges the patient in his daily life. It is usually the reason why the patient is seeking medical advice. It should be written in patient's word without the use of any medical terms (e.g. patient cannot bear weight on his limb and NOT reduce weight bearing ability of the effected limb). If more than one problem exists, select the most challenging problem that the patient faces.

3. Diagnosis

The diagnosis needs to be written in detail. This allows readers of patient's file to understand the exact trauma history briefly without the need to read the whole history section. The following are the most important information that needs to be included:

1. Indicate whether the condition is in one limb, two limbs or in more than one site.
2. Specify the exact site of injury: Bone (shaft, proximal or distal end) or joint.
3. type of injury, and the current method of reduction and fixation
4. Associated complication such as nerve or vascular injury

E.g. spiral fracture of middle 1/3 of the shaft of Rt. Femur with sciatic n. injury and is fixed by skin traction on Thomas splint

<u>4. Physical Assessment</u>

<u>*A-inspection*</u>

Inspection or "eyeballing" is a subjective method that allows therapist to get a better understanding of the affected area. It also guides the therapist where to direct his further assessment steps. Inspection needs to be done from different planes. Therapist cannot judge an area that is covered or misaligned. He needs to stand perpendicular to the area of interest. It is advisable to systematically observe patient. That is why observation is divided into general and local.

1- general

- Facial expression which may reflect pain or distress, medical condition (e.g. yellow eyes may reflect a current liver disease and medical treatment moon-face in case of cortisone therapy).
- Patient's mental abilities. For example, children with Down's syndrome have a unique facial appearance.
- Body posture: This is an assessment of the static position acquired by the body.
- Patient may have a normal or misaligned body parts. This could be assessed from different positions such as supine, sitting and standing. A patient may exhibit a normal or nearly normal posture in one position and altered posture in another position. For example, a patient with "Ankylosing spondylo tit is may appear near normal in sitting but has an obvious forward leaning of the trunk in standing position)
- Body built: whether normal, average or above average (obese). This reflects the nutrition status of the patient, the presence of current diseases (such as cachexia in cancer patients) and the presence of potential risk factors (e.g. obesity predisposes patient to the development of osteoarthritis in lower limb joints, that is why an obese patient may need a delayed walking after operative intervention near the joint compared to a patient with normal body build, in order to prevent the development of osteoarthritis)

- Gait: the pattern of patient's walking may indicate the presence of certain musculoskeletal problems. For example, if patient touches the floor with toe- first gait rather than the usual heel strike, then the therapist needs to conduct a detailed local examination for example: examine the heel for possible source of pain, the ankle for the presence of stiffness and muscle imbalance, and the limb for possible limb discrepancy

2-local

Skin color: yellow white usually indicates ischemia, Blue Vpurple discoloration may indicate congestion late ischemia or contusion, red usually indicates inflammation and the color of copper in the skin covering the joint usually indicate collection of blood inside the joint "heamo-arthorosis".

Skin integrity: the presence of any wounds or scars that needs particular attention either in assessment, treatment or during patient's handling.

Swelling: swelling is a general term that describes an increase in the size of the part, regardless to its cause. The exact cause needs further testing and examination.

- Atrophy or decrease in muscle belly circumference is indicative of muscle weakness. However, weakness MUST be confirmed by muscle testing

- Apparent spasm: when a muscle is severely spasmed, the muscle stands out and its contour could be identified compared to the contra-lateral side. However, this can only be seen in superficial muscles such as the upper trapizus, biceps brachia and Para spinal muscles.

- Leg length discrepancy: however, this could be true or functional, that is why long measurements is needed to confirm that findings.
- Abnormal position of joints or body parts. For example, a patient with leg length discrepancy could flex the knee of the taller leg, or plantar the foot of the short leg in order to touch the ground in a static standing position.
- The use of any assistive devices (splints, walking aids, back supports, eye glasses and auditory aids)

B. Palpation

Palpation and testing is a step forward in examination in order to confirm what was seen by the eyes; usually using more objective methods and measurements. Palpation of affected parts MUST be compared to a normal non-affected similar part on the same limb or on other similar body parts. Palpation must be done to the skin, muscles, bony prominences and joints. It is important to record findings so that patient's progress could be reported.

- *Local Skin Temperature:* when skin temperature is compared with other normal nearby regions or similar regions on the unaffected side, we can realize the presence of underlying pathological processes. For example, warmer skin may indicate underlying inflammation, whereas cooler skin may indicate blood insufficiency or ischemia
- Muscle: Size, shape (e.g. fusiform), consistency (e.g. a gap may indicate partial tear whereas a plumb may indicate trigger points), tone (to indicate normal physiological tone, spasmed or hypertonicity, or weakness or hypotonia). Exact musculatures that can palpate will be studied in detail at the practicum classes.

- Bones: palpate bone for alignment and tenderness. Bony palpation will be studied in detail at the practicum classes.

*C. **Examination:***

- ***Pain assessment***

Pain is usually a big problem that challenges patient that is why it is usually a top priority problem to address. To assess pain you need to identify the exact site of pain, how intense it is, how it feels, whether it radiates to other parts of the body, what factors increases or reproduces pain and what factors that alleviate pain. The easiest method to assess pain intensity is the Visual Analogue scale.

Other assessment tools, questionnaires or charts could be used, depending on the availability and experience. There are many terms that could give an idea of the source of pain. For example:

Referred pain: mechanical relation; no nerve relation
Radicular pain: nerve root & it's dermatome

2- Range of motion assessment

Range of motion assessment is done to available and relevant areas. If a joints needs to be assessed, but due to immobilization it cannot be moved, YOU CAN NOT comment on the ROM, even if you are sure it is limited. Simply, write down it needs to be assessed in the future a-functional ROM Joint Immobility could be measured or the quality of motion or restriction is judged subjectively.

Functional or screening ROM:

A gross movement of a specific joint or the whole limb is done e.g., Apply's scratch test to screen upper limb ROM. It is graded as

Functional, Sub functional or Non-functional. Sub- and non-functional joint needs to be measured by goniometer.

Table: Screening or Functional ROM testing

action	Right	Left
e.g. knee to chest SLR Hand to mouth		

- **Goniometry**

Goniometry using standard goniometer is used to measure the degree of limitation in the affected or previously affected joints. Although normal average values for each joint exist, it is important to compare the range of the affected joint to the same joint in the non affected side. This is because some patients might have altered range due to other systemic causes (e.g. hyper mobility or doubled joint syndrome). Range of motion must be done both passively and actively. It is important to repeat each measurement three times and calculate the average to get a more reliable measure.

Action	right	Left	Normal average
e.g. hip flexion			

- Normal PROM > AROM by 5-10°
- **If** PROM > AROM by more = muscle weakness
- PROM = AROM but not in normal range = joint stiffness

c- Passive End feel testing

This is done by the examiner and is usually done in combination with PROM testing. It has a great value in giving the therapist an idea on the structure that is possibly causing the joint range limitation.

- Only in limited range of motion to detect the cause of limitation
- Passively (reach the point of limitation & apply repeated forced pressure to feel the rebounded effect)

Not done if the joint is near or related to injury site

Normal end feel	Abnormal end feel
Bony: Soft: Firm	Spasm Empty Capsular Bone or bony block Springy block

Quiz: Please, feel in what these terms mean?

3- ***Muscle testing***

Muscle testing is one way to detect the presence of weakness. If a patient is bed ridden or inactive for a long period, you CANNOT assume the presence of muscle weakness if you did not test muscle strength. As in range of motion testing, clinically muscle testing can be done using one of three methods.

1. Functional muscle testing

Therapist applies resistance to a pattern of limb movements rather than a specific joint motion. It is usually used as a screening method to exclude the presence of muscle weakness in affected body parts or when other methods cannot be used. Grading is divided into three levels: Functional, sub-functional or nonfunctional.

Functional = motion with maximal leading resistance through full range of motion

Sub functional = incomplete range or minor resistance

Non functional = only flicker contraction

Action	Right	Left
e.g. knee to chest		

2. Group muscle testing (most commonly used in orthopedic cases)

Grading

0 no contraction

1 visible or palpable contraction

2 complete range of motion with gravity elimination

3 complete range of motion against gravity

4 complete range of motion against gravity and against moderate leading resistance

5 complete range of motion against gravity and against maximal leading resistance with 6 sec. hold at the range end

Muscle group	**Right**	**Left**
e.g. hip abductors		

3- Individual muscle testing (isolate one muscle in action): used in nerve lesion spinal injury or when there is a specific muscular injury such as in tennis elbow where different wrist extensors may be involved

Manual muscle testing is modified to suits the bed ridden patient by either not change position or add a resistance to compensate for the effect of gravity (depending on patient's body built) if the moving segment cannot be placed against gravity

4- Muscle Flexibility testing

Flexibility testing aims at assessing muscles ability to assume maximum length. Normally, a muscle can be stretched fully without pain so that the joint could move in full range of motion. For example, gastrocnemius flexibility will allow the ankle to move without any pain into full dorsiflexion with the knee extended. Not applied if the muscle is near or related to injury sit. If a muscle's flexibility is reduced, then the joint will not move in full ROM, or the muscle will be painful with stretch.

Muscle group	Right	left

5- *Posture assessment*

Posture assessment aims at detecting any deviation away from the normal alignment i.e. deformity. It should be done to the affected part. Other body parts, although not directly affected, may assume a compensatory posture. That is why it might be important to exclude any deviation in nearby segments. Deformity could be structural (fixed) or mobile (correctable)

5. *Clinical gait assessment:*

Qualitative gait assessment charts are available. For easiness of application, these charts direct the therapist to check the presence of a certain gait deviation during a certain phase of gait. A few quantitative gait parameters could be easily measured in clinical setting such as the velocity, cadence; provided that the distance where the patients walk is known beforehand.

6. *Balance assessment*

Balance is the ability of the body segment to rearrange them so that the COG of the body lies within the base of support. Balance assessment starts while patient assumes a wide base of support. The base of support becomes narrower as the testing difficulty increases. Balance testing could be done in a static or a dynamic position. It is important to exclude factors that might affect balance prior testing otherwise a false negative results may be obtained (e.g. muscle weakness, joint instability, sensor deficit, vestibular abnormality)

a- static balance

Position	Reduced or normal balance
e.g. sitting	

b- Dynamic balance

Position	+ve\-ve
e.g. assuming sitting	

7-***Transfer activity and functional Mobility assessment***

The ultimate goal of any patient is to be able to assume the independency in his functional ADL. That is why it is important to assess bed mobility and transfer activity and include them in the treatment plan. Activities that could be assessed include turning in bed, switching from supine to sitting and from seated position to standing

Bed mobility and transfer activities could be graded as:

Moderate 50-75%

Mild 25-50%

Standby <25%

Independent mobile

Other possible assessments in In-patient wards;

This part should be covered in detail during internal medicine clinical round

1. ***Circulatory assessment***

a- arterial assessment (proximal & distal to swelling\fracture site)

- Pulsation: strength and rate in both sides and in different levels.
- Capillary re-filling test (10 sec thumb pressure on nail bed or finger pad)

Right	**Left**	**Normal range**
		Adult 2-3 sec. **Old age 5-6 sec.** **Child 1-2 sec.**

b- Venous assessment

- Congestion
- Varicose veins

c- Swelling assessment

Type whether is pitting or non-pitting: (30 sec thumb pressure against bony prominence)

Non-pitting	Pitting
High protein content **Lymphatic** **Lymph node problem**	**High water content** **Gravitational\orthopedic** **Venous problem**

Size (round measurements) and compared between both limbs (mark a bony prominence to be your reference point and then measure 5 and/or 10 cm above & below depending on the size of the area of interest)

- Area

❖ Swelling : general term about any increase in size

Effusion: intra-particular increase in synovial fluid; if blood is present it is called heamo-arthorosis

Edema: increase in the amount of extra-cellular interstitial fluid

<u>Quiz 2: How to differentiate clinically between the different causes of swelling?</u>

<u>2-Respiratory assessment</u>

a- diaphragmatic excursion

(Fun. - sub fiin.- no fun.)

b- Chest expansion (xiphoid)

----- normal= 3-5 fingers ---------------------- 7 -10 cm

***c**- Cough, sputum*

d- Smoking, anesthesia

2. Patient problem list

Based on the physical examination that was done, therapist needs to list patient's physical problem based on their importance or priority (for patient or for rehabilitation purpose)

Not all abnormal findings are considered problems unless patient is complaining from it or it affects the rehabilitation program. For example, the presence of sub- functional range of motion in the upper limb that does not interfere with patient range of motion and that cannot be corrected by conservative intervention in 70 years old patient may not be considered as a problem

-patient chief complaint is the problem number one to take into account even if it not directly related to the current musculoskeletal disorders e.g. painful neck in a patient with fractured femur needs to be conected so that patient can assume walking when desired.

3.Aims of treatment

1. ***Long term goal***

To achieve normal function as much as possible based on patient condition, age and pathology

2. ***Short term goals***

Short term goals aims at solving concurrent problems. They need to be SMART goals; S: Specific, M: measurable, A: attainable, R: realistic, and T: time-wise

N.B. aim no. 1→ to solve patient chief complain

.Aim no. 2→ to solve prob. No. 2 and so on............

4.Methods of treatment:

2. 1. All learned physical therapy modalities could be used to solve the patient's problems exercise

→=electrotherapy

→=hydrotherapy

→=manual therapy

2. Treatment plan could be arranged according to the treatment goals and the problem list

E.g. problem no. 2==limited ankle dorsiflexion 10 degrees

Aim no. 2= to reach normal range of dorsiflexion 35 degrees

Methods no. 2= a- active ROM exercise

2 = b- auto passive exercise

2= c- stretching exercise for planter flexors

2= d- strengthening exercise for dorsiflexors

2= e- mobilizing exercise for tibiotalar joint

2= f- pulsed U.S. around ankle joint

2 = g- under water weight bearing exercise

5. Discharge Notes

Discharge include the precautions and the instructions that the patients needs to know for his safety, well-being and ability to resume ADL. It usually includes information and illustrations on self care and the use of assistive device, prosthesis or orthoses. It also includes patient's specific home program, the date of follow-up and simple and cler idea aboutpossible complications and when to seek help. Therapist must discuss the discharge notes with the patient in order to ensure correct understanding of the patient.

6.Follow-up Notes

After discharge, patient is usually seen at the out-patient clinic. During patient's visits it is important to repeat assessment in full or partly to assess patient progress. Progress notes should be then reported clearly in writing and/or graphic plotting. Modification of treatment goals and plan should be done accordingly.

Lumber Examination

Lumbar Spine and sacroiliac examination

The examination of the lumbar spine may be seen as a continuation of the procedure already described for the cervical and the thoracic spine; the lumbar spine cannot be evaluated in isolation. Abnormalities of the lumbar spine may lead to compensatory or secondary abnormalities in other portions of the spine or pelvis. Symptoms that appear to emanate from the lumbar region may actually be due to abnormalities of adjacent structures. The principles already enumerated for evaluation of the cervical and thoracic spine continue to be of value in the assessment of lumbar disorders. Because disorders of the lumbar spine often produce pain in the pelvis, the hip, or the thigh, a thorough evaluation of the lumbar spine usually includes examination of these regions.

Inspection Surface Anatomy and Alignment Posterior Aspect

As with the rest of the spine, the dorsal location of the lumbar spine within the body makes the posterior viewpoint the most fruitful one for inspection (Fig.1). When viewed from the posterior aspect, a longitudinal furrow is seen in most patients running down the midline from the thoracic spine to the sacrum. The spinouts processes of the lumbar vertebrae run down the center of this furrow, and they are visible as a series of evenly placed bumps in thin individuals. Forward flexion at the waist usually makes the tips of the spinouts processes more distinct and visible (Fig.1C). Paraspinous Muscles. On each side of the spinouts processes runs a convex column of muscle. This contour is formed by the bulk of the paraspinous muscle mass. The more superficial column of paraspinous muscles is collectively known as the erector spinae, or sacrospinaiis. The erector spine is split longitudinally into three components. From medial to lateral on each side, they are the multifidus, the longissimus, and the ilia-costalis muscles. The individual contours of these muscles cannot be discerned because they lie deep to the lum-bodorsal fascia, and they are visualized as a group. The prominence due to the paraspinous muscles should be equal on both sides of the spine. In the presence of paraspinous muscle spasm, the contour of the muscles on one side of the spine may stand out in visibly greater prominence than those on the opposite side. Although almost any painful lesion of the lumbar spine may cause paraspinous spasm, the most common cause of asymmetric spasm is paraspinous muscle strain. Symmetry. As in the rest of the spine, the verification of symmetry is an important part of inspection of the lumbar spine. It should appear that a plumb line suspended from the vertebra prominent at the base of the neck would bisect the lumbar spine and continue on through the center of the natal cleft between the buttocks. In addition to looking for straightness of the lumbar spine itself, the examiner should carefully inspect and compare the space created between the upper limbs and the trunk as the hands hang loosely at the patient's sides. Noting asymmetry of these spaces may allow the examiner to detect a subtle coronal deformity of the spine that would otherwise go undetected. Pelvic Obliquity. The examiner should also verify that the patient's pelvis is level. An imaginary line drawn between the posterior superior iliac spines or the iliac crests should be parallel to the floor. If these landmarks are not clearly visible, the examiner may have to palpate the iliac crests to verify that they are equidistant from the floor. If a pelvic obliquity is found, it may be the result of a deformity within the spine, such as scoliosis or an anomalous vertebra, or it may be secondary to a leg length discrepancy.

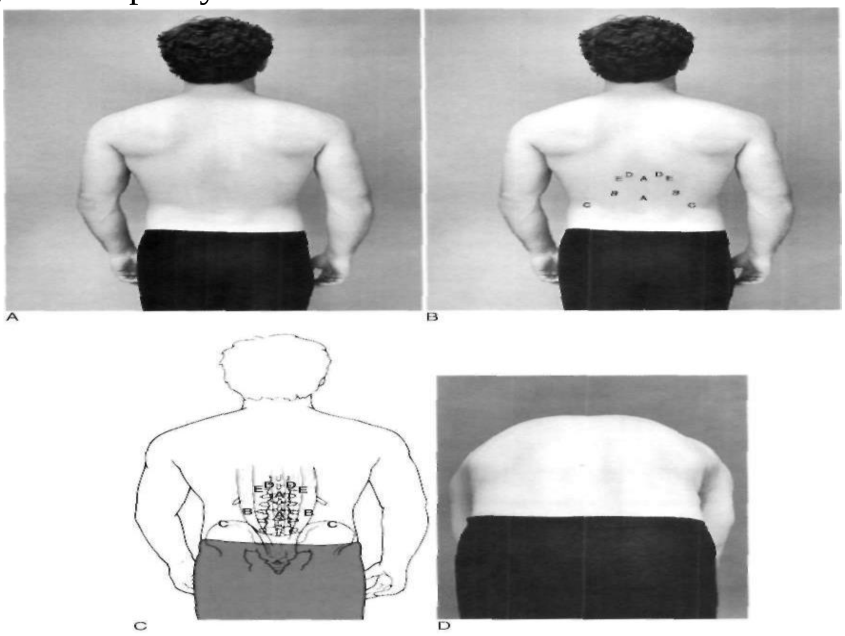


Figure 1. *A, B,* and C, Posterior aspect of the lumbar spine. A, spinouts processes; B, erector spine; C, iliac crests; D, posterior facet joints; E, transverse processes. *D,* Posterior aspect of the lumbar spine in flexion.

Pelvis, Hip, and Thigh. In the case of a leg length discrepancy, a secondary compensatory deformity of the spine is usually present. List. Any departure from symmetry in the lumbar spine is usually caused by a coronal plane deformity. A list is an abrupt planar shift of the spine, above a certain point, to one side (Fig.2). This phenomenon typically occurs primarily in the lumbar spine. It is usually a reversible deformity related to pain and associated muscle spasm. A list may be caused by a herniated lumbar disk. In this case, the spine shifts away from the side of the nerve root that is being pinched by the herniated lumbar disk in an attempt to relieve pressure from the affected nerve root. Sometimes, local muscle strain can also result in a list. **Scoliosis. Scoliosis** is another major cause of coronal asymmetry (Fig. 3A). Although scoliosis is usually considered a coronal deformity of the spine, it is really a helical abnormality involving abnormal vertebral rotation along the axis of the spine. Lumbar scoliosis may be primary or secondary. In primary scoliosis, an actual structural abnormality of the spine is present. In secondary scoliosis, the curvature represents a compensatory adaptation of an otherwise normal spine to an extrinsic factor, such as muscle spasm or pelvic obliquity related to a leg length discrepancy. If the condition is secondary to a pelvic obliquity, leveling the patient's pelvis by placing blocks or books beneath the shorter limb should cause the deformity to disappear. If a pelvic obliquity has been present for a long time, however, permanent soft tissue contractures may develop; consequently, the deformity ceases to be reversible by leveling the pelvis.

As in the cervical and the thoracic spine, lumbar scoliosis may be idiopathic or due to neurologic disorders or vertebral anomalies. The bulkier lumbar musculature may disguise the spinal curve, and the rib hump that often alerts the examiner to the presence of thoracic scoliosis may be mild or absent. Clues such as pelvic obliquity or asymmetry of the spaces between the upper limbs and the trunk are, therefore, extremely important in detecting lumbar scoliosis.

Skin and Subcutaneous Tissue Abnormalities. The examiner should also note any abnormalities of the skinor subcutaneous tissue of the lumbar region that may indicate underlying spinal abnormalities. A lumbal *lipoma*, an abnormal *hair patch*, or a *port wine stain* may be associated with spina bifida or even myelomeningocele. Large tan patches known as *cafe au lait spots* and nodular skin swellings may indicate neurofibromatosis, a condition that may cause secondary deformity of the spine.

Figure 2. *A* and *B*, A list to the left. Note the asymmetry of the spaces between the arms and the trunk in *A* and the increase in the list with flexion in *B.*

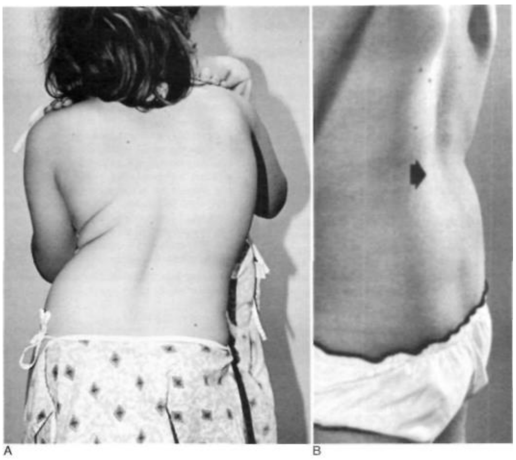


Figure 3. *A*, Thoracolumbar scoliosis. *B*, Spondylolisthesis (*arrow* indicates step-off).

Step-Off Deformity. Severe degrees of spondylolisthesis may produce a visible step-off deformity of the lumbar spine. Normally, the tips of the lumbar spinous processes should protrude posteriorly about the same amount, producing a smooth hollow in the lumbar spine. When spondylolysis occurs, the spinous process and associated posterior elements of the involved vertebra are detached from the rest of the vertebra. In this setting, the body of the involved vertebra and the rest of the spine above it may slide forward, producing a spondylolisthesis. Spondylolisthesis is most likely to occur between L5 and SI. When the amount of spondylolisthesis is severe, an abrupt displacement or step-off is visible (see Fig. 9-3B). Less severe step-offs may only be palpable.

Lateral Aspect

Viewing the patient from the lateral aspect allows the examiner to judge the sagittal alignment of the spine. The lumbar spine is normally lordotic, that is, concave posteriorly. A normal lumbar lordships should exactly complement the thoracic kyphosis and cervical lordosis, so that the base of the occiput rests directly above the sacrum (Fig. 4A).

The normal lumbar lordosis, which averages about 60% is important in order to maintain healthy low back biomechanics. Several possible departures from normal lordosis may be seen, including hyperlordosis, decreased lordosis, lumbar flatback deformity, and gibbus deformity.

Hyperlordosis. Hyperlordosis is usually a flexible postural deformity (see Fig. 4B). This deformity, also known as swayback, results in increased prominence of the buttocks. It is usually associated with flexion contracture of the hips.

Decreased Lumbar Lordosis. Decreased lumbar lordosis is often **a** temporary, reversible deformity related to pain and associated muscle spasm. Conditions in which pain is exacerbated by extension of the lumbar spine, such as *spondylolysis,* may be associated with a reflexive decrease in lumbar lordosis. *Ankylosing spondylitis* may produce a more rigid decrease in lumbar lordosis.

Lumbar flat back syndrome describes a rigid lumbar spine in which the normal lordosis has been completely lost (see Fig. 4*C).* Compression fractures that result in anterior wedging of the lumbar vertebral bodies can produce lumbar flatback syndrome. Advanced degeneration of the lumbar intervertebral disks may also result in this same deformity. Lumbar flatback syndrome may also occur following a long thoracolumbar spinal fusion for correction of scoliosis. Older surgical instrumentation systems tended to allow for only coronal plane deformity correction and straightened the spine in the sagittal plane, leading to a flatback deformity.

Gibbus. A gibbus is a sharp, angular kyphotic deformity often noticed by the protruding spinous process at the apex of the deformity. Gibbus is classically associated with tuberculosis of the spine. In this case, the infection destroys the anterior aspect of a vertebral body and the adjacent disk space, resulting in a localized collapse of the anterior portion of the vertebral column. Vertebral body collapse due to tumors, other infections, or fractures may also produce a gibbus.

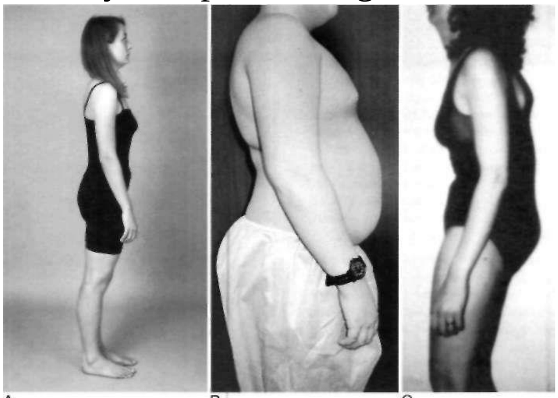


Figure 4. Lateral aspect of the lumbar spine. *A,* Normal alignment *B,* Hyperlordosis. C, Flat back deformity

Gait

Although gait evaluation is not always considered an integral part of a lumbar spine examination, pain or deformity associated with certain conditions of the lumbar spine may produce characteristic gait abnormalities. A classic example is the gait abnormality that may be associated with sciatica. **Sciatica** is most commonly caused by a herniated disk at the L5-S1 or the L4-L5 interspace compressing a nerve root that feeds into the sciatic nerve. Because knee extension and hip flexion place further tension on the painful sciatic nerve, the patient with sciatica may attempt to walk with the hip more extended and the knee more flexed than normal. In addition, the patient may display an **antalgic gait,** putting as little weight as possible on the affected side and then quickly transferring the weight to the unaffected side.

The ability to toe walk and heel walk may also be used to screen for lumbar radiculopathy. These tests allow the examiner to quickly screen for radiculopathy related to the most common lumbar disk herniations. This method also allows the involved muscles to be tested with considerably higher loads than are exerted during manual testing of the same muscle groups. **Heel Walking.** Heel walking tests the strength of the **ankle dorsiflexors.** The patient is asked to walk on his or her heels with the toes held high off the floor (Fig.5). Because this is an unusual activity, the examiner may have to demonstrate the maneuver for the patient. The patient should be asked to take about 10 steps with each foot. This maneuver tests for weakness of the L4 innervated **tibia is anterior,** which would most commonly be weakened by a herniation of the L3-L4 disk. In the presence of severe weakness, the patient is unable to lift the front part of the foot off the floor at all. In milder degrees of weakness, the patient is not able to lift the forefoot as high off the floor as on the other side, or the muscles are noted to fatigue after a few steps have been taken.

Toe Walking. Toe **walking** requires the SI innervated gastrocsoleus muscle group that would most commonly be weakened by a herniation of the L5-S1 disk. The patient is asked to walk on the toes with the heels held high off the floor, again taking about 10 steps on each foot (Fig. 6). Again, severe weakness is manifested by the patient's complete inability to clear the heel of the involved side off the floor. When more subtle degrees of weakness are present, the heel of the involved side is not held as far off the floor as the heel of the opposite side or the muscles are noted to fatigue after a few step.

Figure 5. Heel walking.

Figure 6. Toe walking.

Range of Motion

Motion of the lumbar spine is the result of a complex interaction among bony structures, articulations, and soft tissues. Abnormalities of any of these structures may limit the range of motion of the lumbar spine. The loss of motion may be due to pain, muscle spasm, mechanical block, or neurologic deficit. Range of motion of the lumbar spine is traditionally evaluated with the examiner standing or seated behind the patient. However, the examiner may also need to look from the side to more easily quantify the amount of flexion and extension present

Flexion

To assess the flexion of the lumbar spine, the patient is asked to bend straight forward at the waist as far as possible (Fig. 7). Depending on the amount of flexibility present, the patient may be instructed to attempt to touch the fingertips or the palms to the floor. The amount of flexion present is estimated as the angle between the final position of the trunk and a vertical plane. Thus, 90° of flexion is present when the patient's trunk is parallel to the floor. When measured in this fashion, flexion averages about 80° to 90°.

Another way of quantifying lumbar flexion is to measure the distance from the patient's fingertips to the floor. In the average patient, the fingertips come to rest about 10 cm from the floor. The range of variation in lumbar flexion, however, is quite large. Flexion tends to decrease with age. Because lumbar flexion increases pressure on the intervertebral disks and places tension on sciatic nerve roots, herniation of L4-L5 and L5-S1 disks is frequently associated with painful, limited flexion of the lumbar spine. While assessing lumbar flexion, the examiner should also note whether the spine remains straight during flexion. The deformities associated with scoliosis and a lumbar list may both be accentuated by flexion of the spine (Fig. 2).

It must be recognized that much, if not most, of the motion observed during forward bending is due to flexion at the hips, rather than true flexion of the lumbar spine. It is difficult to eliminate hip flexion and measure pure spine flexion. However, two methods are available to ensure that at least some of the flexion is taking place in the spine. The first is to observe the behavior of the normal lumbar lordships as the patient bends forward. If flexion is actually taking place within the lumbar spine, the normal lord tic contour should flatten out and even mildly reverse itself into a slight kyphosis. If the contour of the lordships remains unchanged during forward bending, the examiner may conclude that little flexion of the lumbar spine is actually occurring. The second technique for verifying that flexion is occurring within the spine is the tape measurement of the apparent increase in the length of the spine during flexion. This is done with the modified **Schubert test**. This method is really just a way of quantifying the change in spinal contour noted by observing the reversal of the lumbar lordships.

Extension

To test for extension of the lumbar spine, the examiner asks the patient to lean backward as far as possible (Fig.8). The amount of extension is quantified by estimating the angle between the trunk and a vertical line. In a normal patient, about 20° to 30° of extension is possible. As with the assessment of flexion, the examiner should not only observe the amount of motion possible but also determine whether the maneuver causes the patient pain. A number of different conditions may limit lumbar spine extension or cause it to be painful. Because extension tends to narrow the diameter of the spinal canal, patients with abnormal narrowing of the spinal canal tend to avoid further extension. The most common example of this is degenerative spinal stenosis, but posttraumatic deformities and space-occupying lesions, such as tumors, may produce the same picture. Lumbar spine extension may also be limited or painful in the presence of disorders of the posterior elements of the vertebrae. Examples include spondylolysis, tumors of the posterior elements, and degenerative arthritis of the posterior facet joints.

Lateral Bending

Lateral bending is tested by asking the standing patient to lean as far as possible to each side. The examiner should stabilize the patient's pelvis with a hand on each iliac crest (Fig.9). This motion actually involves a combination of lateral bending and rotation of the vertebral column. The amount of lateral bending present is difficult to quantitate. It may be estimated by drawing an imaginary line between the vertebra prominent and the sacrum and estimating the angle between this line and the vertical. The average amount of lateral bending present in a normal patient is 20° to 30°.

The examiner should look for asymmetry between the two sides. Patients with herniated disks may avoid lateral bending toward the side of the herniation, as this causes the nerve root to further impinge on the herniated disk. The lateral bending test also provides an opportunity to verify an impression of paraspinous muscle spasm. To do this, the examiner should palpate the paraspinous muscles during the lateral bending maneuver (Fig. 10). Normally, the muscles on the side to which the patient is bending should relax and soften. If they remain tight and rigid, this is evidence that they are in spasm.

Rotation

Lumbar spine **rotation** is estimated by asking the patient to rotate or twist in each direction as far as possible. The examiner should prevent rotation of the pelvis with a stabilizing hand on each iliac crest (Fig. 11). The amount of rotation is difficult to quantitate, but it may be judged by estimating the angle between the new plane of the rotated shoulders and the coronal plane of the stabilized pelvis. The normal range is about 30° to 40° in each direction.

Figure 7. Lumbar flexion.

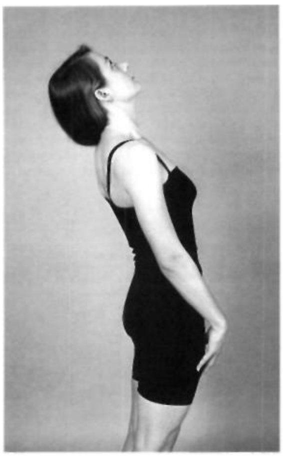


Figure 8. Lumbar extension.

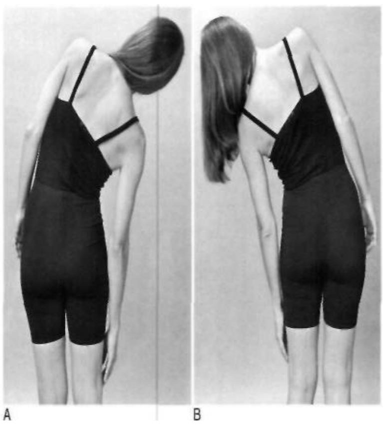


Figure 9. Lateral bending. *A*, Right. *B*, Left. Examiner has been Omitted for clarity. Examiner should normally sit behind the patient with a hand on each iliac crest to stabilize the pelvis.

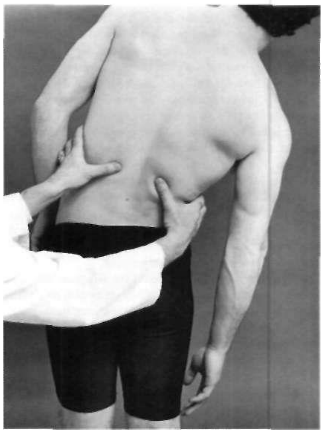
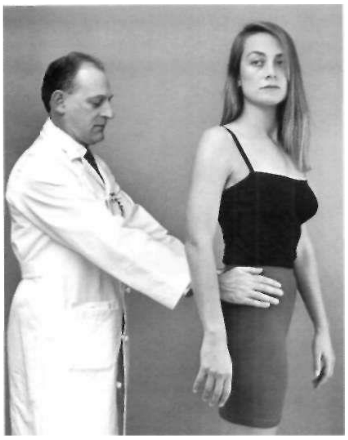
  

Figure 10. Palpation of the paraspinoos muscle during lateral bending. Figure 11. Lumbar spine rotation Figure 12. Palpation of the iliac crests.

• When the Patient Complains of Low-back and Leg Pain

Major Diagnostic Possibilities Include:

- Herniated disk
- Spinal stenosis
- Spondylolisthesis
- Infection
- Tumor

Patient Demographics:

- If the patient is less than 20 years old
- Infection, tumor or spondylolisthesis more likely
- If the patient is 20 to 50 years old
- Herniated disk, spondylolisthesis more likely
- If the patient is older than 50
- Spinal stenosis, spondylolisthesis, herniated disk more likely

Obtain Relevant Medical History:

- If the patient is immunocompromised or has a history of intravenous drug abuse
- Infection is a strong possibility
- If the patient has a history of cancer
- Metastatic spread to the lumbar spine must be suspected

- If the patient has a history of repetitive hyperexten-sion of lumbar spine (e.g., gymnast or football lineman) The Spondylolisthesis is possible

Ask the Patient about the Onset of Symptoms:

- Sudden onset
- More suggestive of herniated disk, infection, or tumor
- Gradual, insidious onset
- Spinal stenosis likely

Ask the Patient to Describe Associated Symptoms:

- Constitutional symptoms such as weight loss, fever, or night sweats
- Suggestive of tumor or infection
- Unilateral leg parenthesis, weakness, or pain
- Typical of herniated disk
- Bilateral buttock/leg pain and cramping with ambulation
- Suggestive of spinal stenosis
- Bowel or bladder symptoms
- Cauda equine syndrome from a midline disc herniation a possibility and must be ruled out as it is a surgical emergency
- Pain worse with ambulation but relieved with sitting, bicycling, or activities where lumbar spine is flexed
- Suggestive of spinal stenosis

Relevant Physical Examination: GENERAL:

- Inspection
- Examination of gait
- Range of motion

Herniated disc:

- Nerve root tension tests (straight-leg raising, Lasegue's test, contralateral straight-leg raising, slump test, bowstring sign)
- Flexion of lumbar spine to reproduce leg symptoms
- Palpation of sciatic notch for tenderness

- Neurologic testing for deficit in the distribution of the involved nerve root

Spinal stenosis:

- Decreased lumbar range of motion
- Leg symptoms reproduced with lumbar spine extension
- Neurologic testing for deficit in the distribution of the involved nerve root

Spondylolisthesis:

- Inspection for decreased lumbar lordosis
- Hyperextension of lumbar spine may reproduce back pain; relieved with flexion
- Palpation for step-off
- Straight-leg raising test to elicit hamstring tightness
- Neurologic testing INFECTION/TUMOR:
- Palpation for point tenderness at involved level
- Palpation for associated muscle spasm
- Neurologic testing
- Palpation

Posterior Aspect

As with the cervical spine, the positioning of the patient during palpation depends on the clinical situation. During an elective office examination, palpation normally is carried out with the patient standing or prone. If the patient is encountered in an emergency situation, however, palpation is carried out in whatever position the patient was originally found. Because the anterior aspect of the lumbar spine is located deep to the abdominal cavity, palpation is normally confined to the posterior aspect.

Spinous Processes. Firm palpation in the posterior midline allows the examiner to identify the tips of the spinous processes of the lumbar vertebrae (see Fig.1). Linking the spinous processes are the supraspinous and intcrspinous ligaments. If the patient is standing, palpation is most comfortably accomplished with the examiner in the seated position. For

orientation, the examiner should identify the top of each iliac crest and draw an imaginary line between the two. This line usually passes through the interspace between the L4 and the L5 spinous processes (Fig.12). The examiner can then identify the individual spinous processes by counting upward or downward from the **L4-L5** interspace. Localized tenderness at a particular level may indicate pathology at that level. Conditions that may cause tenderness localized to one level include sprains or disruptions of the posterior ligaments of the spine, fractures of the posterior elements, and tumors of the posterior elements. In the presence of degenerative arthritis, or spondylosis, tenderness over the posterior vertebrae is of uncertain significance. Marked superficial lumbar tenderness, especially in response to very light palpation, suggests the possibility of symptom magnification.

In the presence of *spondylolisthesis,* palpation of the spinous processes may help confirm the examiner's visual impression of a **step-off** above the involved vertebra. The amount of slippage usually must be at least 50% of the diameter of the lumbar vertebral bodies before the step-off can be detected by physical examination.

Paraspinous Muscles. On each side of the spinous processes lie the muscular columns of the **erector spinae,** or **sacrospinalis,** composed of the multifidus, the longissimus, and the iliocostalis muscles. The individual components cannot normally be distinguished by palpation. In the presence of muscle spasm, the paraspinous muscle column may appear more prominent and feel firmer than usual. Muscle spasm may reflect a local muscle injury or may be a response to a nearby locus of pain within the spine itself. If muscle spasm is suspected, the patient should be asked to bend toward the involved side while the examiner continues to palpate the paraspinous muscle in question (see Fig. 10). Normally, the paraspinous muscles on the side to which the patient is bending should soften and relax. If they remain firm, the impression of spasm is confirmed. Unilateral muscle spasm may cause a list or reactive scoliosis; bilateral muscle spasm may result in the loss of the normal lumbar lordosis.

The examiner should also note whether the paraspinous muscles are tender. Diffuse muscular tenderness may reflect a strain of the muscles being examined. *Trigger points,* tender nodules within the paraspinous muscles, should also be noted. Trigger points are frequently a reaction to a painful stimulus to the paraspinous muscles. They may also indicate the presence of *fibromyalgia.*

Other Bony Structures. The **posterior facet joints** of the lumbar spine are located deep to the paraspinous muscles just lateral to the spinous processes. Localized tenderness over these joints may be caused by facet joint arthritis or a painful facet joint syndrome. Further laterally, the **transverse processes** are also located deep to the paraspinous muscles and are not distinctly palpable. However, the finding of localized unilateral tenderness deep to the paraspinous muscles following trauma should suggest the possibility of a transverse process fracture.

Pain originating in the lumbar spine must frequently be distinguished from pain originating in the **sacroiliac joint,** the posterior **pelvis,** the **hip,** or the **thigh.** Examination of the lumbar spine should, therefore, include palpation of the sacrum and the coccyx, the sacroiliac joint, the sciatic notch, and the other bony and soft tissue structures of the posterior pelvis, the hip, and the thigh.

Manipulation

Muscle Testing

Strength testing of the muscles that move the lumbar spine is not usually emphasized. Nevertheless, the abdominal and the lumbar musculature fulfills an important role by reducing the load on the static elements of the spine. A general assessment of the function of these muscle groups is, therefore, helpful in evaluating the common strain and overuse disorders that are frequent causes of low back pain.

Flexion of the lumbar spine is powered by the abdominal muscles, particularly the **rectus abdominis.** The function of these muscles may be assessed by having the patient perform a crunch, or modified sit-up. In this exercise, the patient lies supine on the examination table with the hip and the knees flexed, hands behind the head. The patient is then instructed to raise his or her shoulders off the table (Fig.13). The height to which the shoulders can be raised and the number of repetitions possible vary tremendously among individuals according to flexibility, fitness level, and prior training. A patient who cannot raise the shoulders even once has significantly weak abdominal muscles.

Extension of the lumbar spine is powered by the **erector spinae** muscle groups. To assess the function of these muscles, the patient is placed in the prone position on the examination table with the hands behind the head. The patient is then asked to lift the chest off the table {Fig. 14). Again, the height that the shoulders rise off thetable and the number of repetitions possible vary widely among patients according to flexibility, fitness level, and training. The pain associated with disorders of the posterior elements of the lumbar spine, such as spondylolysis or facet joint arthritis, or of spinal stenosis may be exacerbated by this test.

Figure 13. Modified situp demonstrates abdominal muscle strength.

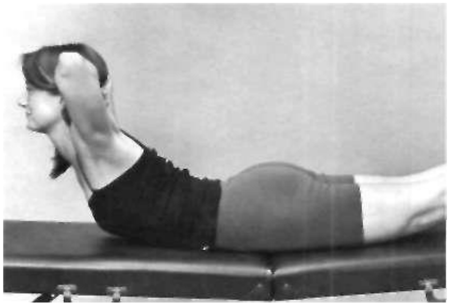


Figure14.Active extension demonstrates erector spinae strength.

When the Patient Complains of Low-Back Pain without Preceding Trauma

Major Diagnostic Possibilities Include:

- Low-back strain
- Degenerative disc disease
- Lumbar arthritis
- Herniated disk
- Spondylolysis/spondylolisthesis
- Spinal deformity
- Compression fracture
- infection
- Tumor
- Nonorganic low-back pain

Patient Age:

In patients less than 20 years old:

- Spondylolysis; isthmic spondylolisthesis
- Tumor

IN PATIENTS 20 TO 50 YEARS:

- Low-back strain
- Degenerative disk disease
- Herniated disk
- Spondylolisthesis
- Nonorganic low-back pain

In patients older than 50 years:

- Low-back strain
- Lumbar arthritis
- Compression fracture
- Infection
- Tumor
- Nonorganic low-back pain

General Medical History:

- If the patient is immunocompromised or has a history of intravenous drug abuse
- Infection is a strong possibility
- If the patient has a history of cancer
- Metastatic spread to the lumbar spine must be suspected
- If the patient has a history of osteoporosis
- Compression fracture should be considered

Ask the Patient to Describe Associated Symptoms:

- Constitutional symptoms such as weight loss, fever, or night sweats
- Suggestive of tumor or infection
- Unilateral leg paresthesias, weakness and pain
- Typical of herniated disk

- May be suggestive of lumbar arthritis with spinal stenosis
- Bilateral buttock/leg pain and cramping with ambulation
- Suggestive of lumbar arthritis with spinal stenosis
- Other possibilities include tumor or trauma resulting in neural compression
- Bowel or bladder symptoms
- May be the result of neural compression caused by a larger disc herniation, tumor or fracture

Relevant Physical Examination:

General:

Inspection Palpation

Examination of gait Range of motion Neurologic testing

Compression FRACTURE:

- Palpation for tenderness at the level of injury
- Inspection for swelling and ecchymosis at the level of injury
- Palpation for step-off
- Pain with range of motion

Spondylolysis/spondylousthesis:

- Inspection for decreased lumbar lordosis
- Hyperextension of lumbar spine to determine if
- pain reproduced
- Palpation for step-off
- Straight-leg raising test to elicit hamstring tightness
- Neurologic testing

LUMBAR SPONDYLOSIS:

Decreased lumbar range of motion Pain with lumbar range of motion

INFECTION/TUMOR:

Palpation for point tenderness at involved level Palpation for associated muscle spasm

Neurologic testing

SPINAL STENOSIS:

- Inspection for loss of lumbar lordosis
- Sciatic notch tenderness
- Passive spine extension reproduces neurogenic
- claudication
- Vascular examination to exclude vascular claudication

HERNIATED DISK:

- Nerve root tension tests (straight-leg raising, Lasegue's test, contralateral straight-leg raising, slump test, bowstring sign)
- Flexion of lumbar spine to reproduce leg symptoms Palpation of sciatic notch for tenderness
- Neurologic testing for deficit in the distribution of the involved root

LOW-BACK STRAIN:

- Palpation for paraspinal muscle tenderness or spasm
- Inspection of gait for list (variable)
- Neurologic examination should be normal

NONORGANIC LOW-BACK PAIN

• Waddell's signs

Neurologic Examination

SENSORY EXAMINATION

The approximate areas of sensory innervation from the lumbar and the sacral nerve roots are shown in Figure 9-15. As with the cervical and the thoracic nerve roots, there is considerable overlap in the sensory dermatomes, and the exact distribution of each dermatome varies somewhat from one individual to another. The initial screening for sensory deficits is usually done with light touch and sharp-dull discrimination testing, as described in Chapter 8, Cervical and Thoracic Spine. The sensory, motor, and reflex tests for each dermatome are summarized in Table 1.

The LI, L2, and L3 dermatomes run in broad bands obliquely across the anterior thigh. LI sensation is tested in the anterior proximal thigh near the inguinal ligament. (Fig.16A). Sensation supplied by the L2 nerve root is tested over the anteromedial thigh, midway between the inguinal ligament and the patella (Fig. 16B). L3 sensation may be evaluated by testing the skin just proximal or medial to the patella (Fig. 16C). The L4 nerve root supplies sensation to the medial leg and the ankle. It is best tested by examining the sensation in the area just proximal to the medial malleolus (Fig.16D). The L5 dermatome includes the lateral and the anterolateral leg and the dorsum of the foot. L5 sensation is usually tested by examining the area just proximal to the first web space (Fig. 16£).The sensory distribution of the S1 nerve root includes the posterior calf, the plantar surface of the foot, and the lateral toes. S1 sensation may be reliably tested over the posterolateral aspect of the heel (see Fig. 16F). The S2 nerve root supplies the posterior thigh and the proximal calf. S2 sensory function may be tested by evaluating sensation in the center of the popliteal fossa (see Fig.16G). The lower sacral nerve roots (S3, S4, S5) supply the sensation in the perianal area. The dermatomes are arranged in concentric rings around the anus, with the S3 dermatome being the most peripheral and the S5 being the most central

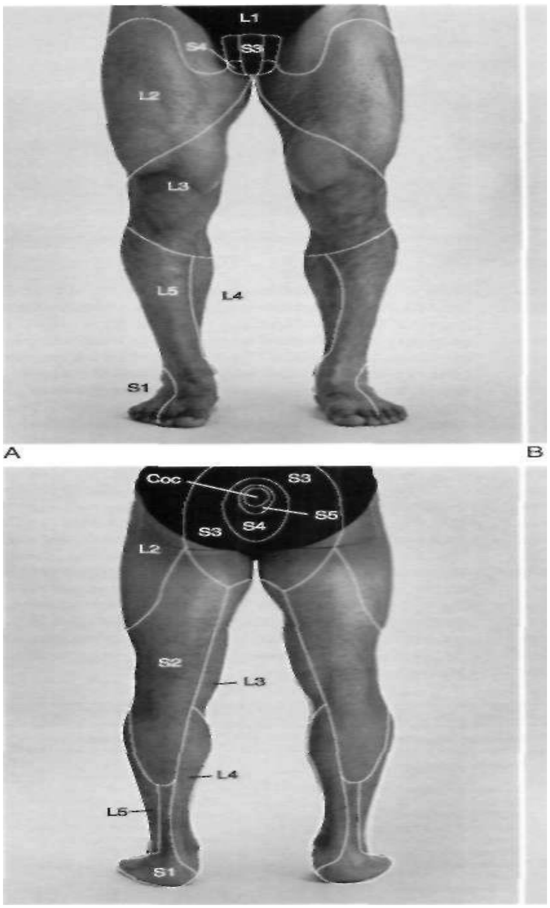


Figure 15. *A-b* Lumbar and sacral dermatomes.

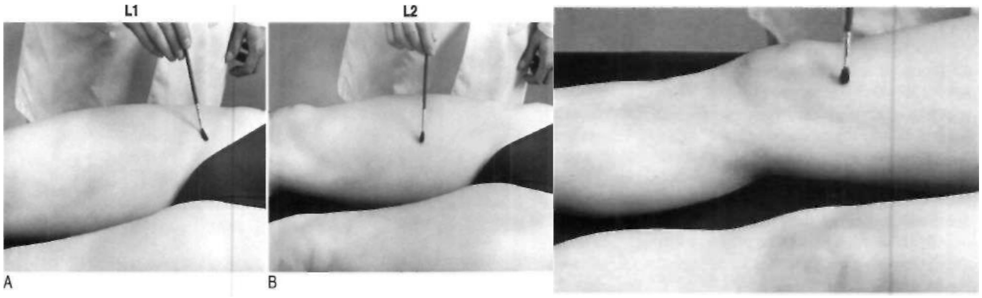


Figure 16. Sensory evaluation by lumbar and sacral dermatome. *A,* L1. *B, L2.C L3.*

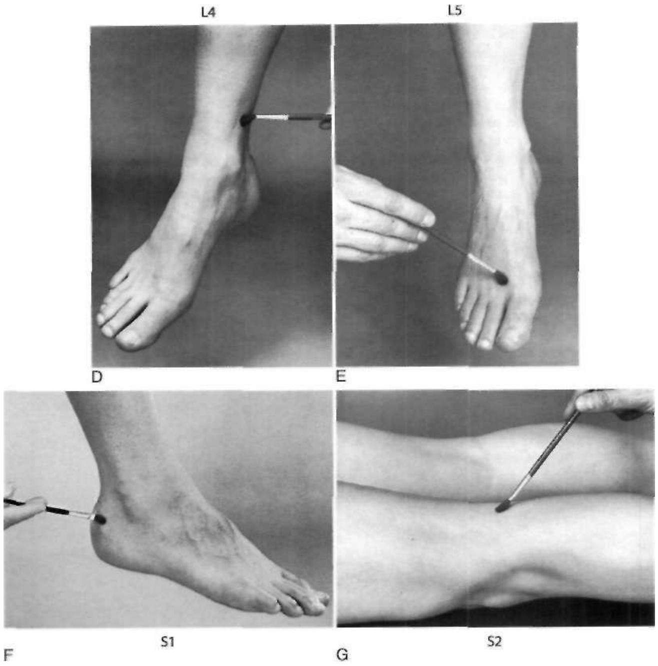


Figure **16, cont'd.** D, L4. *E,* L5. *F,* S1, G, S2.

PHYSICAL FINDINGS IN LUMBOSACRAL RADICULOPATHIES Table 1

DERMATOME	SENSORY TESTING	MOTOR TESTING	REFLEX TESTING
LI	Anterior proximal thigh near inguinal ligament	Iliopsoas (seated hip flexion)	
L2	Mid anteromedial thigh	Iliopsoas (seated hip flexion)	
L3	lust proximal or medial to patella	Quadriceps	Patellar tendon reflex (secondary)
L4	Medial lower leg and ankle	Tibialis anterior	Patellar tendon reflex
L5	Lateral and anterolateral leg and dorsal foot	Extensor hallucis longus Extensor digitorum brevis Gluteus medius	Tibialis posterior reflex Medial hamstring reflex
SI	Posterior calf, plantar foot, and lateral toes	Gastrocsoleus Peronei Gluteus maximus	Achilles' reflex
S2	Posterior thigh and proximal calf	Rectal examination	
S3, S4, S5	Perianal area	Rectal examination	

Motor Examination

The spinal cord terminates at about the L1-L2 level, but its lower nerve roots continue distally as the cauda equina. Each pair of nerve roots exits the spine at the neural foramen formed by the vertebra of the same number and the one below. Thus, the L4 nerve root exits at the L4-L5 neuroforamen, the L5 nerve root exits at the L5-S1 ncuroforamen, and so forth. However, when a lumbar disk herniation occurs, the disk tends to compress the next lower nerve root. Thus, the L5-S1 disk, the most common to herniate, usually compresses the S1 nerve root. Similarly, the L4-L5 disk usually compresses the L5 nerve root, and the L3-L4 disk, the least common of the three to herniate, usually compresses the L4 nerve root. Higher nerve roots are unlikely to be compressed by disk herniations. However, these higher nerve roots may be affected by other types of pathology, such as spinal fractures or dislocations; and congenital malformations, such as spina bifida; tumors; and infections. ***L1 and L2 Nerve Roots.*** The L1 and L2 nerve **roots** supply the iliopsoas muscle, the primary hip flexor. To test the iliopsoas, the patient is seated with the knees flexed to 90° over the end or the side of the examination table. The patient is instructed to raise the thigh off the examination table while maintaining flexion of the knee. The examiner then presses downward on the patient's knee with both hands, asking the patient to resist as strongly as possible (Fig.17). In a normal patient, the examiner should be able to overcome the iliopsoas with moderate difficulty.

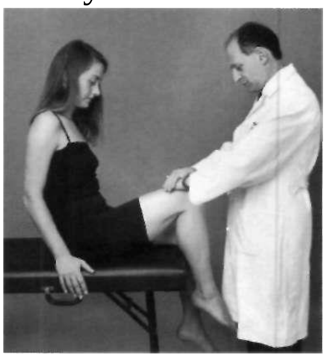


Figure 17. Assessing LI and L2 motor function (iliopsoas strength),

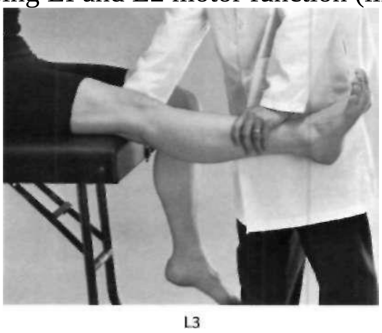


Figure 18. Assessing L3 motor function (quadriceps).

L3 Nerve Root The L3 nerve **root** is usually assessed by evaluating quadriceps strength, although the quadriceps is also innervated by L2 and L4. The quadriceps is also tested with the patient sitting on the end or the side of the examination table. The patient is asked to extend the knee fully and then to maintain the knee in full extension while the examiner pushes downward on the lower leg just above the ankle {Fig.18). In a normal patient, the examiner should be unable to overcome the quadriceps and initiate knee flexion. In fact, in a strong patient, the examiner may begin to lift the patient's pelvis off the examination table as the lower leg is pushed downward with the patient's knee locked in full extension.

L4 Nerve Root The **L4 nerve root** is usually evaluated by testing the strength of the tibialis **anterior** muscle. As previously noted, the examiner may screen for tibialis anterior weakness by asking the patient to heel walk. Specific manual resistive testing of the tibialis anterior is accomplished with the patient seated on the end or the side of the examination table. The patient is asked to maximally dorsiflex the ankle on the side being tested. The patient is then instructed to maintain this position while the examiner presses downward on the foot and attempts to passively plantar flex the ankle (Fig.19). In a normal patient, the examiner should be unable to overcome the strength of the tibialis anterior.

Figure 19- Assessing L4 motor function (tibialis anterior strength).

L5 Nerve Root The **L5** nerve **root** provides the motor supply of the long toe extensors. It is most commonly tested by evaluating the strength of the **extensor hallucis longus.** To test the extensor hallucis longus, the examiner asks the seated patient to pull up or extend the great toe. The examiner then stabilizes the medial aspect of the patient's foot with one hand while pressing downward on the distal phalanx of the great toe with the fingers or the thumb of the other hand. The patient is instructed to resist the examiner's attempt to flex the interphalangeal joint of the toe (Fig.20A).

When normal strength is present, it should be difficult for the examiner to overcome the strength of the extensor hallucis longus. In some patients, the patient's ability to demonstrate strength of the extensor hallucis longus may be limited by nonneuroiogic factors, such as the presence of severe bunions or the anatomic changes due to prior bunion surgery. In these patients, the examiner may assess the motor supply of the L5 nerve root by testing the other digital extensors or the gluteus medius. **The extensor digitorum longus** is assessed in a manner analogous to that used for the extensor hallucis longus. In this case, the examiner stabilizes the forefoot with one hand and asks the patient to extend the toes as far as possible. The examiner then instructs the patient to maintain the extended position of the toes while the examiner attempts to passively flex the toes with his or her fingers (see Fig. 20B). In a normal patient, the examiner is able to overcome the strength of the toe extensors with moderate difficulty.

The gluteus medius is evaluated by assessing the strength of hip abduction. For this test, the patient is in the lateral position on the examination table and is asked to abduct the lower limb away from the table while maintaining knee extension. The examiner then instructs the patient to maintain the position of abduction while the examiner presses downward on the distal thigh, attempting to push the thigh back toward the table (see Fig. 20C). In a normal patient, the examiner has considerable difficulty overcoming the strength of the gluteus medius. In stronger patients, the examiner may be unable to do so.

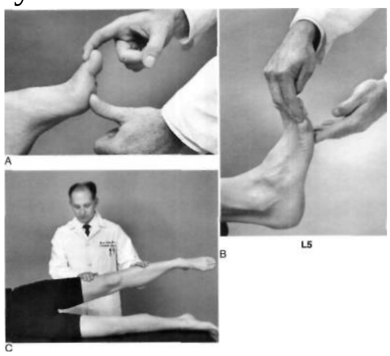


Figure 9-20. Assessing L5 motor function. *A,* Extensor hallucis longus. *B,* Extensor digitorum longus. *C,* Gluteus medius.

S1 Nerve Root. The SI nerve root provides motor supply to the plantar flexors, the evertors of the ankle, and the extensors of the hip. As previously described, the examiner may screen for weakness of the plantar flexors of the ankle by asking the patient to toe walk. Primary plantar flexion strength is provided by the gastrocsoleus complex, with assistance from the toe flexors. Manual resistance testing of the **gastrocsoleus** is usually carried out in the seated patient. The examiner stabilizes the patient's ankle with one hand and instructs the patient to passively plantar flex the ankle. The patient is told to maintain this position while the examiner attempts to force the ankle back into dorsiflexion by pressing upward on the patient's forefoot with the examiner's other hand (Fig.21 A). In a normal patient, the examiner is unable to overcome the powerful plantar flexor muscles and initiate dorsiflexion.

The peroneus longus and brevis muscles, the principal evertors of the foot, are tested in the same basic position as the gastrocsoleus complex. The examiner stabilizes the patient's leg with one hand and asks the patient to rotate the foot outward. The examiner may have to passively place the patient's foot in eversion to communicate the desired position. The patient is then instructed to maintain the foot in the everted position while the examiner attempts to invert the foot by pressing inward on the lateral aspect of the foot (see Fig.21B). In the normal patient, the examiner is able to overcome the strength of the evertors only with difficulty.

The gluteus maximus is also supplied by the SI nerve root. To test it, the patient is asked to lie prone on the examination table and to flex the knee on the side being tested. The patient is then instructed to raise the thigh off the table. Finally, the examiner presses downward on the thigh with both hands while asking the patient to maintain the position of hip extension (see Fig.21C). In a normal patient, the examiner experiences considerable difficulty pushing the thigh back to the table.

S2, S3, and S4 Nerve Roots. The S2, S3, and S4 nerve roots may be compressed or injured by tumors or fractures of the sacrum, or, more commonly, affected by spinal cord injury at a higher level. In the presence of spinal cord injury, the finding of sacral sparing, the preservation of some function of the sacral nerve roots, is a positive factor in predicting the potential for recovery of function.

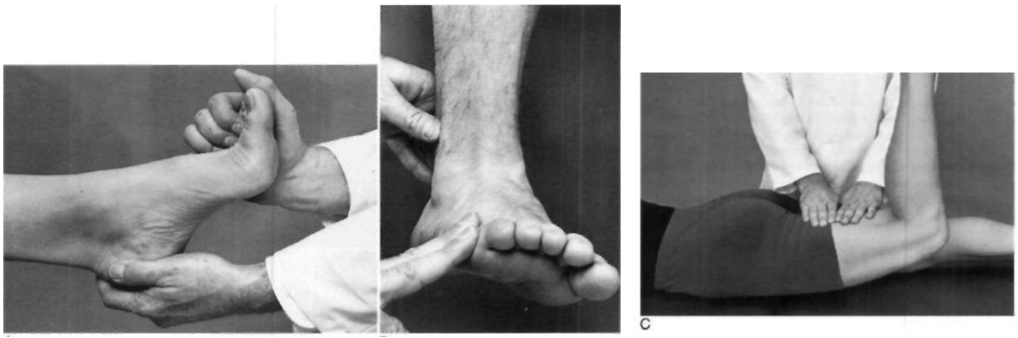


Figure **21.** Assessing SI motor function. A, Gastrocsoleus. *B,* Peroneus longus and brevis. *C*, Gluteus maximus.

The S2, S3, and S4 nerve roots are the principal nerve supply for the bladder, and they also supply the intrinsic muscles of the feet. Motor testing for these functions is difficult. The motor function of the sacral nerve roots is, therefore, usually tested by performing a rectal examination. When normal function is present, the examiner should note fairly firm resistance as the examining finger enters the rectum. The patient is then instructed to try to squeeze the examiner's finger, thus contracting the external anal sphincter. This should produce a strong, readily palpable feeling of constriction around the examiner's finger.

Deep tendon reflexes are not easily assessed for all the lumbar and sacral nerve roots. Two principal deep tendon reflexes are normally tested: the patellar tendon reflex, which primarily involves the L4 nerve root, and the Achilles tendon reflex, which primarily involves the S1 nerve root.

Patellar Tendon Reflex (L4). The **patellar tendon reflex** is usually assessed with the patient seated on the side of the examination table with the knees flexed and the feet dangling. The examiner then sharply strikes the midportion of the patellar tendon with the flat side of a rubber reflex hammer. The examiner's other hand may rest lightly on the patient's quadriceps to feel for a muscle contraction (Fig. 22.A).

To most patients, a contraction of the muscle is felt in response to the strike of the hammer, and in some patients the knee is seen to extend slightly. If no reflex is observed, the examiner may try to reinforce the reflex. To do this, the patient is instructed to hook the fingers of both hands together and pull against each other isometrically. While the patient is pulling, the examiner again strikes the patellar tendon (Fig. 22B). This technique may produce a patellar tendon reflex in patients in whom the reaction is otherwise unobtainable.

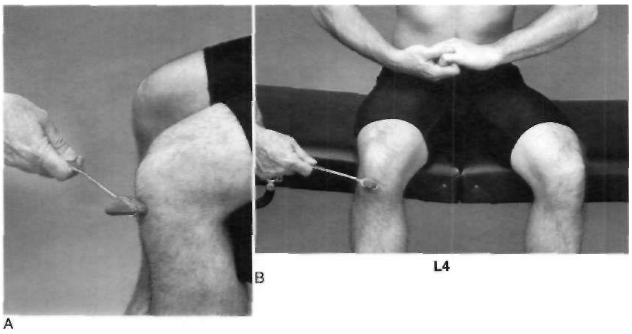


Figure 9-22. *A*, Patellar tendon reflex (L4 nerve root). *B,* Reinforcement technique.

The patellar tendon reflex is more difficult to elicit than the Achilles tendon reflex. In some normal patients, the patellar tendon reflex is symmetrically absent. As in many other aspects of the physical examination, lack of symmetry is the key to evaluating this test. The patellar tendon reflex is primarily used to evaluate the **L4 nerve root.** Some contribution from L3 is also present. ***Tibialis Posterior Reflex (L5).*** The available reflexes for the **L5 nerve root** are difficult to elicit. They include the tibialis posterior reflex and the medial hamstring reflex. The **tibialis posterior reflex** is evaluated in the seated patient. The examiner holds the patient's foot in a small amount of eversion and dorsiflexion and strikes the posterior tibial tendon just below the medial malleolus. The examiner may also place a finger on the posterior tibial tendon and strike the finger instead of striking the tendon directly (Fig. 23A). When the reflex is elicited, a slight plantar flexion inversion response is noted. *Medial Hamstring Reflex (L5).* To elicit the medial hamstring reflex, the patient is placed in the prone position. The examiner passes one hand underneath the patient's leg and places the thumb of that hand on the semitendinosus tendon in the popliteal fossa. The patient's leg is allowed to rest on the examiner's forearm so that the patient's knee is somewhat flexed. The examiner then strikes the thumb, which is pressing on the semitendinosus tendon, with the pointed end of the hammer (see Fig. 23B). When the reflex is elicited, the examiner feels a contraction transmitted through the semitendinosus tendon or actually sees slight flexion of the knee take place.

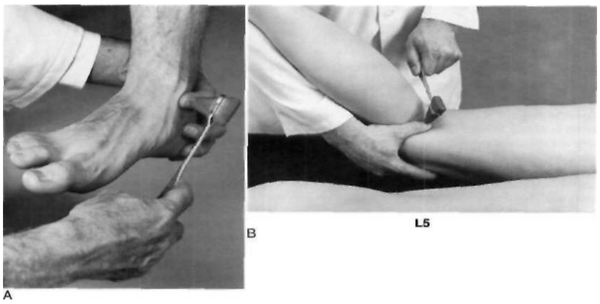


Figure 23. L5 nerve root reflexes. *A*, Tibialis posterior. *B*, Medial hamstring.

Achilles' Tendon Reflex (S1). The **Achilles tendon reflex** represents the **S1 nerve root.** This reflex may be elicited in the patient who is seated with the legs dangling comfortably off the end or side of the examination table. The examiner gently dorsiflexes the foot to place the Achilles tendon under tension, and then strikes the Achilles about 3 cm above the calcaneus using the flat end of the reflex hammer (Fig. 24A).

In most patients, this action produces a visible twitch of the ankle into plantar flexion. As with other deep tendon reflexes, a unilateral decrease in the magnitude of or disappearance of the Achilles reflex suggests a lower motor neuron lesion. The most common cause of this picture is a herniated L5-S1 disk impinging the ipsilateral S1 nerve root. Bilateral hyperreflexia suggests the possibility of an upper motor neuron lesion.

If the examiner experiences difficulty in eliciting the Achilles tendon reflex, the use of **reinforcement** techniques is often helpful. A convenient method for reinforcing the Achilles tendon reflex is to ask the patient to kneel on the examination table with the feet projecting a few inches past the end or side (see Fig.*24B).* The examiner then strikes each Achilles in turn as already described. This technique brings out the Achilles tendon reflex in the vast majority of individuals.

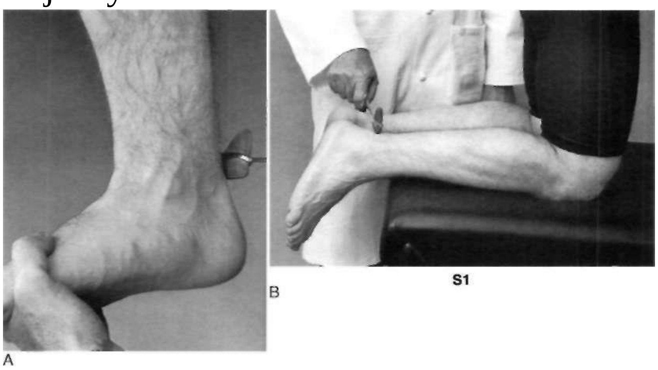


Figure 24. *A,* Achilles' tendon reflex (S1 nerve root). *B,* Reinforcement technique.

Pathologic Reflexes

If undue briskness of the Achilles or the patellar tendon reflexes leads the examiner to suspect the presence of an upper motor neuron lesion, the provocative tests **for ankle clonus** and the **Babinski sign** should be carried out. It is important to remember that the spinal cord usually ends at the inferior margin of the L1 vertebra. Distal to this level, the nerve roots that constitute **the** cauda equina function very much like peripheral nerves. Thus, for an upper motor neuron picture to occur, a lesion must typically be situated at the L1 level or higher.

Nerve Tension Tests

An important component of the lumbar spine examination is to determine whether evidence of nerve root compression exists. Nerve root compression is usually considered probable when stretching the peripheral nerve associated with the nerve root in question reproduces pain in the distribution of that nerve. The most important peripheral nerves deriving from the lumbar and the sacral nerve roots are the femoral and the sciatic nerves. The **femoral nerve** runs down the anteromedial aspect of the thigh and is formed by the L2, L3, and L4 nerve roots. The **sciatic nerve** runs down the posterior thigh and is formed by the L4, L5, S1, S2, and S3 nerve roots.

Straight-Leg Raising Test

The **straight-leg raising test** is the most well-known nerve tension test for the lumbar spine. The test is performed with the patient lying in a comfortable supine position with the head and pelvis flat. While full knee extension is maintained, one of the patient's feet is slowly lifted off the table. The limb is progressively elevated until maximal hip flexion is reached or the patient asks the examiner to stop owing to pain (Fig.25). The angle formed by the lower limb and the examination table at the point of maximal elevation is noted, and the procedure is repeated with the opposite limb.

In a normal patient, straight-leg raising of 70° to 90° should be possible and may be accompanied by a feeling of tightness in the posterior thigh. In the presence of sciatica, the angle of hip flexion is reduced and the patient reports shooting pain radiating down the posterior thigh and often into the lower leg along the distribution of the sciatic nerve. Straight-leg raising stretches the L5 and SI nerve roots 2 mm to 6 mm, but it puts little tension on the more proximal nerve roots. An abnormal straight-leg raising test, therefore, suggests a lesion of either the L5 or the S1 nerve root. Beyond 70° of hip flexion, deformation of the sciatic nerve occurs beyond the spine. Sciatic pain that is reproduced only with hip flexion beyond 70°, therefore, suggests the possibility of sciatic nerve compression outside the spinal canal. If the patient with limited straight-leg raising reports tightness in the posterior thigh rather than sciatica, hamstring tightness is the probable cause. Hamstring tightness may be associated with a wide variety of conditions, including spondylolysis. Lasegue's test, discussed later, does not exacerbate the discomfort of hamstring tightness the way it exacerbates sciatica. Recent studies have confirmed that the straight-leg raise test is extremely sensitive (0.9) but rather less specific (0.26) for confirming the presence of a compressed or irritated lumbar nerve root.

Crossed Straight-Leg Raising Test

Performing the straight-leg raising test on the side opposite that of the sciatica is called the crossed straight-leg raising test. For example, if a patient complains of right-sided sciatica, the examiner performs a straight-leg raising test on the patient's left side. If this maneuver reproduces or exacerbates the patient's right-sided sciatica, the result is extremely sensitive and specific for a herniated L5-S1 or L4-L5 lumbar disk. The crossed straight-leg raising test is less sensitive (.29) but more specific (.88) than the straight-leg raising test for confirming a compressed or irritated lumbar nerve root.

Lasegue's Test

Lasegue's test is a progression of the straight-leg raising test. To perform Lasegue's test, the examiner carries out the straight-leg raising test, pausing when the patient complains of reproduction of his or her typical sciatic pain. While maintaining the degree of hip flexion at which sciatic pain is induced, the examiner passively dor-siflexes the foot of the leg being raised (Fig. 26). This maneuver further deforms the sciatic nerve. If the patient's radicular pain is exacerbated, the diagnosis of sciatica is strengthened. Lasegue's test may also reproduce radicular pain in some cases of lumbar disk herniation in which the straight-leg raising test is otherwise negative. The results of both the straight-leg raising test and the Lasegue test are abnormal in most cases of lumbar disk herniation, however. The sensitivity of Lasegue's test is reported to be 0.7.

Figure 25. Straight-leg raising test

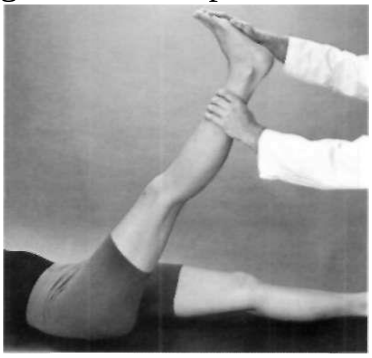
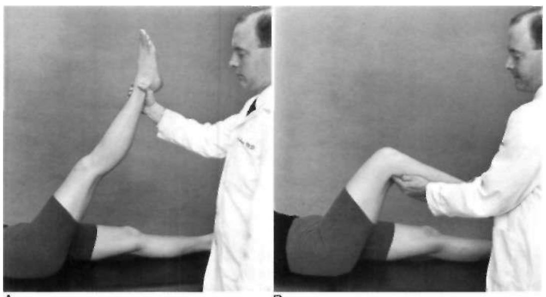


Figure 26. Lasegue's test.

Bowstring Sign

MacNab described another confirmatory test for sciatic nerve tension known as the bowstring sign. To elicit the bowstring sign, the examiner again begins by performing the straight-leg raising test to the point of reproduction of the patient's radicular pain. The knee is then flexed 90°, which usually relieves the patient's symptoms. Digital pressure is then applied to the popliteal fossa over the posterior aspect of the sciatic nerve (Fig. 27). If this again reproduces the patient's radicular pain, the impression of sciatica is further confirmed. The sensitivity of the bowstring sign is similar to that of Lasegue's test in confirming lumbar radiculopathy (0.69).



A B

Figure 27. *A* and *B*, Bowstring sign.

Slump Test

The slump test is really a variant of the straight-leg raising and Lasegue's tests performed in the seated position. The slump test is a progressive series of maneuvers designed to place the sciatic nerve roots under increasing tension. The patient begins the slump test sitting on the side of the examination table with the back straight, looking straight ahead (Fig.28A). The patient is then encouraged to slump, allowing the thoracic and lumbar spines to collapse into flexion while still looking straight ahead (Fig. 28B). The next step is to fully flex the cervical spine (Fig. 28C). The patient is then instructed to extend one knee, thus performing a straight-leg raise (Fig. 28D). The patient then dorsiflexes the foot on the same side, thus duplicating the Lasegue test (Fig.28E). The process is then repeated with the opposite lower extremity.

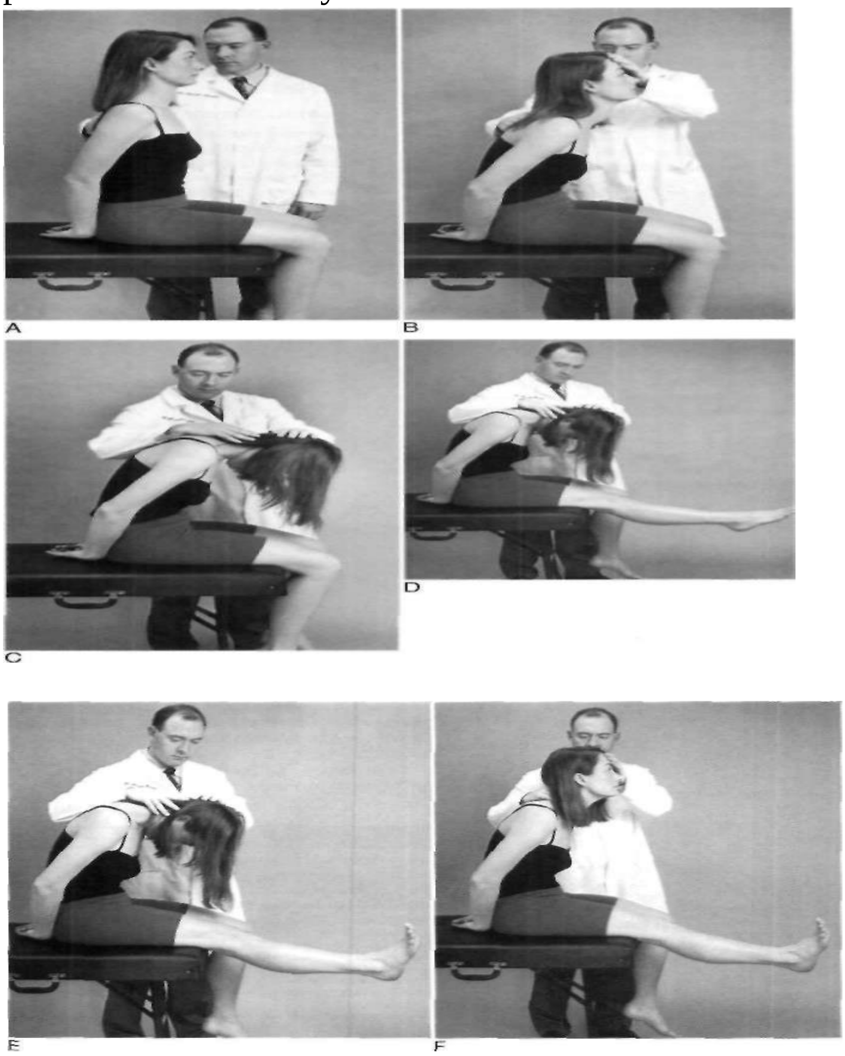


Figure 28. *A-F,* Slump test

At each stage in the procedure, the patient informs the examiner what is being felt and whether radicular pain is produced. Many normal individuals feel tightness in the lower back and the thigh with this series of maneuvers. Reproduction of familiar radicular pain, as in the straight-leg raising, Lasegue, and crossed straight-leg raising tests, is highly suggestive of sciatic nerve root tension. Subsequent extension of the neck relaxes the spinal cord and may thus relieve nerve tension (Fig. 28F).

Femoral Nerve Stretch Test

As noted, the straight-leg raising test and its variants do not place significant tension on the nerve roots above L5. Although compression of the upper lumbar nerve roots is not common, it does occur. Herniations of the L3-L4 disk commonly compress the L4 nerve root. The femoral nerve stretch test is designed to assess compression of the L2, L3, or L4 nerve roots. To perform the femoral nerve stretch test, the patient is positioned prone on the examination table with the knee flexed to at least 90°. The patient's hip is then extended passively by lifting the thigh off the examination table (Fig.29). In the normal patient, this induces only a mild feeling of tightness in the anterior thigh. When one of the nerve roots that contribute to the femoral nerve is compressed, this maneuver reproduces the patient's radicular pain in the anterior thigh.

Miscellaneous Special Tests

Single Leg Hyperextension Test

It has already been noted that hyperextension of the lumbar spine is often painful in the presence of *spondylolysis.* The single leg hyperextension test has been described as a more specific test to detect the presence of spondylolysis and to suggest which side is involved in the process. To perform the single leg hyperextension test, the patient is asked to stand in the straddle position with one lower limb extended behind the other. The patient is then instructed to lean back as far as possible, and the examiner assists the patient in achieving the maximal hyperextension of the spine possible without falling over (Fig. 30). The procedure is then repeated with the position of the lower limbs reversed. In the presence of unilateral spondylolysis, hyperextension tends to exacerbate the patient's pain and the pain tends to be more severe when the lower limb on the affected side is extended posteriorly.

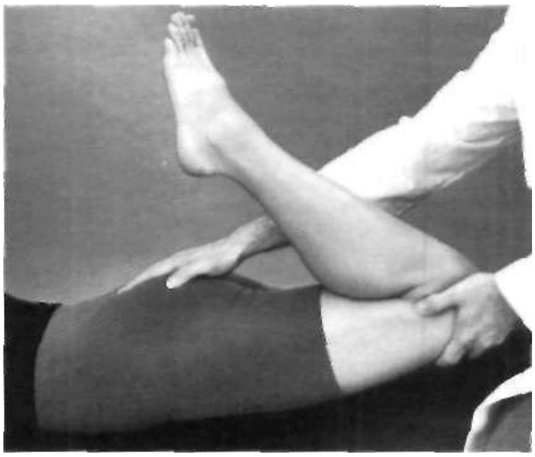


Figure 29. Femoral nerve stretch test

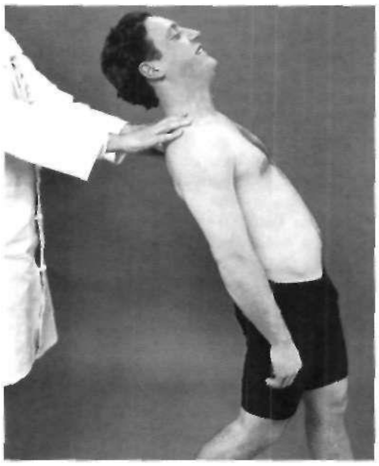


Figure 30. Single leg hyperextension test.

Valsalva's Maneuver

The **Valsalva maneuver** is designed to increase intrathecal pressure and therefore exacerbate pain that is due to pressure on the spinal cord or its nerve roots. To perform the Valsalva maneuver, the patient is instructed to bear down as if attempting to have a bowel movement (Fig. 31). If pain is present owing to pressure on the spinal cord or the nerve roots, this maneuver usually exacerbates the pain. Pain from other causes should not be affected by the Valsalva maneuver.

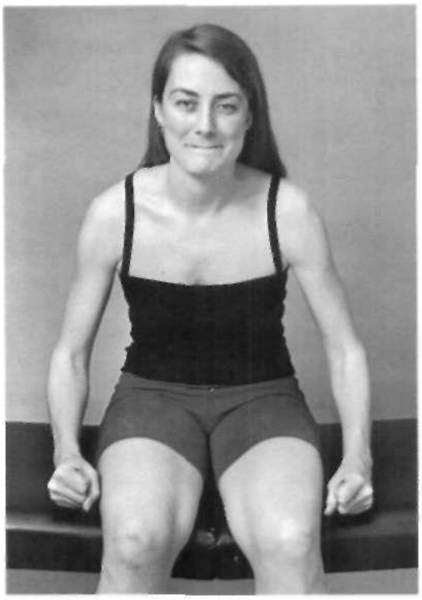


Figure **31.** Valsalva's maneuver.

Nonorganic Signs of Waddell

Waddell's nonorganic signs, already discussed in Chapter 8, Cervical and Thoracic Spine, were actually originally described in conjunction with the lumbar spine. They are helpful signals to alert the examiner to the possibility of nonorganic pathology or organic symptoms that are being enhanced by nonorganic factors.

Examination of Other Areas and Systems Pain due to lumbar spine pathology frequently radiates to the pelvis, the posterior hip, or the thigh. In the case of lumbar disk disease, back pain may sometimes be completely absent, with the patient sensing pain only in the sciatic notch and the posterior thigh areas. Patients with this clinical picture often believe that they have a painful hip joint or a hamstring -strain. Complete investigation of potential lumbar spine pathology, therefore, often includes evaluation of the **sacroiliac joint,** the **sacrum** and the **pelvis,** the **hip** joint, and the **thigh.** Because the symptoms of *claudication* due to peripheral vascular disease are similar to those of *pseudoclaudi-cation* associated with spinal stenosis, an examination of the **peripheral circulation** of the lower extremities is often a necessary adjunct to the lumbar spine examination. Finally, the examiner must always remember that pathology of the **abdomen** or the **retroperitoneum** may present with back pain and must be alert for symptoms or signs that might indicate a disease process in one of these areas.

PHYSICAL FINDINGS IN COMMON CONDITIONS OF THE LUMBAR SPINE

Herniated Lumbar Disk (Herniated Nucleus Pulposus) Reproduction or exacerbation of sciatic symptoms with nerve tension tests (straight-leg raising, Lasegue's lest, slump test, bowstring sign) Reproduction of sciatica with flexion of the lumbar spine Reproduction of sciatica with crossed straight-leg raising test (highly specific) Sciatic notch tenderness Lumbar muscle spasm or list away from the involved nerve root (variable) Neurologic deficit in the distribution of the involved nerve root (variable) Exacerbation of pain by Valsalva's maneuver

Spinal Stenosis

Loss of normal lumbar lordosis Passive spine extension reproduces leg symptoms Sciatic notch tenderness

Motor or sensory deficit (variable) Abnormal straight-leg raising test (infrequent)

Spondylolysis

Lumbar tenderness at the level of involvement (variable) Decreased lumbar lordosis (variable)

Hamstring tightness with straight-leg raising test Pain exacerbated by hyperextension of the lumbar spine (passive extension, active extension, single leg extension test) (frequent) Signs of associated spondylolisthesis, if present

Spondylolisthesis

Signs of spondylolysis (see above) Visible or palpable lumbar step-off (more severe cases) Sciatic notch tenderness (variable)
Motor or sensory deficit (variable)

Lumbar Fracture

- Tenderness at the level of injury
- Localized swelling and hematoma or ecchymosis
- Lower motor neuron deficit owing to injury to the cauda equina or the nerve roots (variable)

- Upper motor neuron deficit if lesion above the level of the cauda equina

Lumbar Spondylosis

- Decreased range of motion
- Pain exacerbated by motion (variable)
- Localized or diffuse tenderness (variable)

Low-Back Strain

- Paraspinous muscle tenderness Paraspinous muscle spasm (variable)
- Symptoms exacerbated by forward flexion List (variable)
- Normal neurologic examination

Take Home Points

1. Lumbar spine examination should include careful inspection, gait, range of motion testing, and a thorough neurologic examination.
2. Palpation of the lumbar spine should be performed to identify any areas of tenderness or "step-off."
3. Neurologic examination should include motor, sensory, and reflex testing in the distribution of the lumbar nerve roots.
4. Nerve tension tests are helpful at identifying pressure on a nerve root such as that caused by a herniated disk. The straight-leg raising test is more sensitive for nerve root compression, while the crossed straight-leg raising test is more specific.
5. Profound or progressive neurologic deficit mandates immediate patient work-up.

The sacroiliac joint

The **sacroiliac joint** or **SI joint (SIJ)** is the joint between the sacrum and the ilium bones of the pelvis, which are connected by strong ligaments. In humans, the sacrum supports the spine and is supported in turn by an ilium on each side. The joint is strong, supporting the entire weight of the upper body. It is a synovial plane joint with irregular elevations and depressions that produce interlocking of the two bones. The human body has two sacroiliac joints, one on the left and one on the right that often match each other but are highly variable from person to person.(fig 32)

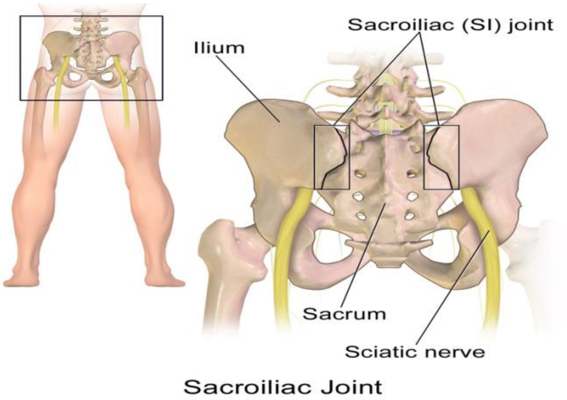


Figure **32.** Sacroiliac joint

Structure

Sacroiliac joints are paired C-shaped or L-shaped joints capable of a small amount of movement (2–18 degrees, which is debatable at this time) that are formed between the auricular surfaces of the sacrum and the ilium bones. The joints are covered by two different kinds of cartilage; the sacral surface has hyaline cartilage and the iliac surface has fibrocartilage The SIJ's stability is maintained mainly through a combination of only some bony structure and very strong intrinsic and extrinsic ligaments. The joint space is usually 0.5 to 4 mm.

As we age the characteristics of the sacroiliac joint change. The joint's surfaces are flat or planar in early life but as we start walking, the sacroiliac joint surfaces develop distinct angular orientations and lose their planar or flat topography. They also develop an elevated ridge along the iliac surface and a depression along the sacral surface. The ridge and corresponding depression, along with the very strong ligaments, increase the sacroiliac joints' stability and makes dislocations very rare. The *fossae lumbales laterales* ("dimples of Venus") correspond to the superficial topography of the sacroiliac joints.

Ligaments

The ligaments of the sacroiliac joint include the following:

- Anterior sacroiliac ligament

- Interosseous sacroiliac ligament
- Posterior sacroiliac ligament
- Sacrotuberous ligament
- Sacrospinous ligament

The anterior ligament is not much of a ligament at all and in most cases is just a slight thickening of the anterior joint capsule. The anterior ligament is thin and not as well defined as the posterior sacroiliac ligaments. The posterior sacroiliac (SI) ligaments can be further divided into short (intrinsic) and long (extrinsic). The dorsal interosseous ligaments are very strong ligaments. They are often stronger than bone, such that the pelvis may actually fracture before the ligament tears. The dorsal sacroiliac ligaments include both long and short ligaments. The long dorsal sacroiliac joint ligaments run in an oblique vertical direction while the short (interosseous) runs perpendicular from just behind the articular surfaces of the sacrum to the ilium and functions to keep the sacroiliac joint from distracting or opening. The sacrotuberous and sacrospinous ligaments (also known as the extrinsic sacroiliac joint ligaments) limit the amount the sacrum flexes.

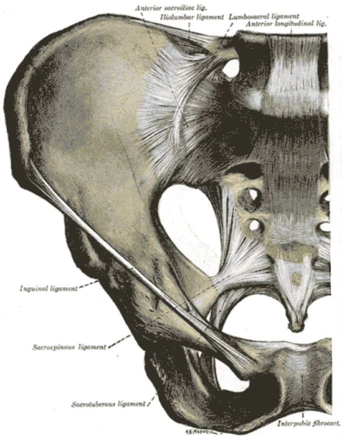


Figure **33.** Articulations of pelvis. Anterior view.

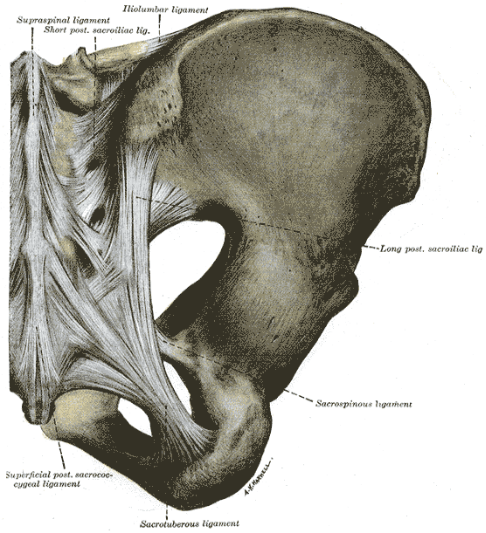


Figure **34.** Articulations of pelvis Posterior. view.

The ligaments of the sacroiliac joint loosen during pregnancy due to the hormone relaxin; this loosening, along with that of the related symphysis pubis, permits the pelvic joints to widen during the birthing process. The long SI ligaments may be palpated in thin persons for pain and compared from one side of the body to the other; however, the reliability and the validity of comparing ligaments for pain have currently not been shown. The interosseous ligaments are very short and run perpendicular from the iliac surface to the sacrum, they keep the auricular surfaces from abducting or opening/distracting.

Function

Like most lower extremity joints, one of the SI joints' functions is shock absorption (depending on the amount of available motion at the sacroiliac joint) for the spine, along with the job of torque conversion allowing the transverse rotations that take place in the lower extremity to be transmitted up the spine. The SI joint, like all lower extremity joints, provides a "self-locking" mechanism (where the joint occupies or attains its most congruent position, also called the close pack position) that helps with stability during the push-off phase of walking. The joint locks (or rather becomes close packed) on one side as weight is transferred from one leg to the other, and through the pelvis the body weight is transmitted from the sacrum to the hip bone.

The motions of the sacroiliac joint

- Anterior innominate tilt of both hip bones on the sacrum (where the left and right move as a unit)
- Posterior innominate tilt of both hip bones on the sacrum (where the left and right move together as a unit)
- Anterior innominate tilt of one innominate bone while the opposite innominate bone tilts posteriorly on the sacrum (antagonistic innominate tilt) which occurs during gait
- Sacral flexion (or nutation) Motions of the sacrum occur simultaneous with motion of the ilium so you must be careful in the description of these as isolated motions.
- Sacral extension (or counter-nutation).

The sacroiliac joints like all spinal joints (except the atlanto-axial) are bicondylar joints, meaning that movement of one side corresponds to a correlative movement of the other side.

Clinical significance

Inflammation and dysfunction

Sacroiliitis and Sacroiliac joint dysfunction

Sacroiliitis refers to inflammation of one or both sacroiliac joints, and is one cause of unilateral low back pain. With sacroiliitis, the individual may experience pain in the low back, buttock or thigh, depending on the amount of inflammation. Common problems of the sacroiliac joint are often called sacroiliac joint dysfunction (also termed SI joint dysfunction; SIJD). Sacroiliac joint dysfunction generally refers to pain in the sacroiliac joint region that is caused by abnormal motion in the sacroiliac joint, either too much motion or too little motion. It typically results in inflammation of the SI joint, or sacroiliitis.

Signs and symptoms

The following are signs and symptoms that may be associated with an SI joint (SIJ) problem:

- Mechanical SIJ dysfunction usually causes a dull unilateral low back pain.
- The pain is often a mild to moderate ache around the dimple or posterior superior iliac spine (PSIS) region.

- The pain may become worse and sharp while doing activities such as standing up from a seated position or lifting the knee towards the chest during stair climbing.
- Pain is typically on one side or the other (unilateral PSIS pain), but the pain can occasionally be bilateral.
- When the pain of SIJ dysfunction is severe (which is infrequent), there can be referred pain into the hip, groin, and occasionally down the leg, but rarely does the pain radiate below the knee.
- Pain can be referred from the SIJ down into the buttock or back of the thigh, and rarely to the foot.
- Low back pain and stiffness, often unilateral, that often increases with prolonged sitting or prolonged walking.
- Pain may occur during sexual intercourse; however, this is not specific to just sacroiliac joint problems.

Sacroiliac joint dysfunction is tested using provocative and nonprovocative maneuvers. Nonprovocative sacroiliac joint examination maneuvers would include Gillet Test, prone knee flexion test, supine long sitting test, standing flexion test, and seated flexion test. There is a lack of evidence that these sacroiliac joint mobility maneuvers detect motion abnormalities.

Given the inherent technical limitations of the visible and palpable signs from these sacroiliac joint mobility maneuvers another broad category of clinical signs have been described called provocative maneuvers. These maneuvers are designed to reproduce or increase pain originating from within the sacroiliac joint. When the provocative maneuvers reproduce pain along the typical area raises suspicion for sacroiliac joint dysfunction. However no single test is very reliable in the diagnosis of sacroiliac joint dysfunction. Weakness, numbness, or the loss of a related reflex may indicate nervous system damage.

The current gold standard for diagnosis of sacroiliac joint dysfunction emanating within the joint is sacroiliac joint injection confirmed under fluoroscopy or CT-guidance using a local anesthetic solution. The diagnosis is confirmed when the patient reports a significant change in relief from pain and the diagnostic injection is performed on 2 separate visits. Published studies have used at least a 75 percent change in relief of pain before a response is considered positive and the sacroiliac joint deemed the source of pain.

Pregnancy

The hormonal changes of menstruation, pregnancy, and lactation can affect the integrity of the ligament support around the SIJ, which is why women often find the days leading up to their period are when the pain is at its worst. During pregnancy, female hormones are released that allow the connective tissues in the body to relax. The relaxation is necessary so that during delivery, the female pelvis can stretch enough to allow birth. This stretching results in changes to the SIJs, making them overly mobile. Over a period of years, these changes can eventually lead to wear-and-tear arthritis. As would be expected, the more pregnancies a woman has, the higher her chances of SI joint problems. During the pregnancy, micro tears and small gas pockets can appear within the joint.

Muscle imbalance, trauma (e.g., falling on the buttock) and hormonal changes can all lead to SIJ dysfunction. Sacroiliac joint pain may be felt anteriorly, however, care must be taken to differentiate this from hip joint pain.

Women are considered more likely to suffer from sacroiliac pain than men, mostly because of structural and hormonal differences between the sexes, but so far no credible evidence exists that confirms this notion. Female anatomy often allows one fewer sacral segment to lock with the pelvis, and this may increase instability.

Sacroiliac joint STRESS TESTS

Patrick's Test. Several tests are designed to screen for pain arising from the joints of the pelvis. They may be helpful in localizing pain due to pathology such as arthritis or infection of these joints. They are provocative tests designed to elicit pain by stressing an affected joint. The most well known of these is **Patrick's test** of the sacroiliac joint. Patrick's test is also known as the **FABER test,** an acronym for Flexion-ABduction External Rotation, the figure-four position in which the test is performed.

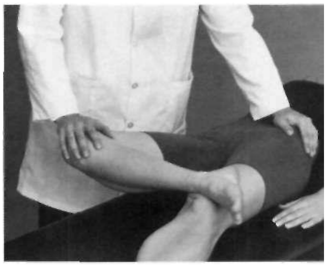
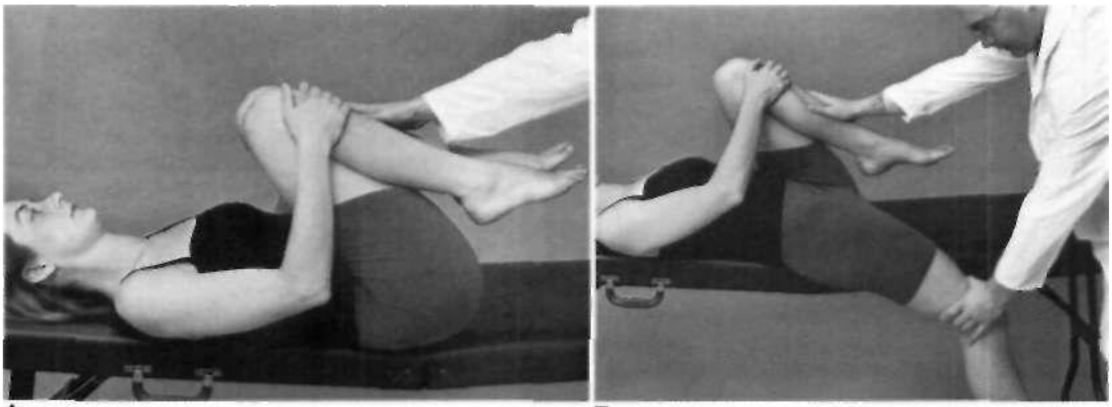


Figure 35. Patrick's test

To perform Patrick's test, the patient is placed supine on the examination table, and the limb to be examined is guided into the figure-four position with the ipsilateral ankle resting across the contralateral thigh proximal to the knee joint. The examiner then presses downward on the ipsilateral knee with one hand while providing counterpres-sure with the other hand on the contralateral ASIS {Fig. 35). This maneuver tends to stress the sacroiliac joint on the side being tested. In the normal patient, this maneuver should not be painful. If Patrick's test produces posterior hip pain, pathology of the sacroiliac joint should be suspected. An arthritic hip may also be painful when placed in this position, but the pain is normally felt in the anterior groin. The figure-four position also places the iliopsoas muscle on stretch. Pathology of the iliopsoas, such as an intrapelvic abscess irritating the iliopsoas sheath, leads to pain in this position. This is sometimes called the **iliopsoas sign.**

Gaenslen's Test. Gaenslen's test is another indirect stress test for the sacroiliac joint. To perform it, the patient is positioned supine on the examination table with the buttock of the side to be examined projecting over the side of the table. The patient is instructed to draw both knees up to the chest, as in the first step of the Thomas test (Fig.36A). The examiner carefully stabilizes the patient while the ipsilateral thigh is allowed to drop off the side of the table, thus fully extending the hip (Fig. 36B). This maneuver stresses the ipsilateral sacroiliac joint. If it induces pain in the sacroiliac joint, then pathology of that joint is suggested.



A B

Figure 36. *A* and *B*, Gaenslen's lest.

Lateral Pelvic Compression Test. The **lateral pelvic compression test** is a screening examination for pathology of the major joints of the pelvic ring. To perform it, the patient is placed in the lateral decubitus position on the examination table. The examiner presses on the iliac crest, thus compressing the pelvis against the examination table (Fig. 37). Pain localized by the patient to either sacroiliac joint or the pubic symphysis is indicative of pathology at that site.

Anteroposterior Pelvic Compression Test. The anteroposterior pelvic compression test is analogous to the lateral pelvic compression test but compresses the pelvis in a different plane. In this case, the patient lies supine on the examination table, and the examiner presses downward on the pubic symphysis (Fig.38). This maneuver may be slightly uncomfortable but should not be painful in a normal patient. As in the lateral pelvic compression test, pain localized to one of the major joints of the pelvis suggests pathology in that joint.

Figure 37. Lateral pelvic compression lest

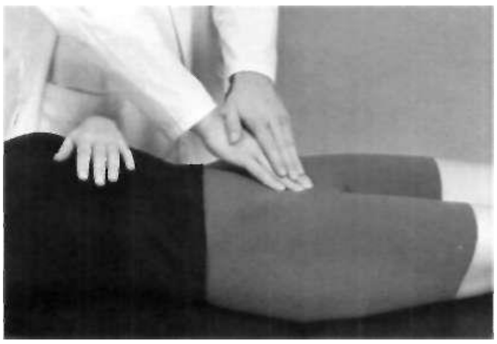


Figure **38.** Anteroposterior pelvic compression test.

Pubic Symphysis Stress Test. The pubic symphysis stress test is designed to detect instability or pain associated with an injured or inflamed pubic symphysis. It is performed with the patient lying supine on the examination table. The examiner places one hand on the superior aspect of one pubic bone and the other hand on the inferior aspect of the other pubic bone. The hands are then pushed toward each other, creating a shearing motion at the pubic symphysis (Fig. 39). The test is positive if motion or pain is produced with this maneuver. In the case of an acute fracture or major disruption, gentle palpation may be sufficient to arrive at a diagnosis.

Figure **39.** Pubic symphysis stress test *(arrows* indicate direction of applied forces).

Cervical and Thoracic Spine examination

The spine performs two important functions in the human body. First, it provides stability and continuity, supporting the head on the thorax and the thorax on the pelvis. Second, it protects and transmits the neural elements of the central nervous system (CNS) from the brain to the periphery. The injuries and the disorders that affect the spine can interfere with one or both of these functions and may produce symptoms accordingly.

The structure of the spine reflects its function. The spine is composed of 24 distinct vertebrae—7 cervical, 12 thoracic, and 5 lumbar—perched on the solid base provided by the sacrum and the pelvis. The structure of each vertebra follows the same basic pattern, with modifications, as required, to fulfill its own particular function. The anterior portion of each vertebra (except Cl) is a modified cylinder known as the *vertebral body.* The column formed by these bodies provides much of the stability of the spine. Linking each pair of vertebral bodies is an intervertebral disk that provides elements of stability, flexibility, and shock absorption. The portion of each vertebra posterior to the body is known as the *posterior elements.* These include the *pedicles,* which link the rest of the posterior elements to the vertebral body; the *laminae;* the *posterior facet joints;* and the *transverse* and *spinous processes.* The posterior elements create a protective canal for the spinal cord and its nerve roots, provide additional stability, and function as attachment sites for the intrinsic muscles of the spine. The intimate relationship of the structural elements to the neurologic elements of the spine means that structural abnormalities, such as herniated disks, fractures, or degenerative changes, can often produce neurologic symptoms.

The cervical spine serves as a pedestal for the head and is adapted to allow the mobility necessary to vary the position of the head in relationship to the surrounding environment. The increased exposure and mobility of the cervical spine places it at greater risk for trauma or chronic degenerative changes.

In contrast to the cervical spine, the thoracic spine is stiff and stable. Not only are the individual vertebrae designed to permit only limited movement but also the articulating ribs provide even greater stability and support. The thoracic spine's design provides much of the explanation for the low incidence of disk injuries and degenerative disorders in the thoracic spine compared with the cervical spine.

INSPECTION

Surface Anatomy and Alignment

When inspecting the cervical and the thoracic spine, the overriding goal should be to detect any departure from perfect symmetry. Possible causes of asymmetry include malunions or nonunions of fractures, developmental abnormalities such as scoliosis, muscular asymmetry such as that seen in torticollis, or localized masses from tumors or glandular enlargement.

Posterior Aspect

To inspect the cervical and the thoracic spine from the posterior aspect, the patient is asked to stand facing directly away from the examiner (Fig. 1). Because the spine is located just deep to the dorsal surface of the body, posterior inspection reveals the most specific information regarding spinal pathology. From the top of the head to the natal cleft over the sacrum and the coccyx, all structures should appear perfectly symmetric. The head should be centered squarely on the neck. At the point where the cervical spine joins the occiput at the base of the skull, a definite bump, called the inion, should be either clearly visible or palpable, depending on the hairstyle and the build of the patient (Fig. 2). Beginning at the inion, the spine should be visible as a linear furrow running all the way to the sacrum, studded with small bumps that represent the spinous processes of the vertebrae. In the normal situation, the spine should be so straight that a plumb line dropped from the inion would pass perfectly over it and hang down in the natal cleft. Vertebra Prominens. At the cervicothoracic junction, one large spinous process is seen to stand out from those above and below it. This is often called the vertebra **prominens,** and it identifies the spinous process of C7. Above this, the spinous processes of the cervical vertebrae are bifid and less prominent. Forward flexion of the neck and back tends to make the C7 and Tl spinous processes more prominent in a thin individual (Fig. 3).

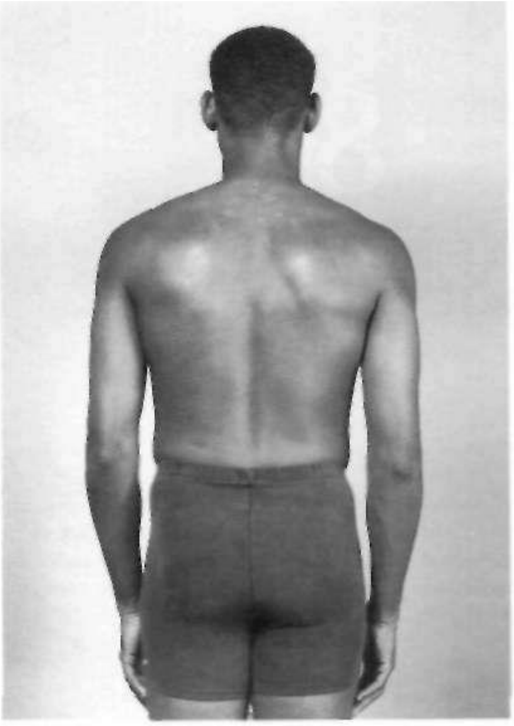
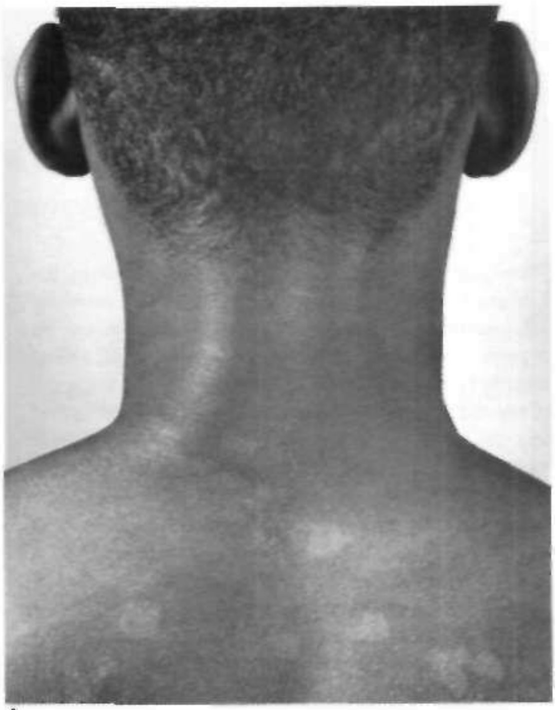
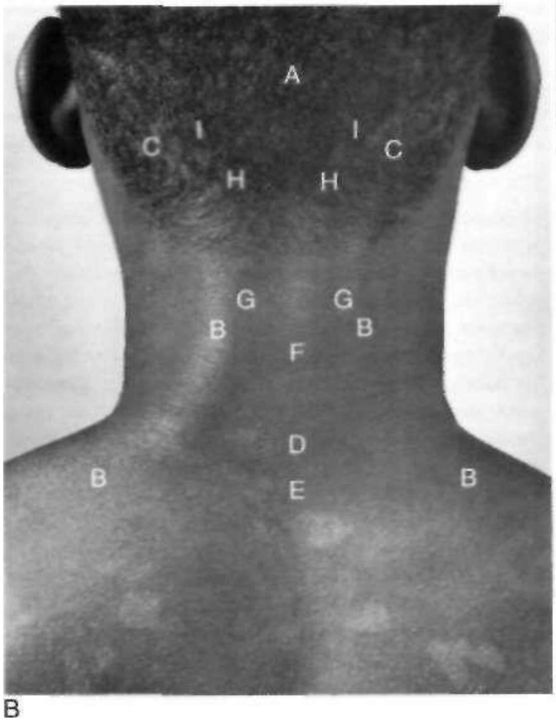


Figure 8-1. Posterior aspect of the spine.



A



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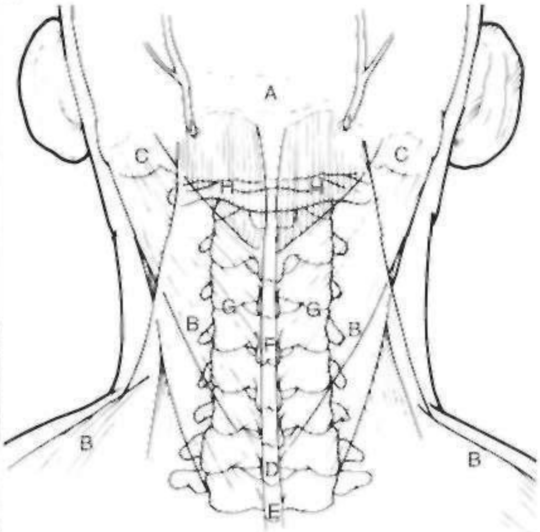


C

Figure -2. *A, B,* and *C,* Posterior aspect of the neck. *A,* inion; *B,* trapezius; C, transversocostal muscle group; *D,* C7 spinous process; *E,* Tl spinous process; F. nuchal ligament; G. posterior face! joint; H, suboccipital muscles; I, greater occipital nerve.

Figure 3. Posterior aspect of the neck in forward flexion.

Trapezius. The **trapezius** is the most superficial and the most easily identifiable of the posterior neck muscles. Each trapezius is roughly triangular, originating from the occiput and the spinous processes of C7 through T12 and inserting laterally on the clavicle, the acromion, and the scapular spine. The upper border of the trapezius is quite prominent as it blends into the medial shoulder.

Deep to the trapezius lies the **transversocostal** group of muscles and the even deeper **transversospinal** group. The transversocostal group includes the *splenitis capitis,* the *splenitis cervicis,* the *iliocostalis cervicis,* and the *longis-simus cervicis* and is visible in the proximal neck lateral to the superior trapezius.

Lateral Structures. Lateral to the spine, the other structures visible from the posterior position should also appear symmetric. The shoulders should be level, and the scapulae located equidistant from the spine. The rib prominences on either side of the spine should be symmetric. When the patient is instructed to relax and to allow the upper extremities to hang limply at the sides, the size and the shape of the space between the arms and the sides of the body should be identical. At the base of the spine, the posterior landmarks of the pelvis should appear symmetric and level. A pelvis that does not appear to be level may be the result of either a leg length discrepancy in a patient with an otherwise normal spine or a fixed spinal deformity.

Departure from symmetry in any of these parameters may suggest a localized anomaly or a deformity of the spine in the coronal plane. An example of a localized anomaly is **Sprengel's deformity,** a congenital condition in which one of the scapulae remains fixed proximally in a tightly contracted position. Coronal deformities of the spine include a *list* and *scoliosis.*

List. A list is a pure planar shift to one side in the coronal plane (Fig. 4). It may be caused by pain, muscle spasm, or certain anomalies. When a list is present, the proximal part of the spine is shifted to one side, so that a plumb line dropped from the occiput or the vertebra prominens docs not hang directly over the natal cleft and the spaces between the upper extremities and the trunk are asymmetric. Lists are more common in the lumbar spine than in the cervical or thoracic spine.

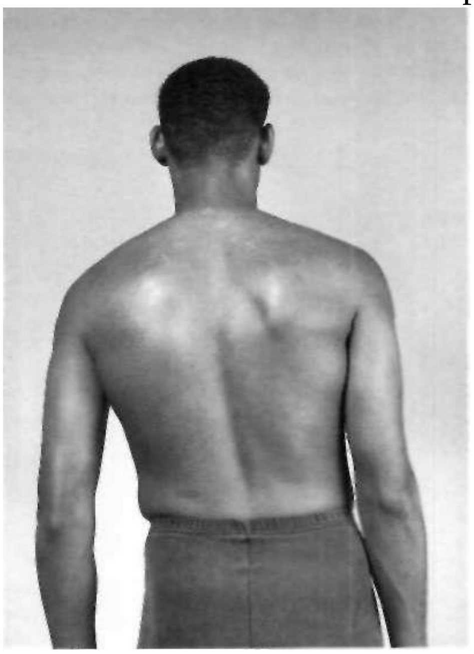


Figure 4. A list to the left side.

Scoliosis. Scoliosis is a more complex, helical deformity in which a curve in the coronal plane is combined with abnormal rotation of the vertebrae in the transverse plane (Fig. 5).A well-compensated scoliosis, defined as one in which thoracic and lumbar curves are roughly equal in magnitude but opposite in direction, may be surprisingly difficult to detect during observation of the spine in the standing patient. In these cases, visually tracing the path of the spinous processes may help the examiner appreciate that they follow a subtle S curve, although the vertebra prominens is located directly above the natal cleft.

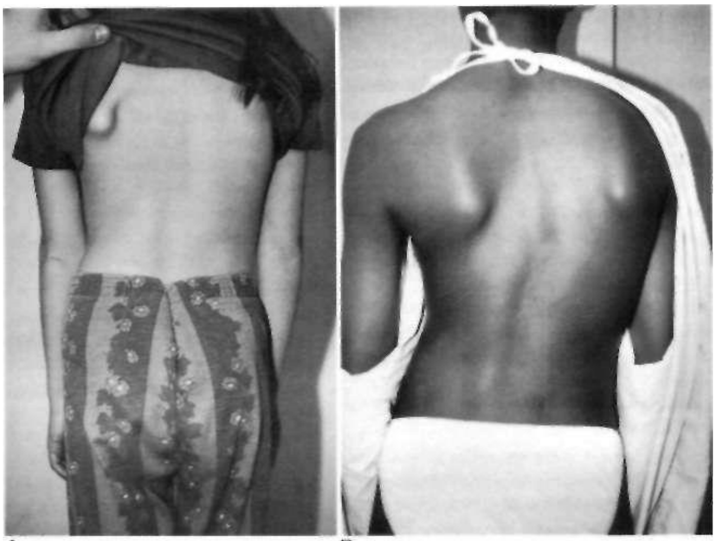


Figure 8-5. Scoliosis. *A*, Mild. *B*, More severe.

If a subtle scoliosis is suspected, looking for the **rib prominence** usually associated with thoracic scoliotic curves makes the deformity easier to detect. The rib prominence is a reflection of the rotational component of scoliosis. The ribs articulate with the transverse processes of the corresponding vertebrae. The vertebrae involved in the scoliotic curve are rotated around the longitudinal axis of the spine, with the transverse processes on the convex side of the curve rotating posteriorly and those on the concave side rotating anteriorly. The ribs on the convex side, therefore, are more prominent, and those on the concave side are less prominent. The resulting rib prominence, therefore, appears on the convex side of the curve. In the most common type of scoliosis, *adolescent idiopathic scoliosis*, the thoracic convexity and, thus, the rib prominence are most often located on the right side. If scoliosis is suspected, asking the patient to bend forward as far as possible emphasizes the rib prominence (Fig. 6).

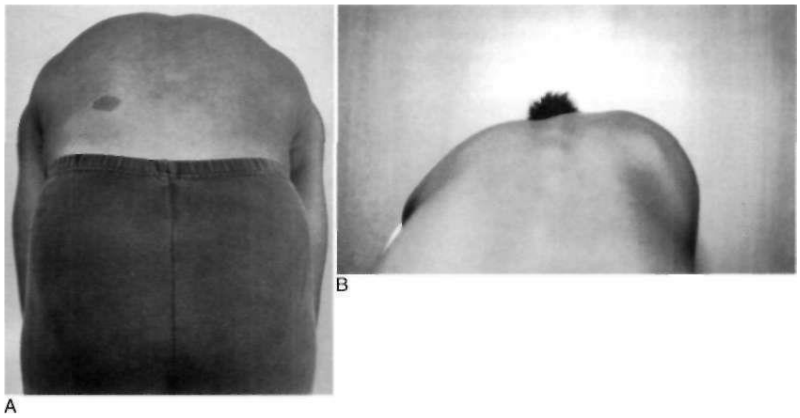


Figure -6. Examination for rib prominence. *A,* Normal. *B,* Abnormal

smooth, moderate curve, whereas scoliosis due to congenital or vertebral abnormalities more frequently produces short, sharp curves, if the scoliosis extends into the cervical spine, particularly in cases of congenital scoliosis, asymmetric twisting of the neck, known as torticollis, may be present. In very severe cases of scoliosis, the serpentine course of the spine may so shorten its effective length that the rib cage appears to rest on the iliac crests.

Skin Lesions. While examining the patient's back, the clinician should look for skin lesions that are known to be associated with conditions that may cause spinal deformity. Examples are a hairy nevus, which may be associated with spina bifida, and the cafe au lait spots or the cutaneous nodules of neurofibromatosis.

LATERAL ASPECT

Cervical Lordosis. From a lateral perspective, the cervical and the thoracic spine should be observed in both the sitting and the standing positions. When viewed from the side, the spine is not at all straight; it is a series of gentle, complementary curves (Fig. 7).

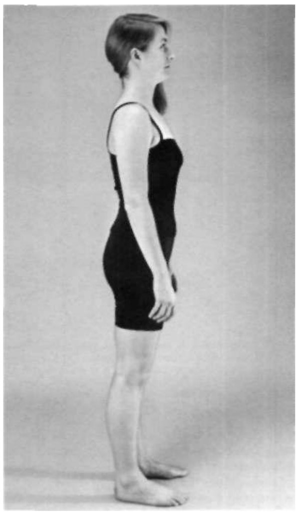


Figure 7. Lateral view of the spine.

A curve that is concave posteriorly is called a lordosis, and *one* that is convex posteriorly is called a kyphosis. A cervical lordosis, with the head resting comfortably over the middle of the trunk, is present in normal individuals. A reduction in this normal lordosis, with straightening of the curve, is a common, nonspecific reaction to cervical spine pain. More dramatic reduction or even reversal of this lordosis may be seen in *ankylosing spondylitis.* In the most extreme examples of this condition, the patient's chin may come to rest against the chest with the line of gaze fixed toward the ground (Fig. 8A). A milder deformity is the so-called sniffing position, in which the face of the patient appears to be thrust out anteriorly. Flexion at the cervicothoracic junction, with extension of the proximal segments, results in this position of cervical protrusion (Fig. 8B). The sniffing position is frequently associated with a cervicothoracic kyphosis.

Thoracic Kyphosis.

The normal cervical lordosis is usually balanced by a smooth transition into a normal thoracic kyphosis. This kyphosis is particularly noticeable in the upper thoracic spine. Normal thoracic kyphosis is between 21° and 33° when measured radiographically by the Cobb method. Because the amount of thoracic kyphosis is difficult to quantitate by physical examination, departures from the normal degree of thoracic kyphosis are usually assessed by a general comparison with the examiner's prior experience of the normal range. Thoracic kyphosis that is increased above the normal range gives a distinct round-shouldered appearance (see Fig. 8C). Possible causes include ***Scheuermann's disease***, which is an adolescent growth disturbance that produces wedge-shaped vertebral bodies; ankylosing spondylitis; congenital vertebral anomalies; and prior compression fracture. In the presence of severely increased kyphosis, the head appears to be positioned far anteriorly of the thoracic spine and the trunk also appears to be shortened. A particularly sharp-angled kyphosis is called a **gibbus.** A gibbus usually reflects a sharp angulation of the spine at a single vertebral level. Possible causes include congenital anomalies, such as wedge-shaped vertebrae, or vertebral body collapse due to tumor, infection, or trauma. A pathologic reduction in the normal thoracic kyphosis is unusual. Such a **flat back** appearance may be observed after surgery to correct thoracic scoliosis (see Fig. 8D).

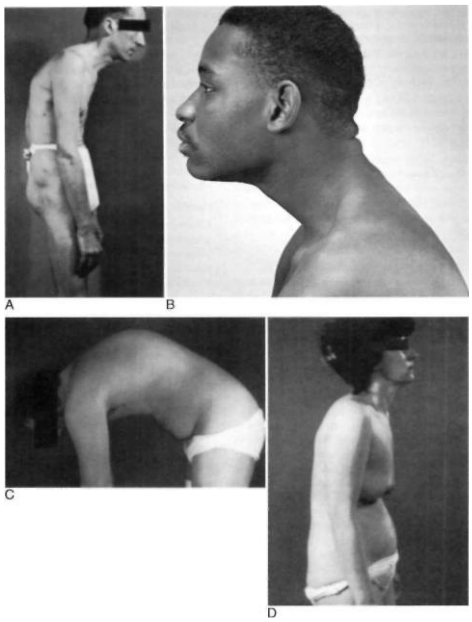


Figure 8. *A*, Flexion deformity of ankylosing spondylitis. *B*, Sniffing position. *C*, Scheuermann's kyphosis. D, Flat back deformity

ANTERIOR ASPECT

Landmarks. Anterior inspection of the spine is of limited usefulness owing to the dorsal location of the structure being examined. However, the examiner should again check carefully for the appearance of symmetry. The neck should appear straight, with the head sitting squarely on the shoulders and the chin positioned directly above the sternal notch (Fig. 9).

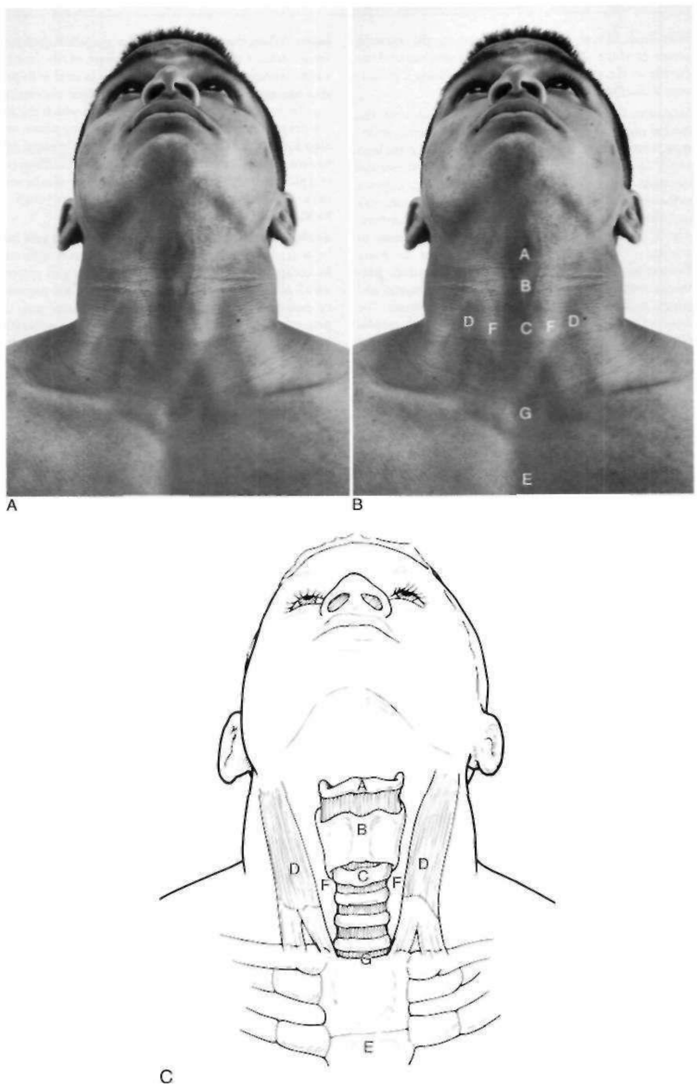


Figure 9. *A, B,* and *C*, Anterior aspect of the neck. *A*, hyoid; B. thyroid cartilage; C cricoid cartilage; D, sternocleidomastoid muscles; *E,* sternum; *F,* Chassaignac's tubercles; G. sternal notch.

Pain or fixed deformity may cause the head to be held at an angle. Prominent midline anterior landmarks include the hyoid bone, the thyroid cartilage, and the cricoid cartilage. Although evaluation of these structures does not fall within the domain of the orthopaedic physical examination, their identification allows the examiner to localize an abnormality at the corresponding level of the cervical spine. For this purpose, the examiner should keep in mind that the **hyoid** lies approximately at the level of **C3,** the **thyroid cartilage** at the level of C4 and C5, and the cricoid **cartilage** at the level of C6. Lateral to the midline, the two **sternocleidomastoid muscles** are prominent landmarks that are visible in most individuals. These muscles originate on the mastoid processes of the skull and insert on the sternum and the clavicle at the sternoclavicular joints, forming a prominent V configuration.

Sternum. Proceeding distally, the examiner observes the sternal notch at the confluence of the two sternocleidomastoid muscles. The notch is typically located at the level of the T3 and T4 vertebral bodies. Below this extends the sternum, a relatively narrow flat bone. Although it serves as the origin of the pectoralis major muscle, the sternum's central strip has little overlying soft tissue. It is, therefore, usually visible as a depression between the breasts in women or the pectoralis major muscles in men. Deformities of the sternum do occur. These include **pectus excavatum,** an abnormally concave sternum, and **pectus carinatum,** an abnormally convex sternum. The final significant anterior landmark (for orthopaedic purposes) is the umbilicus, which is contained in the T10 dermatome.

• GAIT

An evaluation of gait is imperative for any thorough assessment of the spine. Some of the neurologic syndromes associated with disorders of the cervical or the thoracic spine produce characteristic gait disturbances. Observation of the spine during ambulation can also provide valuable information about the dynamic and the static behavior of the weightbearing cervical spine.

Shuffling and Slap Foot Gaits. Injury to the posterior columns of the spinal cord produces a *posterior cord syndrome,* a condition characterized by the loss of proprioception in the extremities that are innervated below the lesion. When the individual with a posterior cord syndrome takes a step, he or she is unaware of the position of the swinging foot in space and thus is unable to predict the exact moment of heel strike. This uncertainty may be manifested by a **shuffling gait,** in which the feet are dragged on the ground during the swing phase, or a

slap foot gait, in which the feet strike the ground in a violent, unpredictable manner. Although a shuffling gait is typical of posterior cord syndrome, it may also be seen in a variety of other neurologic disorders, such as Parkinson's disease.

Broad-Based Gait. A **broad-based** or **halting gait** may be seen when stenosis of the cervical spine is complicated by compression of the spinal cord. In this gait pattern, which is caused by faulty programming of the sequence of muscle movements necessary for a normal gait, the patient's stance is widened owing to balancing difficulties during single leg stance. The rhythm of the gait is frequently jerky, again owing to central programming dysfunction. The pathogenesis of this pattern is unclear, but these patients frequently have difficulty walking over uneven ground and complain of loss of balance.

Range of Motion

CERVICAL SPINE

To properly assess the range of motion of the cervical spine, it is important that the thoracic spine be supported. This is accomplished most easily by having the patient sit in a straight-backed chair. Ideally, the chair back should extend to the midscapular level but not above it (Fig. 10).

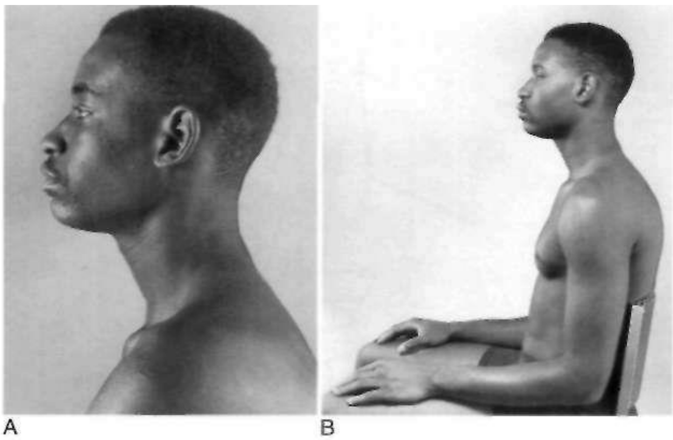


Figure 10. Neutral position for evaluation of flexion and extension. *A*, Cervical. *B*, Thoracic.

In assessing each direction of movement, the examiner tries not only to measure the amount of motion possible but also to determine whether or not the various movements are painful. Any difficulties during the arc of motion, such as hesitation or midrange pain, should be noted. Midrange pain is typically due to instability of the structure being moved. When midrange pain is present, the total range of motion may be normal, but the movement is not conducted smoothly or with a constant velocity. This pain most commonly occurs in cases of subacute or chronic instability, such as would be produced by degenerative disk disease. For example, if the disk is painful when the neck is in a neutral position, the patient would be observed to hesitate in the neutral position when moving from full flexion to full extension.

Flexion and Extension. To assess flexion, the examiner asks the patient to attempt to touch the chin to the chest. A patient with a normal cervical spine should be able to make firm contact between the chin and the chest or come very close to it (Fig. 11). Measuring the distance between the chin and the chest at the point of maximal flexion is the most useful way to quantify this movement for future comparison.

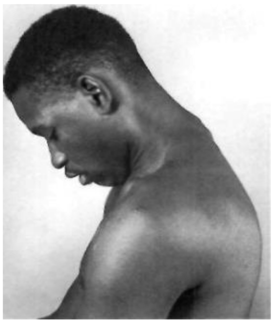


Figure 11. Active cervical flexion.

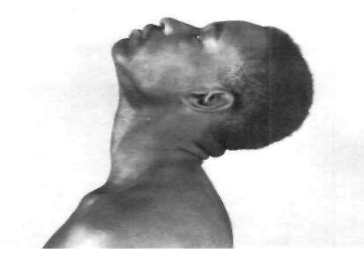


Figure 12. Active cervical extension.

To assess extension, the patient is asked to tilt the head back and to look up toward the ceiling (Fig. 12). Maximum extension is a combination of cervical, thoracic, and occipitocervical motion. If normal extension is present, the patient should be able to tilt the head back until the face is parallel with the ceiling. Approximately 50% of flexion-extension motion occurs between the occiput and CI. The amount of extension may be reduced in the presence of degenerative arthritis or a fixed deformity such as scoliosis or kyphosis. In addition, acute cervical nerve root compression may also limit extension owing to pain.

Lateral Rotation. Lateral rotation to both the right and the left should be assessed. To measure lateral rotation, ask the patient to rotate the chin laterally toward each shoulder, in turn (Fig. 13). The spinous processes are seen to rotate away from the side to which the chin points. Normal lateral rotation is typically about 60° in each direction, but it may reach close to 90° in some individuals. This is best assessed by standing in front of or directly behind the patient and observing the arc of rotation as the head moves. Approximately 50% of normal rotation occurs between C1 and C2, the atlas and the axis.

Lateral Bending. Lateral bending to both the right and the left sides is assessed by asking the patient to attempt to touch each ear to the ipsilateral shoulder (Fig. 14). When combined with a normal shoulder shrug, maximal lateral bending should permit the shoulder to nearly touch the car. The amount of motion may be quantitated by measuring the distance between the shoulder and the ear at maximal effort or by estimating the angle that the midline of the face makes with the vertical.

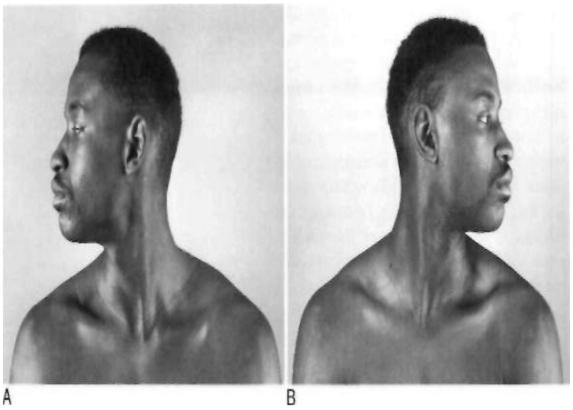


Figure 13. Active lateral rotation of the cervical spine. *A*, Right. *B*, Left.

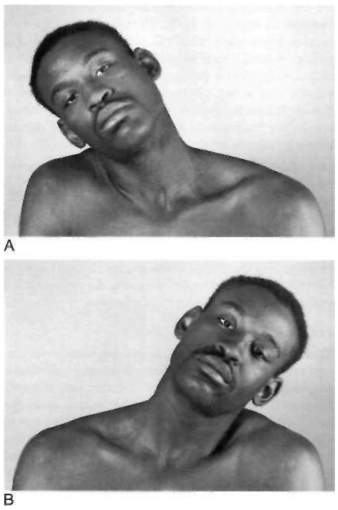


Figure 14. Active lateral bending of the cervical spine.

THORACIC SPINE

Flexion and Extension. In dramatic contrast with the cervical spine, the thoracic spine permits little motion. What is present consists of a small amount of flexion and extension. To assess flexion and extension of the thoracic spine, the patient is seated against a straight-backed chair in order to eliminate lumbopelvic motion. The patient is asked first to flex and then to extend the thoracic spine (Figs. 15 and 16). The small amount of motion present may be detected by observing the change in relationship between the thoracic spine and the vertical chair back. In the presence of ankylosing spondylitis, the range of flexion and extension of the spine is limited.

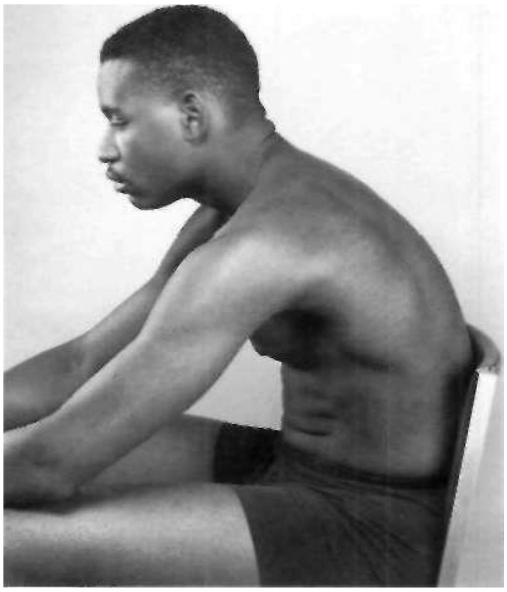


Figure 16. Active thoracic extension.

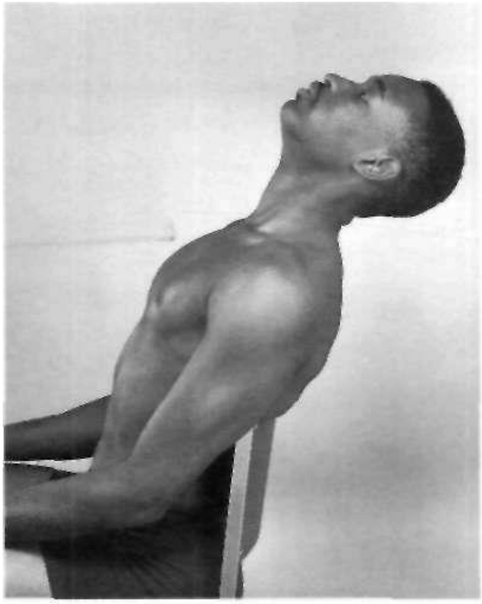


Figure 15. Active thoracic flexion.

A traditional way to detect this stiffness when ankylosing spondylitis is suspected is to use a tape measure to assess the **apparent change in length** of the spine between flexion and extension. This is done by measuring the distance between the vertebra prominens and the sacrum with a tape measure when the patient is standing erect. The patient is then instructed to bend forward as far as possible, and the same interval is measured (Fig. 17).

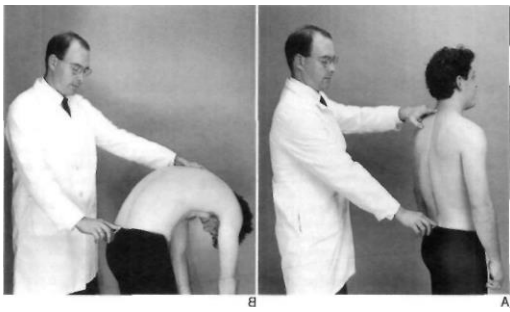


Figure 17. *A* and *B,* Measurement of apparent elongation of the spine with flexion.

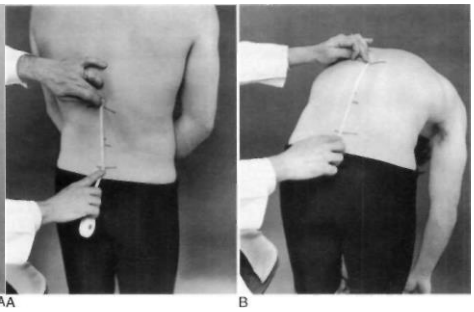


Figure 18. *A* and *B,* Modified Schober's test

A variant of this technique is the **modified Schober test,** which quantifies lumbosacral flexion. To perform this measurement, the examiner marks points 10 cm above and 5 cm below the lumbosacral junction in the extended spine. The patient is then asked to maximally Hex, and the examiner measures the distance between the same two points (Fig. 18). Normally, the length of the dorsal aspect of the spine should appear to increase about 6 cm. Excursion of much less than this amount suggests the presence of ankylosing spondylitis, particularly if a kyphotic deformity is present.

Another screening test for ankylosing spondylitis is to measure the amount of chest expansion possible. This is normally done by encircling the patient's chest with a flexible tape measure at the nipple line. The patient is then asked to maximally exhale and the chest circumference is noted (Fig. 19A). Next, the patient is asked to maximally inhale and the circumference again is documented (Fig. 19B). The distance between these two measurements should be about 5 cm. If it is less than 2.5 cm, chest expansion is decreased. This may be a sign of ankylosing spondylitis. This measurement is more difficult to perform in females, in whom ankylosing spondylitis is fortunately less common.

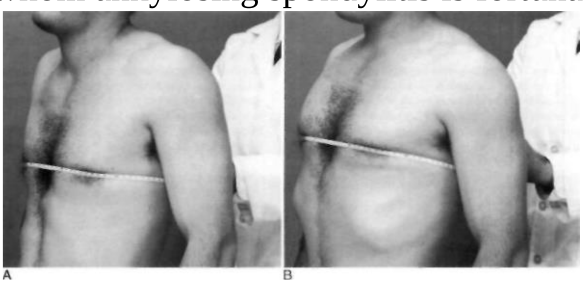


Figure 19. *A* and *B*, Measurement of chest expansion

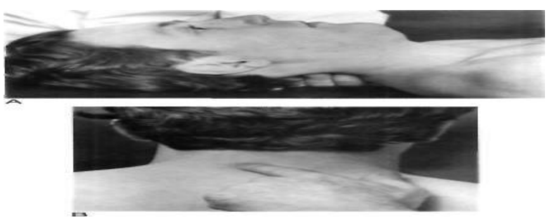


Figure20. Palpation of the cervical spine. *A*, Supine position. *B*, Seated position

• PALPATION

Palpation has several uses in the evaluation of the cervical spine. First, it may reveal a subtle *deformity* or malalignment that was overlooked during inspection or hidden from visual examination because an acutely injured patient was encountered in a supine position. Second, palpation may detect paraspinous *muscle spasm.* Such spasm may reflect injury to the muscle itself or may merely be an involuntary response to a painful condition involving adjacent structures. Finally, careful palpation may identify an area *of point tenderness.* Point tenderness may allow the examiner to identify the level of a discrete lesion or even the exact site of injury, such as a posterior facet joint. In a patient with a history of recent trauma, point tenderness strongly suggests a fracture or a significant ligamentous disruption. Palpation of the spine is performed primarily from the posterior aspect.

POSTERIOR ASPECT

The cervical spine is most commonly palpated with the patient in either the supine or the seated position. The supine position allows the patient to relax more completely and may, thus, permit the identification of more anatomic detail (Fig. 20A). The disadvantage of the supine position is that the examiner cannot directly visualize the structures being palpated. The seated position (Fig. 20B) may compromise muscle relaxation, but it permits direct visualization of the area being examined. The prone position, although not widely employed, permits a compromise between the two extremes. If the patient is initially seen in an emergency situation, such as on an athletic field or following a motor vehicle accident, the question of preferred position is moot. In the emergency situation, the patient should be examined in the position in which he or she is first encountered until the examiner is satisfied that the possibility of an unstable cervical spine has been ruled out. If the examiner is unable to make this decision with confidence, the patient should be transported to a hospital with the neck immobilized until a good radiographic evaluation can be conducted.

Cervical Spine

Spinous Processes. Palpation of the cervical spine usually begins at the inion, located at the base of the skull (see Fig. 2). The examiner's palpating fingertips proceed distally in the midline, attempting to identify each spinous process. The first identifiable spinous process should be that of C2. Palpation proceeds distally toward the more prominent C7 and Tl spinous processes. The examiner should ask the patient whether gentle pressure on each of the spinous processes is painful. Such tenderness may signify an injury localized to that particular vertebra. In the emergency situation, documentation of localized tenderness is sufficient reason to consider the cervical spine potentially unstable and to immobilize and transport the patient accordingly.

In addition to palpating each of the spinous processes for *tenderness,* the examiner should also use palpation to evaluate their *alignment.* Normally, the spinous processes should be arranged in a perfectly linear fashion and regularly spaced. An acute lateral shift between two spinous processes may be due to a unilateral facet joint dislocation or fracture. An increase in the space between two otherwise normally aligned spinous processes raises the possibility of a posterior ligamentous disruption or fracture.

The **nuchal ligament** connects the cervical spinous processes, beginning at the base of the skull and extending to C7. Its prominence increases as the neck flexes. Conversely, the proximal spinous processes are easier to palpate when the cervical spine is extended.

Posterior Facet Joints. After palpating in the midline, the examiner's fingers should move laterally about 2 cm to the region of the **posterior** facet **joints.** Owing to the overlying musculature, firmer palpation is needed to appreciate the resistance of the underlying bony structures. The examiner palpates from proximal to distal in a systematic manner. Although the specific outlines of the individual joints cannot usually be appreciated, the identification of localized tenderness over one of these joints may allow the examiner to identify the site of arthritic degeneration or ligamentous injury.

Posterior Cervical Musculature. While palpating lateral to the midline, the examiner also is able to evaluate the posterior cervical musculature, consisting of the upper portion of the **trapezius** and the underlying intrinsic neck muscles. Occasionally, a localized mass owing to a hematoma or other lesion may be palpable. Muscle spasm may indicate injury to the muscle itself, or it may be an involuntary reaction to pain in an adjacent structure. Cervical spine pain may be referred to portions of the trapezius, either superior to the spine of the scapula or between the thoracic spinous processes and the medial border of the scapula. Palpation of these areas may reveal localized tender nodules, or *trigger points*

The *splenitis capitis* and other members of the **trans-versocostal** group are partly covered by the upper trapezius, but they may be palpated more distinctly in the proximal neck where they are exposed lateral to the trapezius. The deeper **transversospinal** group is not distinctly palpable but may contribute to the apparent tenderness of the overlying musculature.

Deep to the trapezius at the base of the skull lie the **suboccipital muscles,** the *rectus capitis (posterior) major*, the *rectus capitis minor*, and the *obliquus capitis superior* and *inferior.* The **greater occipital nerve,** also known as the **suboccipital nerve,** traverses the triangle formed by these muscles. Tenderness in this area may be due to occipital neuritis, muscle strain, or, in cases of rheumatoid arthritis, potential C1-C2 instability.

Thoracic Spine. The thoracic spine is stabilized by the associated ribs. Because of this, major injuries here require substantially more energy than in the cervical

spine and, thus, are less common. However, palpation of the thoracic spine may be used to detect localized tenderness or discontinuity just as in the cervical spine.

ANTERIOR ASPECT

The principal landmarks of the anterior neck have already been described. When not readily visible, the hyoid bone, the thyroid cartilage, and the cricoid cartilage can be gently palpated. The primary purpose of identifying these structures is to orient the examiner to the corresponding vertebral level of spinal pathology.

The hyoid is a horseshoe-shaped bone that lies just caudal to the angle of the mandible at about the level of the C3 vertebral body (see Fig. 9). The hyoid is rarely visible but usually easily palpable. The examiner may gently grasp this firm curved structure between the thumb and the index finger (Fig. 21).

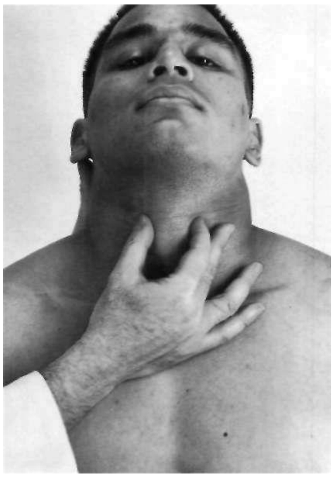


Figure 21. Palpation of the hyoid.

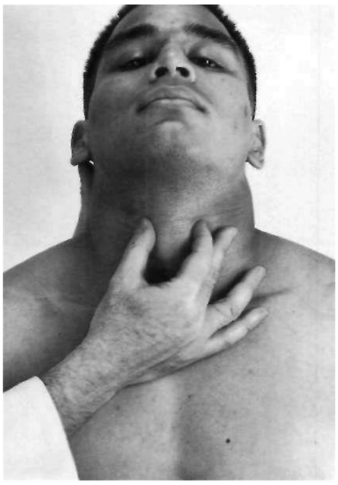


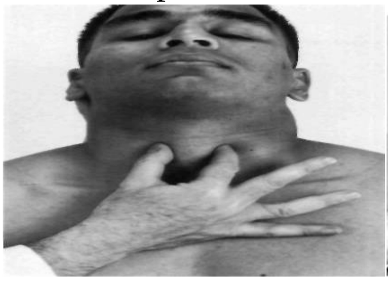
Figure 22. Palpation of the thyroid cartilage.

Just inferior to the hyoid bone is the thyroid cartilage. The thyroid cartilage forms the Adam's apple, which is prominently visible in many men. This large superficial wing-like structure is freely mobile (Fig. 22). The thyroid cartilage is located at the level of the C4 and C5 vertebral bodies.

Inferior to the thyroid cartilage is a narrow groove followed by the prominent curved band that is the anterior portion of the cricoid cartilage ring (Fig. 23). This mobile ring is located approximately at the level of the *C6* vertebral body. The examiner's fingers may then be slid laterally to the right or the left of the cricoid in the small depression formed by the anterior strap muscles and the anterior borders of the sternocleidomastoid. Direct gentle posterior pressure should result in the detection of the **tubercles of Chassaignac,** or **carotid tubercles,** located on C6.

Typically, pulsations of the carotid artery are felt just medial to Chassaignac's tubercles. The examiner should take care

not to compress both carotid arteries simultaneously.



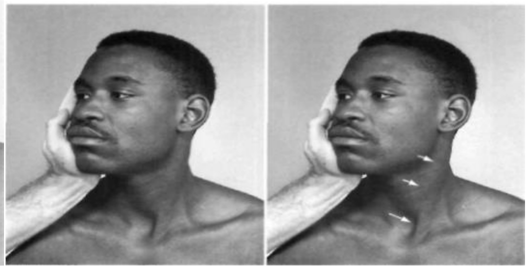


Figure 23. Palpation of the cricoid cartilage. Figure 24. *A* and *B*, Assessing right lateral rotation strength. (*Arrows* in *B* indicate tensed left sternocleidomastoid muscle.)

• MANIPULATION

Muscle Testing

Strength testing of the muscles that move the cervical spine is not usually emphasized as much as the evaluation of the muscles that are innervated by the various cervical nerve roots. Nevertheless, it is important to establish that the protective function of the intrinsic cervical musculature is present. In addition, the identification of specific weak muscle groups, although not as significant as the identification of a specific central or peripheral neurologic deficit, may allow the clinician to formulate a treatment plan to restore normal function.

Muscle tests are normally conducted with the patient seated or standing. The patient's ability to support the neck in the erect position is an indication that the muscles are at least strong enough to overcome the force of gravity. All strength testing should be done gently, with the examiner providing firm, controlled resistance. This avoids sudden uncontrolled movements that could be painful or injurious.

LATERAL ROTATORS

The **sternocleidomastoid** muscles function as both cervical rotators and flexors. Because they are innervated by the *spinal accessory nerves,* a complete injury to one of these nerves would paralyze the corresponding sternocleidomastoid muscle. Isolated contraction of one sternocleidomastoid rotates the cervical spine, so that the patient's chin points away from the contracting muscle: the *left* sternocleidomastoid produces **right lateral rotation,** and the *right* sternocleidomastoid produces **left lateral rotation.**

To test a given sternocleidomastoid muscle, the examiner places the palm of one hand on the opposite side of the patient's head or face and instructs the patient to attempt to rotate the head to that side as strongly as possible. The tension in the sternocleidomastoid being tested should be quite visible (Fig. 24). Normally, the examiner should be unable to overcome the patient's strength of rotation.

FLEXORS

When fired together, the two **sternocleidomastoids** are the principal flexor muscles of the neck. To test **flexion** strength, the examiner places a resisting palm against the patient's forehead and stabilizes the thorax if necessary with the other hand. The patient is instructed to flex the neck against the examiner's resistance as forcefully as possible. Contraction of both sternocleidomastoid muscles should be quite visible, and the examiner should be unable to overcome the patient's inherent muscle strength (Fig. 25).

EXTENSORS

Extension of the cervical spine is powered by the **posterior intrinsic neck muscles** and upper portion of the **trapezius.** Extension is tested in a manner analogous to the test of flexion strength. The examiner places the resisting hand on the patient's occiput and instructs the patient to extend the neck as forcefully as possible (Fig. 26). Again, the examiner should be unable to overcome the normal intrinsic muscle strength of the neck extensors.

LATERAL BENDERS

Lateral bending of the neck is powered primarily by the scalene muscles. To test the strength of these muscles, the examiner places the palm of one hand on the corresponding side of the patient's head and a stabilizing hand on the contralateral shoulder. The patient is then instructed to push against the examiner's palm as forcefully as possible (Fig. 27). In a normal case, the examiner is unable to overpower the patient's inherent lateral bending strength.

Neurologic Examination

A thorough neurologic examination is a basic part of cervical and thoracic spine evaluation. A neurologic examination should include a search for motor or sensory deficits, absent or abnormal reflexes, and root tension

signs. Neurologic function is best evaluated in a systematic examination organized by dermatomes. The sensory, motor, and reflex tests for each dermatome are summarized in Table 1. Because the most common neurologic deficit associated with cervical spine disorders is a radiculopathy, such a systematic examination allows the clinician to identify the specific nerve root involved. In the case of more extensive deficits associated with spinal cord injuries, this same examination allows the clinician to determine the neurologic level of deficit.

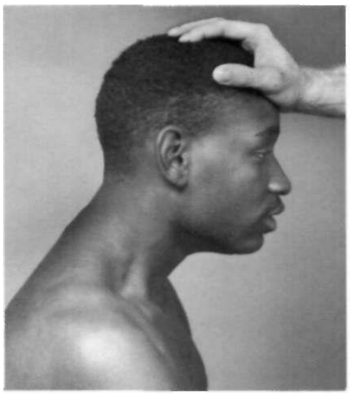
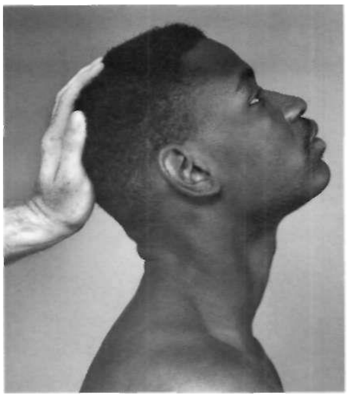
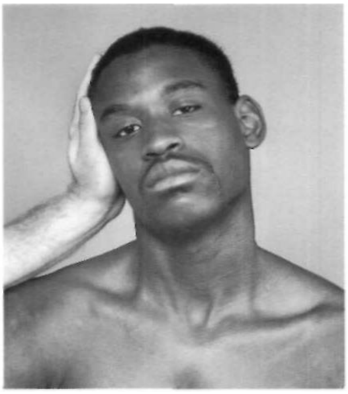




Figure 25, Assessing flexion strength. Figure 26. Assessing extension strength. Figure 27. Assessing lateral bending strength.

table 1 physical findings in cervical and thoracic radiculopathies

DERMATOME	SENSORY TESTING	MOTOR TESTING	REFLEX TESTING
C4	Lateral neck		
C5	Area over the middle deltoid	Deltoid Biceps brachii (secondary)	Biceps reflex
C6	Dorsum of the first web space and thumb	Biceps Brachii Wrist extensors	Brachioradialis reflex Biceps reflex (secondary)
C7	Long finger	Wrist flexors Long finger extensors Triceps brachii	Triceps reflex
C8	Little finger and ulnar side of hand	Long digital flexors (grip)	
TI	Medial arm at the elbow	Finger abduction and adduction (interossei)	
T2	Medial upper arm and adjacent chest		
14	Nipple line		
T10	Umbilicus	Trunk flexion (Beevor's sign)	Abdominal muscle reflex

When the Patient Complains of Neck Pain after Trauma

Major Diagnostic Possibilities Include:

- Fracture
- Ligamentous injury
- Cervical strain/sprain
- Disk injury

May be necessary to rule out underlying pathologic lesion of the vertebra such as tumor, infection, or osteoporosis

Ask the Patient to Describe the Original Injury Episode:

- Major trauma such as a motor vehicle accident or a fall from a height with immediate pain
- Exclude fracture or ligamentous injury
- Minor trauma such as a lifting or twisting injury, fall from low height
- Consider cervical strain/sprain, fracture in osteoporotic patients, or herniated intervertebral disk

Ask the Patient to Describe Current Symptoms:

- Constant neck pain, made worse with any activity
- Exclude fracture or major ligamentous injury.
- Neck pain, made worse with bending or twisting
- Suggestive of a cervical strain/sprain
- Herniated disk, fracture, or ligamentous injury remain possibilities
- Neck pain associated with radiating arm pain, paresthesias or weakness
- Indicates possible neural compression arising from:
- Herniated disk
- Fracture or ligamentous injury with neural encroachment or injury
- Neck pain associated with arm pain and weakness, and gait disturbance
- Suggestive of spinal cord compression

Relevant Physical Examination:

GENERAL:

If suspicious of spinal fracture, ligamentous injury, or dislocation, immobilize patient and assess for hemodynamic stability and other associated injuries:

- Inspection for swelling and ecchymosis at the level of injury
- Palpation for midline point tenderness at the level of injury
- Palpation for step-off at site of injury
- Neurologic testing for associated upper or lower motor neuron deficits

CERVICAL STRAIN:

- Palpation for paraspinal muscle tenderness or spasm
- Range of motion typically painful
- Neurologic examination typically normal

HERNIATED DISK:

- Flexion of cervical spine may reproduce symptoms of upper extremity pain
- Nerve root tension signs (Spurling's, Lhermitte's, upper limb tension tests)
- Neurologic testing for deficit in the distribution of the involved cervical nerve root

2 • When the Patient Complains of Neck Pain without Preceding Trauma

Major Diagnostic Possibilities Include:

- Cervical strain
- Degenerative disc disease
- Herniated disc
- Spinal deformity
- Infection

- Tumor

GENERAL MEDICAL HISTORY:

- If the patient is immunocompromised or has a history of intravenous drug abuse, infection is a strong possibility
- If the patient has a history of cancer, metastatic spread to the spine must be suspected
- If the patient has a history of osteoporosis, fracture should be considered
- ASK THE PATIENT TO DESCRIBE ASSOCIATED SYMPTOMS:
- Constitutional symptoms such as weight loss, fever or night sweats; suggestive of tumor or infection
- Unilateral arm paresthesias, weakness and pain; typical of herniated disc
- Bilateral arm pain or weakness, with gait dysfunction; suggestive of cervical spine stenosis. Other possibilities include tumor or trauma resulting in neural compression
- Relevant Physical Examination:

GENERAL:

- Inspection
- Palpation
- Examination of gait
- Range of motion
- Neurologic testing

FRACTURE:

- Palpation for tenderness at the level of injury
- Inspection for swelling and ecchymosis at the level of injury
- Palpation for step-off

CERVICAL DISK DISEASE:

- Decreased range of motion
- Pain with range of motion

HERNIATED DISK:

- Nerve root tension tests {Spurling's, Lhermitte's, upper limb tension tests)
- Neurologic testing for deficit in the distribution of the involved root

INFECTION/TUMOR:

- Palpation for point tenderness at involved level
- Palpation for associated muscle spasm
- Neurologic testing

CERVICAL STENOSIS:

- Neurologic exam: lower motor neuron signs in arms; upper motion neuron signs in legs
- (e.g., hyperreflexia, clonus, Babinski's sign) Lhermitte's sign

CERVICAL STRAIN:

- Palpation for paraspinal muscle tenderness or spasm
- Neurologic examination should be normal

3 • *When the Patient* Complains *of Neck and Arm* Pain

Major Diagnostic Possibilities Include:

- Herniated disc
- Cervical stenosis
- Infection
- Tumor

Obtain Relevant Medical History:

- If the patient is immunocompromised or has a history of intravenous drug abuse, infection is a strong possibility
- If the patient has a history of cancer, metastatic spread to the cervical spine must be suspected.
- Ask the Patient about the Onset of Symptoms:
- Sudden onset
- More suggestive of herniated disk, infection or tumor
- Gradual, insidious onset

- Likely cervical stenosis
- Ask the Patient to Describe Associated Symptoms:
- Constitutional symptoms such as weight loss, fever or night sweats
- Suggestive of tumor or infection
- Unilateral arm paresthesias, weakness or pain
- Typical of herniated disk
- Unilateral, bilateral arm symptoms, with history of gait dysfunction (e.g., halting, unsteady gait)
- -Suggestive of cervical stenosis
- Relevant Physical Examination: GENERAL:
- Inspection
- Examination of gait
- Range of motion

HERNIATED DISK:

- Nerve root tension tests (Spurling's, Lhermitte's, upper limb tension tests)
- Neurologic testing for deficit in the distribution of the involved root

CERVICAL STENOSIS:

- Decreased cervical range of motion
- Upper and lower extremity paresthesias reproduced with cervical flexion (Lhermitte's test)
- Neurologic testing for deficit in the distribution of the involved roots

INFECTION/TUMOR:

- Palpation for point tenderness at involved level
- Palpation for associated muscle spasm
- Neurologic testing

SENSORY EXAMINATION

Patterns of Sensory Loss. Testing for light touch is a good screening tool for assessing the distribution of a sensory loss in order to characterize it as radicular, non-radicular, or global. Radicular sensory loss reflects the injury of a specific nerve root and should, therefore, correspond to the dermatome associated with that nerve root. A nonradicular sensory loss suggests a more peripheral nerve injury; the involved area is more diffuse and overlaps several dermatomes. A **glove** or **stocking distribution** of sensory dysfunction signifies a circumferential sensory deficit in the entire portion of the involved limb distal to a certain point. Conditions that may be associated with a glove or stocking sensory deficit include diabetic peripheral neuropathy, reflex sympathetic dystrophy, and nonorganic disorders.

Light Touch. All sensory testing is carried out with the patient's eyes closed. For screening purposes, **light touch** can be tested by lightly stroking the patient's skin with a soft object, such as a small paintbrush, a cotton wisp, or a tissue (Fig. 28A). The examiner strokes the area in question as well as adjacent areas and asks the patient to acknowledge each touch. In this manner, the examiner can gradually delineate an area that is anesthetic or hypoesthetic. The abnormal area can be marked on the patient and compared with diagrams of dermatomes and the sensory distribution of peripheral nerves. For more precise testing, special filaments made expressly for this purpose may be used.

Sharp-Dull Discrimination. Sharp-dull discrimination testing may be used to confirm the results of a light touch examination. In this case, the patient is asked to identify whether the area being examined is being touched with the sharp or dull end of a safety pin (Fig. *28B* and C. This distinction should normally be an easy one for the patient to make; in an area of diminished sensation, the patient has difficulty distinguishing between sharp and dull.

Vibration Sense. Vibration sense can be tested using a tuning fork of 256 Hz over bony prominences such as the humeral epicondyles or the radial styloid. The examinerrests the base of the vibrating fork on the bony prominence and asks the patient to report when the vibration stops (see Fig. 28D). The examiner then stops the vibration suddenly with the free hand (see Fig. 28E). Normally, the patient identifies the cessation of vibration quite readily. Vibration sense should never be absent in the fingers or bony prominences. Some elderly individuals may, however, lose vibration sense distally. Otherwise, loss of vibration sense is associated with injury to the posterior columns of the spinal cord or peripheral nerves.

Proprioception. Loss of **proprioception,** also a sign of posterior column dysfunction, may be associated with aging, injury, or cerebellar dysfunction. To assess proprioception, the patient is instructed to close his or her eyes and the examiner grasps one of the patient's fingers or toes. The examiner then alternately flexes and extends the digit several times, randomly stopping in flexion or extension (see Fig. 28F and G). The patient should be able to identify whether the digit ends the maneuver in extension or flexion.

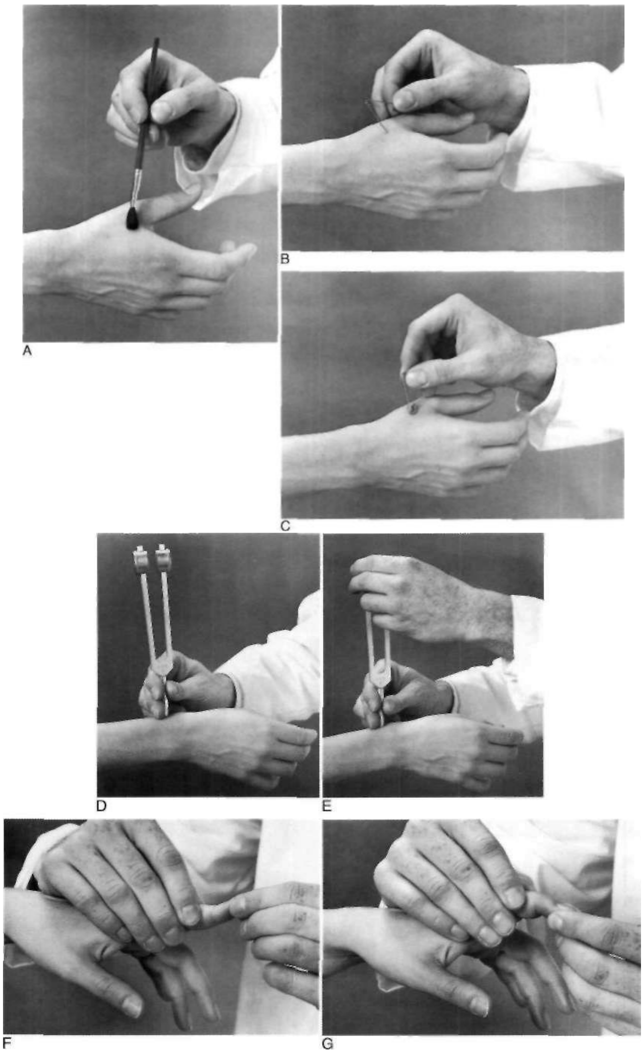


Figure **28.** Sensory testing. *A,* Light touch. *B,* Sharp. *C,* Dull. Figure **8-28, cont'd.** D and *E,* Vibration. Fand *G,* Proprioception

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Two-Point Discrimination. The most sensitive means of assessing sensory loss in the upper extremities is two-point discrimination testing.

This is most useful for deficits in the C6, the C7, or the C8 dermatomes. A subject with normal sensation should be able to distinguish points 5 mm apart on the fingertips.

Sensory Dermatomes. The approximate areas of sensory innervation from the cervical and thoracic nerve roots are shown in Figure 29. There is considerable overlap in the sensory dermatomes, and the exact distribution of each dermatome varies somewhat from one individual to another. Sensory deficits are usually sought by evaluating sensation in relatively small areas that can reliably be expected to correspond to specific dermatomes in most individuals. The C4 nerve root is most effectively assessed by testing the lateral neck (Fig. *30A).* The C5 nerve root can be evaluated by testing sensation over the middle deltoid (Fig. 30B). The C6 nerve root supplies the dorsum of the first web space and the index finger (Fig. 30C, the C7 nerve root supplies the long ringer (Fig. 30D), and the C8 nerve root supplies the little finger and the ulnar aspect of the hand (Fig. 30E). The Tl nerve root can be evaluated by testing the medial arm about the elbow (Fig. 30F), and the T2 nerve root supplies the upper medial arm adjacent to the axilla and a contiguous portion of the chest (Fig. 30G). The other thoracic nerve roots supply sensation to successive strips of skin across the trunk. Remembering that the nipples identify the T4 dermatome and the umbilicus, the T10 dermatome helps the examiner identify the approximate level of sensory deficit in the distribution of the thoracic nerve roots.

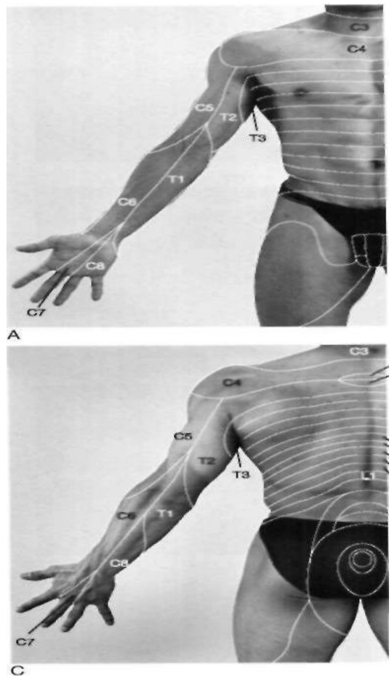


Figure 29. Cervical and thoracic dermatomes. A and C, After Foerster. *B* and *D,* After Recgan and Garrett.

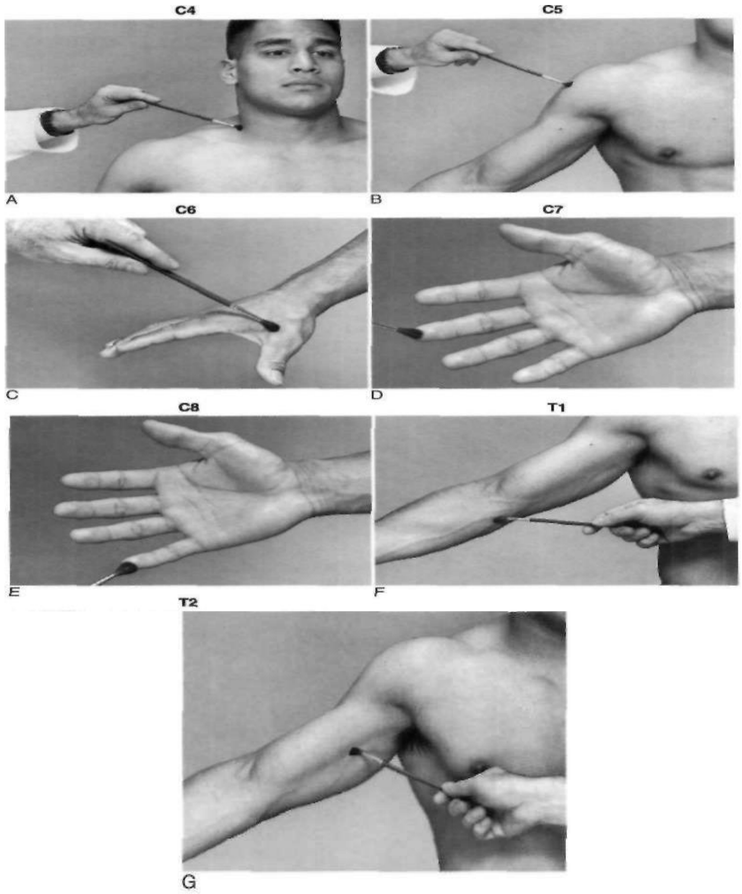


Figure 30. Sensory evaluation by cervical dermatome. *A,* C4. *B,* C5. C, C6. D, C7. *E,* C8. F, Tl. *G,* T2.

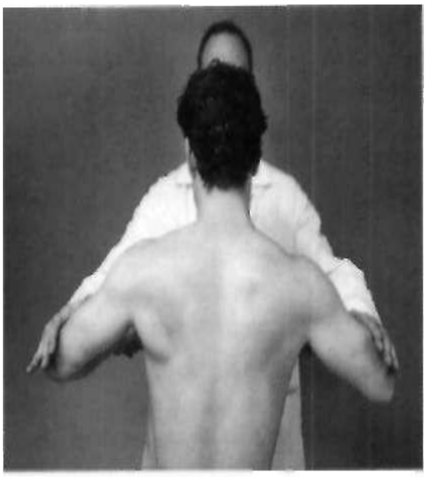
MOTOR EXAMINATION

There is considerable overlap in the motor dermatomes of muscles supplied by the cervical nerve roots. In general, one or two muscles or muscle groups are selected to test each nerve root. These muscles or groups are usually chosen for their ease of examination or purity of innervation.

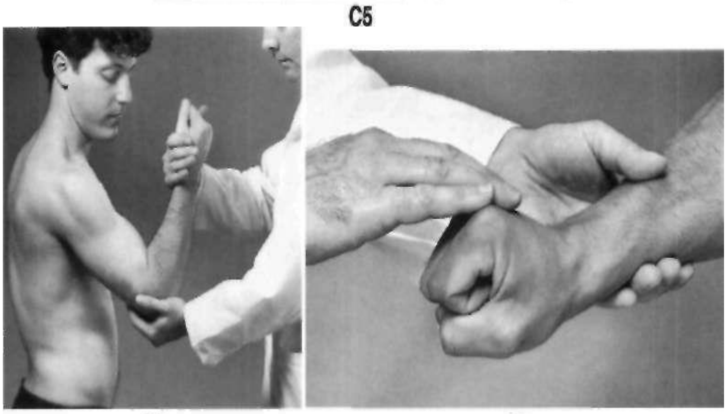
C5 Nerve Root. The C5 nerve root, which exits the spine through the C4-C5 neuroforamen, is best assessed by testing deltoid strength. The patient is seated in a comfortable upright position and asked to abduct the arm with the elbow flexed. The examiner then exerts downward pressure on the elbow while the patient tries to resist with a pure abduction force (Fig. 8-31). In most normal patients, the examiner is not able to break the deltoid strength. The C5 nerve root also contributes to the biceps brachii. Because the innervation of the biceps is shared with C6, substantial neurologic dysfunction must be present before biceps weakness is perceived.

Even in the face of a complete C5 motor deficit, moderate or normal biceps strength remains because of this dual innervation.

C6 Nerve Root. The C6 nerve root, which exits the spine through the C5-C6 neuroforamen, innervates the biceps brachii and the wrist extensors. To test the biceps, the examiner supports the patient's flexed elbow with one hand and grasps the patient's wrist with the other. The examiner then attempts to passively extend the elbow while the patient attempts to keep it flexed (Fig. 32A). In most normal patients, the examiner is unable to overcome the patient's biceps strength. Owing to the biradic-ular innervation of the biceps noted previously, even a complete C6 motor deficit may not lead to total biceps paralysis.



C5



A C6 B C6

Figure 31. Assessing C5 motor function {deltoid strength). Figure 8-32. Assessing C6 motor function. *A,* Biceps. *B,* Wrist extensors.

To test the wrist extensors, the examiner asks the patient to flex the involved elbow and extend the wrist while the arm is held tightly at the side. The examiner stabilizes the patient's forearm with one hand while exerting downward pressure on the dorsiflexed wrist (see Fig. 32B). In most normal patients, the examiner is not able to overcome the patient's wrist extensor strength. Because the C5-C6 disk is the cervical disk most commonly involved in herniation or degeneration, a C6 radiculopathy is the most likely to be encountered.

C7 *Nerve Root.* The C7 nerve root, which exits the spine through the C6-C7 neuroforamen, is most easily assessed by testing the wrist flexors. The position is very close to that used for the assessment of wrist extensor strength. In this case, however, the patient is asked to make a fist and flex the wrist as strongly as possible while the examiner attempts to overcome the patient's strength and force the wrist into extension (Fig.

33.A). Normally, the examiner can overcome the patient's flexion strength only with considerable difficulty.

The C7 nerve root may also be assessed by testing the strength of the long finger extensors. In this test, the examiner asks the patient to extend the fingers fully with the wrist in the neutral position. The examiner then stabilizes the patient's wrist with one hand and attempts to passively flex the patient's metacarpophalangeal joints while the patient resists maximally (see Fig. 33B). The examiner should be able to flex the fingers only with difficulty.

C7 also innervates the triceps brachii. To test triceps strength, the examiner grasps the patient's wrist and gently flexes the patient's elbow. The examiner's other hand stabilizes the patient's upper arm. The patient is then asked to extend the elbow as strongly as possible (see Fig. 33C). Normally, the examiner is unable to overcome the patient's triceps strength, and a strong patient may push the examiner away. Alternatively, the patient can be asked to hold the elbow in full extension while the examiner attempts to flex it. The examiner is not normally able to overcome the patient and flex the elbow.

C8 Nerve Root. The C8 nerve root, which exits the spine through the C7-T1 neuroforamen, is best assessed by testing the long digital flexors and, thus, the patient's grip. One method of assessing the grip is to place the index and the long fingers in the patient's palm and ask him or her to squeeze these digits as tightly as possible (Fig. 34A). This method is sometimes difficult to quantitate and may be painful for the examiner if the patient is very strong.

An alternative method is for the examiner to place his or her flexed fingers against the patient's palm and ask the patient to make a tight fist. This causes the examiner's and the patient's fingers to be hooked together in a reciprocal manner. The examiner then instructs the patient not to allow the fist to be pulled open and then attempts to do so (see Fig. 34B). In most normal patients, the examiner is unable to overcome the patient's grip.

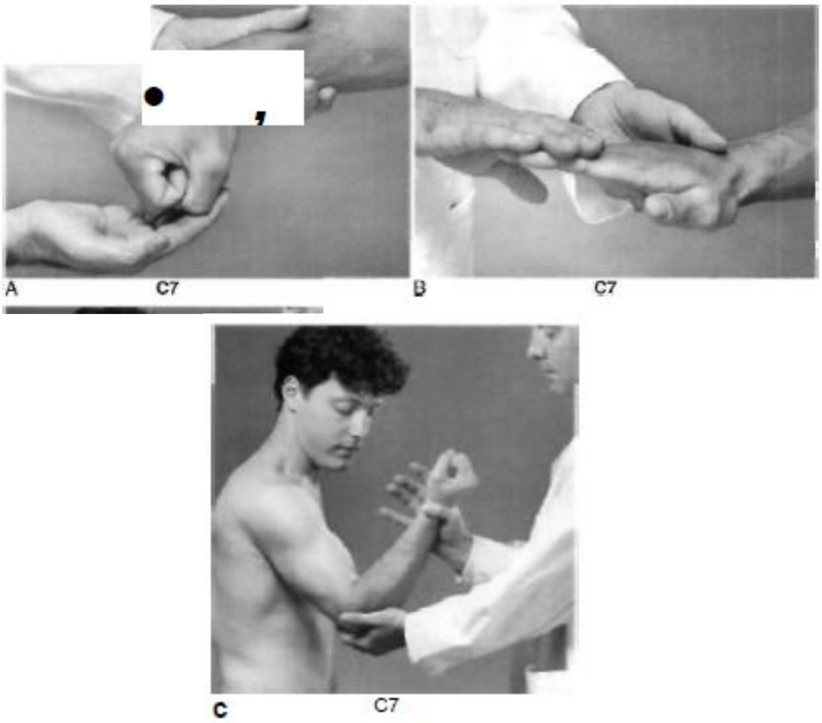


Figure 33. Assessing C7 motor function. *A*, Wrist flexors. *B*, Long finger extensors. C, Triceps brachii.

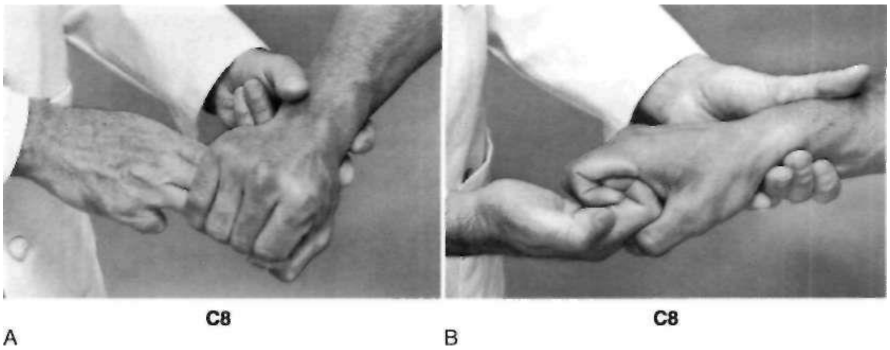


Figure 34. Assessing C8 motor function. *A*, Long finger flexors. *B*, Alternative technique.

Tl Nerve Root. The **Tl nerve root** exits the spine through the T1-T2 neuroforamen. Tl motor function is usually assessed by testing the strength of the interosseous muscles, which govern abduction and adduction of the fingers. **Finger abduction** can be tested most easily by asking the patient to hold both hands out and spread the fingers as far apart as possible. The examiner then grasps the patient's spread fingers between the examiner's thumb and index finger and attempts to push them back together while the patient resists maximally (Fig. 35A). Normally, the examiner should be able to overcome the patient's efforts to maintain finger abduction with a moderate degree of difficulty. With this technique, both hands may be tested simultaneously and the strength of abduction compared.

An alternative technique is to test the **first dorsal interosseous** in isolation. To test the first dorsal interosseous, the examiner stabilizes the patient's hand with one of the examiner's own hands and places the index finger of the examiner's other hand against the radial aspect of the patient's index finger. The patient is then instructed to press the index finger being tested against the examiner's finger as hard as possible (Fig. 35B). Not only can the strength be assessed by this method but also the contraction of the first dorsal interosseous can be confirmed visually or by palpation.

Finger adduction is also a motor function of the Tl nerve root. To test it, the examiner places an index card between the patient's extended long and index fingers and instructs the patient to squeeze the two fingers together as tightly as possible. The examiner then proceeds to withdraw the card from between the fingers, estimating the force required (Fig.35C). Normally, the examiner should be able to withdraw the card but with some difficulty.

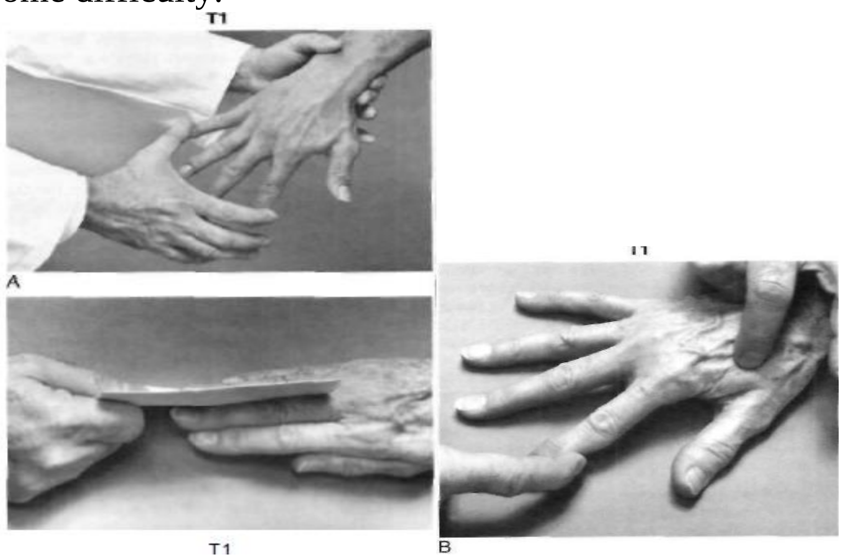


Figure **35.** Assessing 11 motor function. .A, Finger abduction. *B,* First dorsal interosseous. C, Finger adduction.

Lower Thoracic Nerve Roots. Motor function of specific thoracic nerve roots is not normally assessed. **Beevor's sign,** however, may be used to screen tor asymmetric loss of thoracic root motor function. Beevor's sign is a gross test of muscular innervation from the thoracic spine. In this test, the patient is asked to do a half sit-up with the knees flexed and the arms behind the head (Fig.36). In the normal patient, symmetric coordinated abdominal muscle contraction should keep the umbilicus in the midline during this maneuver. Compression or destruction of a thoracic nerve root, such as might be caused by osteophyte or tumor, results in weakness of the musculature in the dermatome innervated by that root. This causes the umbilicus to deviate toward the stronger uninvolved side. This deviation is called Beevor's sign. Asymmetric weakness of the musculature innervated by the thoracic nerve roots may also be seen in cases of spinal dysraphism or poliomyelitis.

Fig. 36A Beevor’s sign: Negative—the umbilicus does not move

Fig. 36b In this position, umbilical movement indicates a weak segmental portion of the rectus abdominus and paraspinal muscles (positive Beevor’s sign).

REFLEX EXAMINATION

Biceps Tendon Reflex (C5). The biceps tendon reflex is usually used to assess the **C5 nerve root. I** However, because the C6 nerve root also contributes to innervation of the biceps, the C5 radiculopathy may only result in diminution, not complete elimination, of the biceps reflex. To test the biceps reflex, the examiner grasps the patient's arm at the elbow, placing the examiner's own thumb on the patient's biceps tendon.

The patient's forearm is allowed to rest on the examiner's forearm, in order to encourage complete relaxation. The examiner then lightly taps his or her own thumb with the reflex hammer (Fig. 37). In most normal patients, the examiner should feel a contraction of the biceps transmitted through the tendon in response to the tap. Usually, a contraction of the biceps is visible, as well. ***Brachioradialis Reflex*** *(C6).* The brachioradialis reflex is usually chosen to test the C6 nerve root. To test the brachioradialis reflex, the examiner supports the patient's forearm in a position of neutral rotation so that the radial aspect of the forearm is pointing upward. The wrist is allowed to fall into ulnar deviation. The examiner then taps the radial aspect of the forearm about 4 to 8 cm proximal to the radial styloid (Fig.38). This should produce a visible contraction of the brachioradialis muscle and, in many cases, a quick upward motion of the forearm. Because the biceps brachii is innervated by C6 as well as C5, the biceps reflex can also be examined when a C6 radiculopathy is suspected.

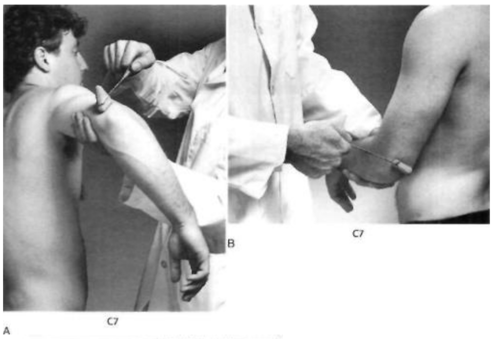
C5

Figure **37.** Biceps reflex (C5).

C6

Figure 38. Brachioradialis reflex (C6).

The triceps reflex is usually used to assess the C7 nerve root. The triceps reflex is best elicited with the patient in a position of 90" shoulder abduction and 90° elbow flexion. The examiner should support the arm completely, asking the patient to relax ail musculature. The examiner should feel that the patients limb would flop back to the side if the examiner released it. When adequate relaxation is sensed, the examiner strikes the triceps tendon just proximal to the olecranon (Fig.39A). Normally, this should cause a visible contraction of the triceps and, sometimes, a slight extension of the elbow. The triceps reflex may also be elicited with the patient's arm at the side in a position similar to that used for the biceps reflex (Fig.39B). This position is useful for patients who find the 90° of shoulder abduction uncomfortable.



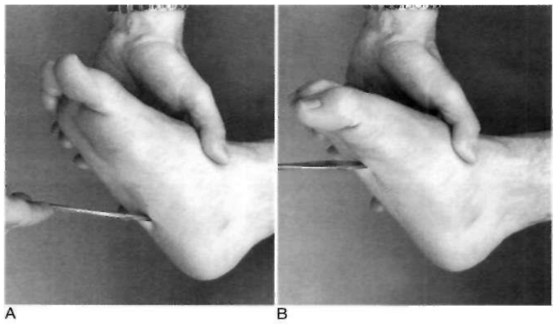


Figure 39. ***A,*** Triceps reflex (C7). B, Alternative technique.

Figure 40. *A* and *B,* Eliciting a normal plantar rellex. C, Babinski's sign (abnormal).

Grading Reflexes. Because briskness of deep tendon reflexes varies considerably from one individual to another, the examiner should test several reflexes on both sides of the patient to verify that an apparently abnormal reflex is abnormal for that particular patient. Particularly significant is a reflex that is abnormal compared with the corresponding reflex on the opposite side of the body. Reflexes are typically graded as hyporeactive, normal, or hyperreactive. The examiner must make this subjective assessment through comparison with patients examined in the past. A normal reflex typically produces a palpable contraction, often associated with a slight movement of the limb. Strong or violent responses to reflex testing are suspicious for hyperreactivity. Hyporeactive reflexes are very difficult to elicit or are completely absent. Generalized areflexia may be present in metabolic states such as hypercalcemia. A *lower motor neuron lesion* is characterized by weakness and hyporeflexia, whereas an *upper motor neuron lesion* is typified by hyperreflexia and the presence of pathologic reflexes such as the Babinski reflex. A unilaterally diminished or absent reflex is the most common abnormal finding and suggests nerve injury at the root level or distal to it.

Plantar Reflex. The Babinski sign is a pathologic reflex that indicates upper motor neuron involvement. To test the plantar reflex, the examiner asks the patient to sit comfortably with the feet dangling from the examination table. The examiner grasps the patient's foot with one hand, then gently strokes the lateral border of the sole of the foot beginning about the level of the heel and moving distally (Fig.40A). In a normal patient, the initial response is a downward reflection of the great toe (Fig.40B), although the toes may subsequently dorsiflex. When the Babinski sign is present, the toes immediately dorsiflex when the plantar surface of the foot is stroked (Fig. 40C).

Clonus. Clonus is another sign of hyperreflexia that suggests an upper motor neuron lesion. It is usually assessed with the patient sitting on the examination table. While stabilizing the patient's leg with one hand, the examiner grasps the patient's forefoot with the other hand and quickly and forcefully pushes it into dorsiflexion (Fig.41). When clonus is present, such a sudden dorsiflexion produces a rhythmic involuntary motion that alternates between plantar flexion and dorsiflexion. Each cycle of motion is called a *beat of clonus.* One or two beats of clonus may be present in otherwise normal individuals. When clonus is sustained beyond two beats, an upper motor neuron lesion, such as proximal spinal cord compression, should be suspected.

Cervical Spinal Stenosis. Cervical spinal stenosis typically produces *lower motor neuron* findings at the level of the lesion and *upper motor neuron* deficits distal to the level of the lesion. For example, in the case of cervical stenosis at the C5-C6 level, one would normally find lower motor neuron signs of the C6 nerve root and upper motor neuron signs distal to that. Thus, in this particular example, the lower motor neuron deficit would be manifested by weakness in the biceps and the wrist extensors with diminution of the biceps and the brachioradialis reflexes. Upper motor neuron involvement distal to the level of the lesion would be reflected in hyperreflexia of the triceps, the quadriceps, and the gastrocnemius reflexes. Other upper motor neuron signs such as clonus and the Babinski reflexes might or might not be present.

Abdominal Muscle Reflexes. Abdominal muscle reflexes may be tested as a method of screening for thoracic spinal cord compression. To assess abdominal reflexes, the patient is positioned comfortably in a supine position with the abdomen exposed. The handle of the reflex hammer is then gently stroked across the abdomen in a radial manner beginning at the umbilicus and proceeding toward the 2-o'ciock, the 4-o'clock, the 8-o'clock, and the 10-o'clock positions, in succession (Fig.42). Normally, such stimulation should cause the abdominal musculature to involuntarily contract, resulting in movement of the umbilicus in the direction of the quadrant being stimulated. Absence of the normal response indicates thoracic spinal cord compression on the side of the diminished reflex. Remembering that the upper abdominal musculature is innervated by the T7 through T1O nerve roots and the lower abdominal musculature is innervated by the T1O through LI nerve rootlps the examiner identify the approximate level of involvement.

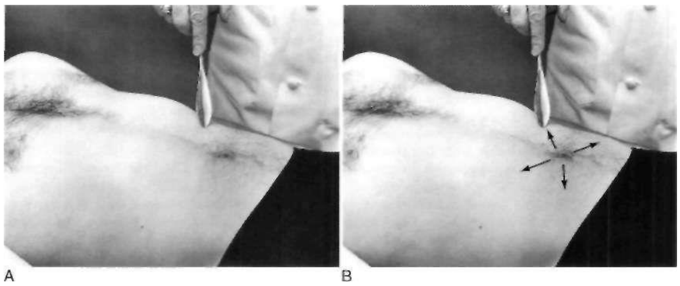


Figure 41. Eliciting ankle clonus. Figure 42. *A* and *B*, Eliciting abdominal reflexes. *(Arrows* in B indicate the direction of stroking.)

Upper Limb Tension Tests

A number of upper limb nerve tension tests have been described by authors including Elvey, Kennealy, and Butler. These are sometimes known as the straight-leg raising tests of the arm because they are analogous to the nerve root tension signs of the lower extremity, such as the Lasegue test, the slump test, and the femoral nerve stretch test. Like their lower extremity counterparts, these maneuvers aim to reproduce or exacerbate neurologically based -symptoms by placing tension on the cervical nerve roots and the associated peripheral nerves. As in the lower extremity tension tests, these maneuvers often produce some degree of symptoms in normal individuals, such as aching or stretching sensations. The patient's response to the test is considered abnormal if the maneuver reproduces the patient's familiar pain, which usually radiates distal to the elbow.

UPPER LIMB TENSION TEST 1

The upper limb tension test 1 (ULTT1) is a series of maneuvers applied to the upper extremity to place tension on the C5, the C6, and the C7 nerve roots, and it is described as median nerve dominant because the median nerve is the peripheral nerve most stressed by these maneuvers. Thus, the test is not specific with regard to a given level, but indicates irritation or compression of any one, two, or three of the involved roots, all of which contribute to the median nerve. However, each portion of the maneuver should be done carefully and gently because considerable tension may be placed on sensitive nerve roots. Throughout the procedure, the examiner maintains communication with the patient to determine whether radicular symptoms are reproduced and, if so, at what point in the test.

To perform this test on the patient's right side, the patient is positioned in a relaxed supine position along the right edge of the examination table. The examiner stands next to the table at the patient's right side. The examiner's left hand then grasps the patient's right hand securely and gently abducts the patient's shoulder, allowing the patient's arm to rest along the examiner's right thigh. The examiner's right hand is placed in contact with the superior aspect of the patient's right shoulder and driven firmly against the examination table. This allows the examiner's right hand to serve as a post that prevents further elevation of the patient's shoulder girdle (Fig. 43A). The patient's shoulder is then abducted to about 110° (Fig. 43B). While maintaining this position, the examiner supinates the patient's forearm and extends the patient's wrist and fingers (Fig. 43C). The next step is to externally rotate the patient's shoulder to 90° (Fig.43D). Next, the patient's elbow is slowly extended (Fig. 43E). Finally, the patient is asked to laterally bend the neck, first toward the shoulder being examined (Fig. 43F) and then away from it (Fig. 43G). If nerve root tension is present, laterally bending the neck toward the side being tested should relieve the symptoms, whereas bending it away from the side being tested should exacerbate them. Optionally, an assistant may perform a straight-leg raise to further increase nerve root tension (Fig. 43H).

The ULTT1 maneuver produces a sensation of stretching or aching in the antecubital fossa in almost all subjects. This is not considered an abnormal response. Pain suggestive of true radicular involvement would radiate to the lateral deltoid and the midarm (C5), down the dorsal radial aspect of the forearm to involve the index finger and the thumb (C6), or centrally down the forearm to involve the dorsum of the hand and the long finger (C7).

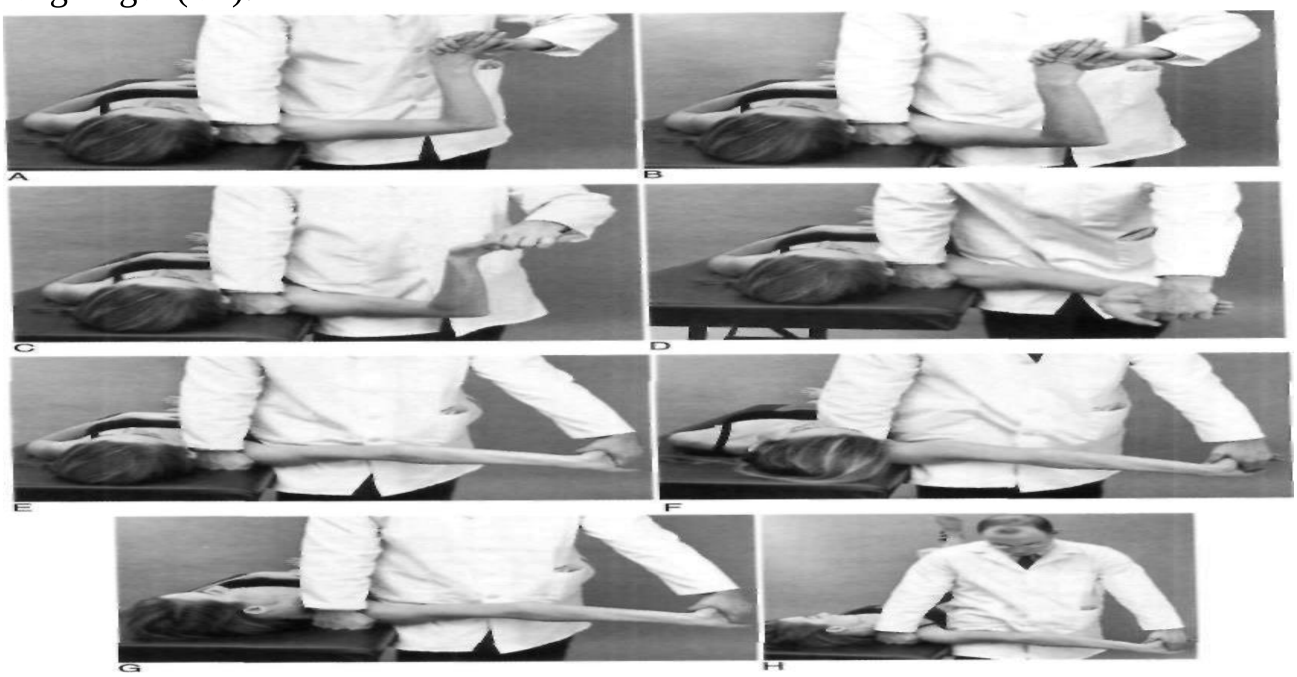


Figure 43. *A-H*, Upper limb tension test 1 (ULTT1).

UPPER LIMB TENSION TEST 2

The upper limb tension test 2 (ULTT2) also tests for irritation of the C6 or C7 nerve roots. There are two variants of this test, one that is median nerve dominant and one that is radial nerve dominant. They are both performed with the patient lying supine on the examination table.

Median Nerve Dominant. To perform the median nerve dominant variation, the patient is positioned at an angle so that the scapula of the side being tested projects past the edge of the table. When the right side is being tested, the examiner stands at the head of the table with the examiner's left thigh resting against the superior aspect of the patient's right shoulder. The examiner's left hand holds the patient's right elbow and the examiner's right hand holds the patient's right wrist (Fig.44A). In a controlled manner, the examiner carefully depresses the patient's shoulder girdle with pressure from the examiner's thigh (Fig. 44B). The patient's shoulder is abducted about 10° so that the arm is clear of the table. While maintaining the shoulder depression, the examiner next extends the patient's elbow (Fig. 44C). Then, the examiner uses both hands to externally rotate the patient's upper limb at the shoulder (Fig. 44D). The examiner's right hand then grasps the patient's fingers securely and uses them to extend the metacarpophalangeal joints and dorsiflex the wrist (Fig.44E). Abducting the patient's shoulder to 90° while maintaining the shoulder depression further increases nerve root tension (Fig.44F). As in the ULTTl, the patient's response is considered abnormal only if radicular pain is elicited.

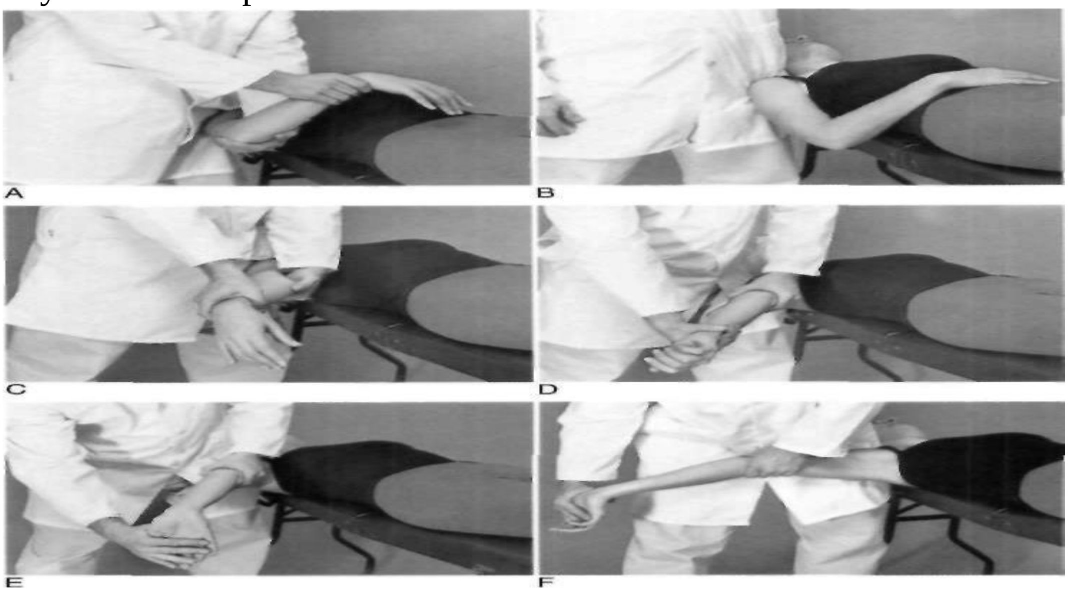


Figure 44. *A-F*, Upper limb tension test 2 (ULTT2), median nerve dominant variation. (In *B*, the examiner has temporarily released the patient's arm so that the shoulder depression can be seen by the reader.)

Radial Nerve Dominant. The radial nerve dominant variant of the ULTT2 begins in the same position. Again, the patient is positioned obliquely on the table so that the shoulder to be examined extends past the edge of the table. The examiner's left thigh is again used to depress the patient's right shoulder, and the patient's elbow is extended as it was for the ULTTl (Fig. 45A). This time, the examiner's hands are used to internally rotate the entire upper extremity at the shoulder (Fig. 45B).

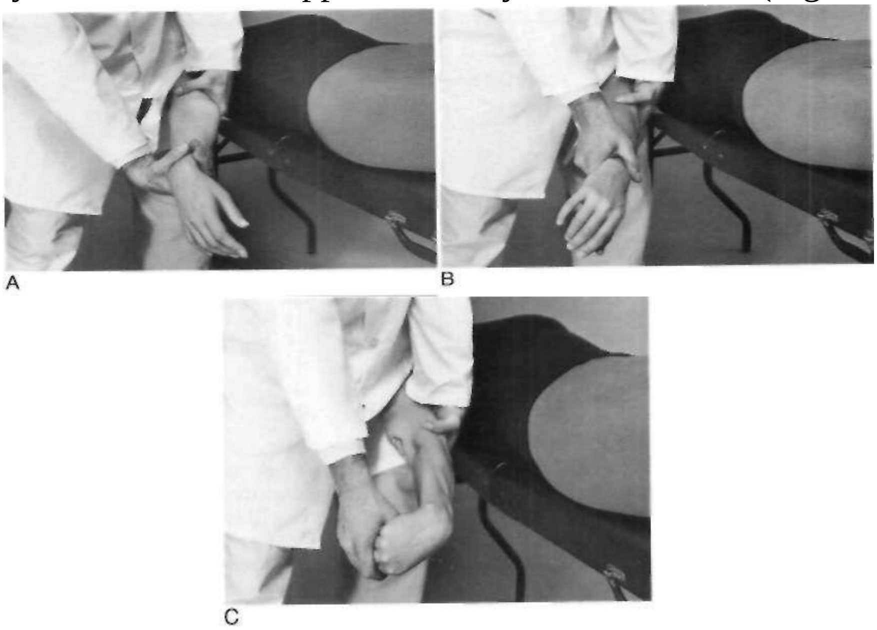


Figure 45. ***A-C,*** Upper limb tension test 2 (ULTT2), radial nerve dominant variation.

while maintaining the shoulder depression, the elbow extension, and the internal rotation of the limb, the examiner's right hand is used to grasp the patient's right hand and flex the patient's wrist, thumb, and fingers (Fig.45C). As with the previous test, the response is considered abnormal if this maneuver elicits radicular pain, particularly in the radial nerve distribution.

UPPER LIMB TENSION TEST 3

The upper limb tension test 3 (ULTT3) is performed to assess possible irritation of the C8 and Tl nerve roots. It is designed to be ulnar nerve dominant. Owing to the relative hypomobility of the cervicothoracic junction lesions of

these lower nerve roots are more difficult to assess. For this test, the patient and the examiner are positioned as for the ULTT1. The examiner should assume a wide-based stance so that his or her weight can be shifted forward when required. To examine the right side, the patient's flexed right elbow is rested against the examiner's pelvis, just below the anterior superior iliac spine. The examiner's left hand grasps the patient's right hand by the fingers, and the examiner's right hand is again pressed into the examination table against the superior aspect of the shoulder to prevent elevation (Fig.46A). The patient's wrist is then dorsiflexed and the forearm supinated (Fig.46B). While maintaining this position, the patient's elbow is maximally flexed (Fig.46C). The examiner's right hand is then used to depress the patient's shoulder (Fig.46D). The patient's shoulder is externally rotated and then abducted, approximating the patient's hand to his or her own ear (Fig.46*E)*. Asking the patient to laterally bend the neck away from the side being tested places additional tension on the nerve roots (Fig.46F), whereas bending toward the side being tested relaxes the tension somewhat. In response to the ULTT3 maneuver, normal subjects feel a tugging sensation in the axilla. The response is considered abnormal if the patient feels pain radiating down the arm past the elbow to the ring and little fingers (C8) or into the axilla (Tl).

Additional nerve root tension can be added by having an assistant perform a simultaneous straight-leg raise on the ipsilateral side or by performing the test in the slump position. If the slump variant is selected, the ULTTs are performed as described but with the patient seated. The patient is asked to maximally flex the trunk and hips while keeping the knees extended. This places the cauda equina under stretch and provides additional tension.

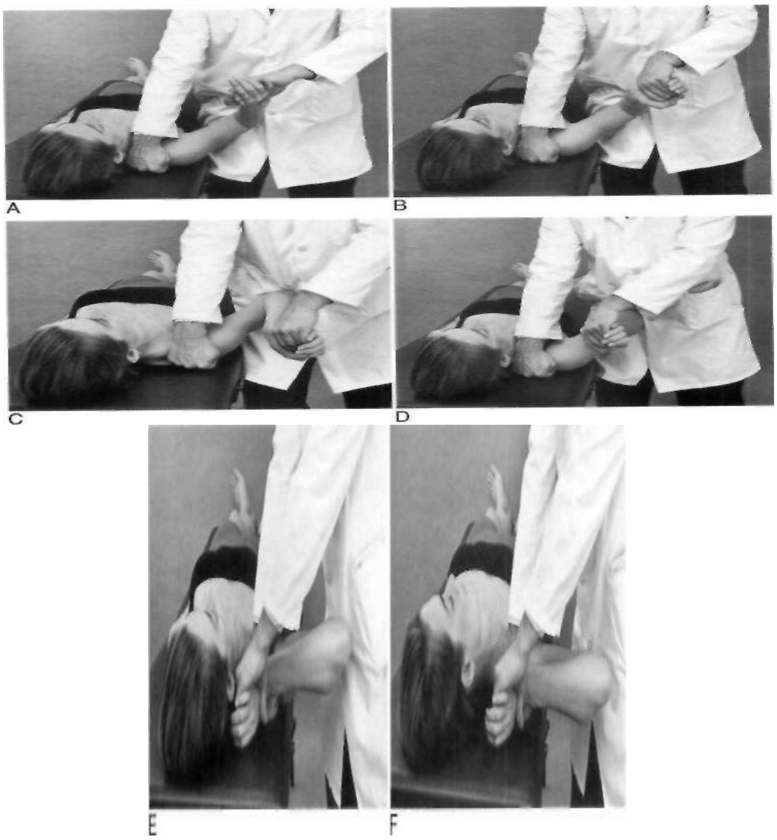


Figure 46. ***A-F,*** Upper limb tension test 3 (ULTT3).

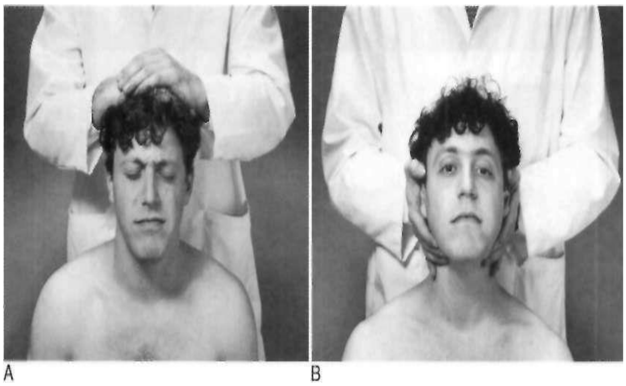
Miscellaneous Special Tests

AXIAL COMPRESSION TEST

The axial compression test and Spurling's test are designed to determine whether axial compression elicits or aggravates the patient's painful symptoms. They should not be performed when nerve root compression with a motor deficit is suspected or detected. To perform the **axial compression test,** the examiner stands behind the patient who is seated with the cervical spine **in a** neutral position. The examiner then places both hands at the crown of the patient's head and compresses, thus supplying an axial load (Fig.47A). The application of the force should be gentle and gradual because it may elicit a very painful response. The patient is asked to report whether the maneuver produces pain or other unpleasant sensations, as well as the quality and distribution of the symptoms created. A **distraction test** of the neck may relieve the symptoms (Fig.47B).

SPURLING'S TEST

If the examiner is suspicious of lateralizing pathology, such as a disk prolapse, the compression maneuver may be repeated with various amounts of cervical flexion, extension, lateral bending, or rotation in an attempt to find the position that elicits the maximal response (Fig. 8-48). In Spurling's test, the neck is extended and rotated toward the involved side prior to axial compression. This maneuver is designed to exacerbate encroachment on a cervical nerve root by decreasing the dimensions of the foramen through which the nerve root exits the spine. In response to the axial compression test or Spurling's test, a patient may feel no discomfort, a sensation of heaviness, nonradicular or pseudoradicular pain, or radicular pain. Pain related to muscular strains or mild ligamentous sprains is not normally aggravated by these tests. *Nonradicular* or *pseudoradicular* pain includes pain that radiates to the occiput, the scapula, or the shoulders, or occasionally down the arm but not distal to the elbow. Such pseudoradicular pain may be the result of a mechanical or degenerative process in the cervical spine such as spondylolisthesis or degenerative disk disease without nerve root compression. *Radicular* pain radiates into the upper extremity, usually below the elbow, along the distribution of a specific dermatome. In the younger individual, this is most commonly the result of nerve root compression owing to intervertebral disk prolapse. In the older patient, radicular pain is usually produced by foraminal stenosis owing to the combination of disk degeneration and secondary facet hypertrophy.***LHERMITTE'S MANEUVER*** Lhermitte's maneuver is performed by asking the seated patient to maximally flex the cervical and the thoracic spine (Fig.49). Lhermitte's sign is considered present when this maneuver produces distal paresthesias in multiple extremities or the trunk. Lhermitte's sign is thought to be indicative of spinal stenosis and resulting spinal cord compression. In the patient with a narrowed cervical spinal canal, flexion can further reduce the dimensions of the canal, causing cord compression and the paresthesias described. In the patient without cervical spinal stenosis, maximal flexion simply results in a pulling sensation at the cervicothoracic junction without any radiating symptoms at all.



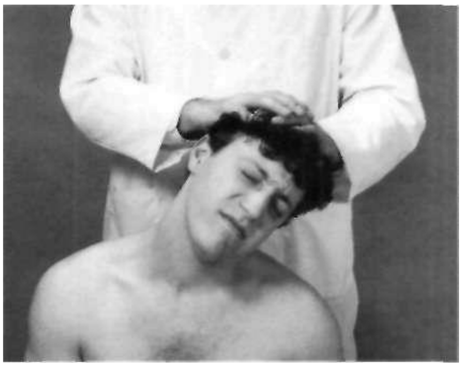


Figure 47. *A*, Axial compression test. *B*, Distraction test.

. Figure 48. Spurling's test

Figure 49. Lhermitte's maneuver.

Figure 50. Nonanatomic tenderness.

Nonorganic Signs of Waddell

Waddell described five signs that the examiner may note during the initial evaluation that suggest the possibility of nonorganic pathology. These are physical findings that cannot be explained by current knowledge of anatomy and physiology. They are thought to represent functional or behavioral maladaptations to the disease process or reaction to real or perceived pain. It should be borne firmly in mind that they are not pathognomonic of functional or nonorganic pathology, but rather they are just a component of the overall assessment. These signs were originally described in conjunction with the lumbar spine.

NONANATOMIC TENDERNESS

The first of Waddell`s signs is superficial nonanatomic tenderness. This sign is considered present when the patient reports disproportionate pain in response to extremely light touch or tenderness whose distribution does not correspond to the configuration of known anatomic structures (Fig.50). The examiner must make this somewhat subjective judgment based on previous experience with the response of other patients to similar levels of pressure. If the examiner senses that the patient's pain response is out of proportion to the pressure applied during a normal examination, the examiner may wish to further test by palpating the involved area with extremely light pressure or by palpating structures that are seldom tender. It should be kept in mind that reflex sympathetic dystrophy and its variants may cause hypersensitivity in an extremity.

SIMULATION SIGN

Waddell's second sign is called the simulation sign. It is considered present if there is an exaggerated response to the axial compression test or a painful response to the rotation simulation maneuver. In the case of the axial compression test, organic pain should be experienced only in the neck, the shoulders, or the upper extremities, Patients who report pain in the low back or radiating down the entire spine in response to the axial compression test are judged as having a positive simulation sign. The alternative way to test for simulation is by the rotation simulation maneuver. In this maneuver, the shoulders are rotated in a manner coplanar with the pelvis while the patient is standing (Fig. 51). This is essentially a log roll and puts no torsional force on the thoracic or lumbar spines. It should, therefore, not provoke pain from those regions. A report of pain in response to the rotation simulation maneuver is, therefore, considered a positive simulation sign and suggests nonorganic pathology.

DISTRACTION SIGN

The third sign of Waddell is called the distraction sign. When a positive distraction sign is present, the response of the patient to the straight-leg raising test varies depending on whether it is performed with the patient in the supine or the seated position. In the presence of true nerve root tension, the patient should experience radiating pain in whichever position the straight-leg raising test is performed. Patients with nonorganic pain often know by experience that straight-leg raising in the supine position should be painful but may not realize that passive extension of their knee while seated produces the same position of tension on the sciatic nerve roots (Fig.52). They may, thus, inconsistently fail to report pain in response to the seated-leg raising maneuver. Such an inconsistent response is said to represent a positive distraction sign because the patient is distracted from the nature of the test by the unfamiliar position.

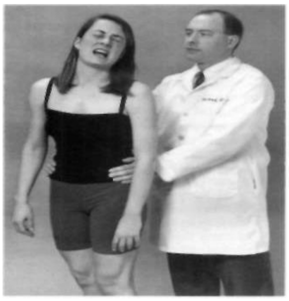


Figure 51. Rotation simulation maneuver

Figure 52. Distraction sign. Supine straight-leg raising reproduces symptoms, but seated-leg raising does not.

REGIONAL SENSORY OR MOTOR DISTURBANCE

The fourth nonorganic sign of Waddell is called regional sensory or motor disturbance. A regional sensory disturbance is considered present when abnormal sensation is noted in a nonanatomic distribution such as a stocking or glove distribution in the leg or the arm, respectively. A regional motor disturbance is suspected if the examiner discovers diffuse motor weakness of multiple muscle groups, such as weakness of every muscle group tested in the upper extremity, or if the examiner senses, during strength testing, that the patient's muscles suddenly give way in a nonphysiologic manner.

OVERREACTION

The fifth nonorganic sign of Waddell is called **overreaction.** This sign is considered present when the patient reacts physically or verbally in an inappropriately theatrical manner to light forms of palpation or gentle examination techniques. Again, the evaluation of this sign depends on the examiner's previous experience with a broad range of normal patient behavior.

Waddell's original description of the five signs was in connection with a study of patients' responses to spine surgery. Waddell noted that three or more signs were present in patients who had had unsuccessful back surgery. Waddell also found that the most sensitive sign was over-reaction. Because the assessment of these signs is subjective, their significance increases when several are present. It should be remembered that in certain organic disease states, individual Waddell signs may be present. This is clearly the case in the stocking distribution of numbness that can occur in the presence of diabetic neuropathy.

ADSON TEST

This test is used to determine the state of the subclavian artery, which may be compressed by an extra cervical rib or by tightened scalenus anticus and scalenus medius muscles, which can compress the artery where it passes between them on its way to the upper extremity. To perform the Adson test, take the patient's radial pulse at the wrist. As you continue to feel the pulse, abduct, extend, and externally rotate his arm. Then instruct him to take a deep breath and to turn his head toward the arm being tested (Figs. 53). If there is compression of the subclavian artery, you will feel a marked diminution or absence of the radial pulse.

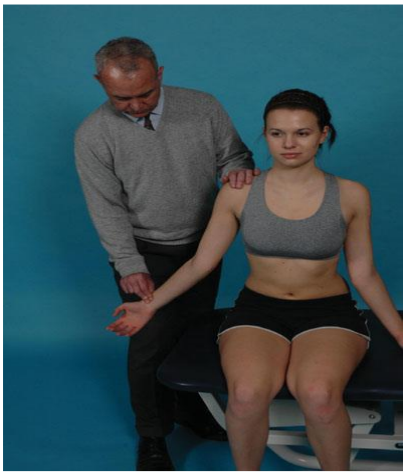


FIGURE 53 Adson's test.

Vertebral Artery Test: Cervical Rotation Supine

PURPOSE The purpose of this test is to screen for vertebral artery insufficiency and collateral circulation to the brain.

PATIENT POSITION The patient is supine with the head on a pillow and the top of the head even with the top edge of the table.

THERAPIST POSITION The therapist stands at the head of the patient.

HAND PLACEMENT Left hand: The hand supports the left side of the patient's head with the fingers spread. **Right hand:** The hand supports the right side of the patient's head with the fingers spread.

PROCEDURE The therapist must instruct the patient to look at the therapist's forehead throughout the procedure, and the therapist must move with the patient to maintain a clear view of the patient's eyes throughout the procedure to assess for nystagmus. The therapist must also continually seek verbal feedback from the patient throughout the test. A delayed response or a report of dizziness, lightheadedness, or nausea is considered positive. As the therapist supports the patient's head, the cervical spine is slowly rotated to the right to the end of available range. The therapist pauses in this position for 3 to 5 seconds to assess the patient's response. If the test results are still negative, the therapist gently adds lateral flexion to the right and extension and holds this position for 5 to 10 seconds. If the test results are negative, the therapist repeats to the opposite side.

NOTES If the patient has a positive response, the therapist repositions the head to a neutral or slightly flexed position immediately and continues to monitor the patient. The therapist supports the patient's head on one or two pillows and passively positions the patient's legs in a 90/90 position either on a stool or on the therapist's shoulders. The therapist continues to monitor the patient until the positive response completely subsides.

FIGURE 54 Vertebral Artery Test

Shoulder Abduction Test

PURPOSE If this position alleviates the patient’s radicular arm pain, nerve root irritation is suggested as the cause of the arm pain.**PATIENT POSITION** The patient is positioned sitting.

PROCEDURE The patient is seated and asked to place the hand of the symptomatic extremity on the head. Positive test results occur with reduction or elimination of symptoms. The therapist should ask open-ended questions with this test, such as, “Does this change your symptoms in any way?”

FIGURE 55 Shoulder Abduction Test

Physical Findings In Common Conditions Of The Cervical And The Thoracic Spine

Cervical Radiculopathy

Restricted range of motion

Radiating pain exacerbated by the axial compression test and/or the Spurling test (frequent) Upper limb tension test reproduces or exacerbates the patient's familiar radicular pain Motor, sensory, and/or rellex deficit in the distribution of the involved
nerve root (variable).

Cervical Spondylitic Myelopathy (Cervical Spinal Stenosis)

- Restricted range of motion
- Lhermitte's maneuver produces distal paresthesias
- Broad-based gait (variable)

- Lower motor neuron findings of the nerve roots at the level of the lesion (motor, sensory, and/or reflex deficit in distribution of the involved nerve root) (variable)
- Upper motor neuron deficit below the level of the lesion (hyperreflexia, ankle clonus, Babinski's sign)

Cervical Fracture

Point tenderness at the level of the injury

Palpable deformity, such as step-off or break in the normal alignment or spacing of the spinous processes

Neurologic deficit (may vary from none or partial spinal cord injury syndrome to complete spinal cord injury)

Partial spinal cord injury syndromes include anterior cord syndrome, central cord syndrome, Brown-Sequard syndrome, and posterior cord syndrome.

Cervical Strain (Whiplash Injury, Mechanical Cervical Pain)

Diffuse tenderness of the posterior neck muscles Reduced range of motion

Normal neurologic examination

Physical Examination of the Knee

The knee joint, the largest joint in the body, is a modified hinge joint known as a ginglymus joint. It allows for a wide range of motion, with the greatest range of motion in flexion, similar to the elbow.

The knee is highly susceptible to traumatic injury due to its location at the end of two long lever arms, the tibia and the femur, which subject it to maximum stress. Additionally, the knee lacks the protection of fat or muscle layers, making it more exposed and vulnerable to injury.

The bony contours of the knee are easily palpable, making the diagnostic process easier compared to other joints.

During inspection, the patient's gait should be smooth and rhythmic. The knee is bent during the swing phase of walking, and the quadriceps contract to accelerate the lower limb. The hamstrings then contract to decelerate the leg before heel strike. The knee should be fully extended at heel strike and remain flexed during all stages of the stance phase.

Swelling in the knee can be classified as localized (bursal) or generalized (intra-articular). Bursal swelling is commonly found over the patella or the tibial tubercle. Intra-articular swelling can be caused by hemorrhage, synovial irritation (synovitis), or synovial thickening, and it affects the entire knee joint.

Inspect the muscle contours above the knee for any visible muscular atrophy, especially near the knee joint. Pay attention to the vastus medialis muscle, which may atrophy after knee surgery.

To inspect the anterior aspect of the knee, have the patient stand straight with knees fully extended. The patella should be symmetrical and level. Normally, the tibia has a slight valgus angulation compared to the femur. Valgus refers to the lateral side of the knee joint, while varus refers to the medial side. Knock-knees (valgus) and bowlegs (varus) are common deformities of the knee joint.

From a lateral perspective, observe that the knee should be fully extended when the patient is standing. If the knees are slightly flexed and the patient is unable to straighten them upon command, especially if the flexion is unilateral, it may indicate pathology. Slight hyperextension is considered normal as long as it is bilateral. Hyperextension of the knees is more common in females and individuals with "lax ligaments" (genu recurvatum).

When preparing for palpation, have the patient sit on the edge of an examining table. If you are seated on an examination stool facing the patient, you can anchor their leg between yours, allowing both hands to be free for examination. For a bedridden patient, they should be in a supine position with their knees flexed to 90°.

Palpation of the knee is easier when it is flexed because the skin stretches tautly over the bones, making the skeletal landmarks more distinct. Additionally, the muscles, tendons, and ligaments around the joint become relaxed in the flexed, non-weight-bearing position, making it easier to palpate the bony prominences and joint margins.

Medial Aspect:

To orient yourself for palpation, place your hands on the knee joint so that your fingers curve around to the posterior popliteal area. Place your thumbs on the anterior portion of the knee and press into the soft tissue depressions on either side of the infrapatellar tendon. These depressions serve as central points of orientation for palpating the medial aspect of the knee joint.

When pressing into them, you are actually palpating a portion of the joint line between the femur and tibia.

Medial Tibial Plateau:

Push your thumb inferiorly into the soft tissue depression until you can feel the sharp upper edge of the medial tibial plateau. The upper, non-articulating edge of the plateau is palpable posteriorly to the junction of the tibial plateau and the femoral condyle and anteriorly to the infrapatellar tendon. The plateau itself serves as one point of attachment for the medial meniscus.

Tibial Tubercle:

Follow the infrapatellar tendon distally to where it inserts into the tibial tubercle. Just medial to the tubercle lies the subcutaneous surface of the tibia, below the flare of the tibial plateau. This area is clinically significant due to the pes anserine insertion and bursa.

Medial Femoral Condyle:

As you move your thumb upward, you will find the medial femoral condyle, part of which is palpable immediately medial to the patella. More of the femoral condyle can be palpated if the knee is flexed more than 90°. Occasionally, you may be able to feel a defect in the cartilaginous surface, secondary to osteochondral fragments or osteoarthritis. The condyle is also palpable along its sharp medial edge, extending proximally as far as the superior portion of the patella and distally to the junction of the tibia and femur. Small bony outgrowths (osteophytes) are often palpable in individuals with knee osteoarthritis.

Adductor Tubercle:

Return to the medial surface of the medial femoral condyle and move further posteriorly until you locate the adductor tubercle in the distal end of the natural depression between the vastus medialis and hamstring muscles.

Lateral Aspect:

The area on the side of the knee, just next to the infrapatellar tendon, serves as a reference point for locating the bony prominences on the lateral side

Lateral Tibial Plateau:

Press down with your thumb into the soft tissue depression until you can feel the upper edge of the lateral tibial plateau. Palpate along its sharp edge, known as the lateral joint line, up to the point where the tibia and femur meet.

Lateral Tubercle:

The lateral tubercle is a prominent bony protrusion located just below the lateral tibial plateau. Palpate it while also feeling the infrapatellar tendon and the tibial tubercle

Lateral Femoral Condyle:

Return to the soft tissue depression and move upward and outward to locate the sharp edge of the lateral femoral condyle. You can palpate along its smooth surface all the way to the junction of the tibia and femur Keep in mind that the lateral femoral condyle has less surface available for palpation compared to the medial femoral condyle, as it is partially covered by the patella. However, if the knee is flexed beyond 90°, more of the condylar surface can be palpated.

Lateral Femoral Epicondyle:

The lateral femoral epicondyle is situated on the outer side of the lateral femoral condyle

Head of the Fibula:

From the lateral femoral epicondyle, move your thumb downward and backward across the joint line. You will find the fibular head at approximately the same level as the tibial tubercle

Trochlear Groove and Patella:

The trochlear groove is the track where the patella glides, but it does not directly articulate with the tibia.

To locate these structures, begin by placing your thumbs over the medial and lateral joint lines, and then move upward along both lines.

From the femoral condyles, palpate upward to the highest point of the patella. Then, above the patella, palpate toward the center until you reach the depression of the trochlear groove

When the knee is flexed, the patella is fixed within the trochlear groove, but it becomes mobile during extension. Therefore, the undersurface of the medial and lateral portions of the patella are more accessible for palpation when the knee is extended. Note that it is easier to push the patella inward (medially) than outward (laterally). Occasionally, you may encounter a cartilaginous defect under the patella or a roughened patellar border due to osteoarthritis.

Soft Tissue Palpation:

To facilitate palpation of the soft tissue structures around the knee, position the patient sitting on the edge of the examination table with their knees flexed at a 90° angle. Sit on a stool facing the patient.

Zone I - Anterior Aspect:

Quadriceps:

The quadriceps muscles generally insert as a group into the upper and inner edges of the patella. The quadriceps tendon then passes over the patella to form the infrapatellar tendon, which inserts into the tibial tubercle. Two muscles within the quadriceps group, the vastus medialis and the vastus medialis and vastus lateralis, two muscles within the quadriceps group, create visible bulges on the inner and outer sides of the knee and can be easily palpated.

These bulges become more prominent during isometric contraction. It is worth noting that the muscle mass of the vastus medialis extends further down than the mass of the vastus lateralis. Since the other quadriceps muscles are covered by a common fascial layer, it is challenging to palpate them individually. Therefore, it is recommended to evaluate them as a group. Palpate both thighs simultaneously, comparing the quadriceps muscles for symmetry and noting any defects such as ruptures or tears. Defects are typically found distally in the rectus femoris or the vastus intermedius, just above the patella. These defects may present as transverse areas that feel softer compared to the normally firm quadriceps muscles. Look for any signs of atrophy, particularly in the vastus medialis, which often experiences atrophy following knee joint effusion and knee surgery. Assess for quadriceps mechanism atrophy by using the edge of the tibial plateau as a fixed bony reference point and measuring the circumference of each thigh approximately three inches above the knee. Any difference in girth is considered significant.

Infrapatellar Tendon:

This tendon runs from the lower border of the patella and can be palpated down to its insertion into the tibial tubercle. In young individuals, this insertion site can be tender (Osgood-Schlatter's syndrome). The infrapatellar fat pad is located immediately behind the infrapatellar tendon, at the level of the joint line. Tenderness in this area may indicate hypertrophy or contusion of the fat pad. When the infrapatellar tendon is avulsed from its insertion, it no longer feels rigid, and a palpable defect develops, accompanied by severe tenderness in the area of the tibial tubercle.

Since bursitis is a common condition around the knee joint, it is important for the examiner to be familiar with the location of clinically significant bursae in the area. Most of these bursae are found in the anterior region.

Superficial Infrapatellar Bursa:

The superficial infrapatellar bursa is located in front of the infrapatellar tendon and can become inflamed due to excessive kneeling.

Prepatellar Bursa:

The prepatellar bursa covers the front part of the patella. It can become inflamed from a combination of excessive kneeling and leaning forward (known as housemaid's knee). Note that when the leg is extended, the skin over the patella can be lifted, similar to the skin over the elbow's olecranon. The prepatellar bursa helps the skin glide smoothly over the patella, especially during flexion.

Pes Anserine Bursa:

The pes anserine bursa is situated between the tendons of the sartorius, gracilis, and semitendinosus muscles (known as the pes anserine insertion) and the upper-medial part of the tibia, just medial to the tibial tubercle. It is not palpable under normal circumstances. However, if it becomes inflamed, you may be able to feel some swelling and thickening.

Zone II - Medial Aspect:

Starting from the medial soft tissue depression, move your thumb medially and posteriorly along the upper edge of the tibial plateau until you reach the junction of the tibia and femur.

Medial Meniscus:

The medial meniscus is connected to the upper edge of the plateau by small coronary ligaments, which are difficult to palpate. However, if the meniscus is detached (due to tears in the coronary ligaments), tenderness may be felt in the joint margin area. The anterior margin of the medial meniscus itself is barely palpable deep within the joint space. The meniscus has some mobility, and when the tibia is internally rotated, its medial edge becomes more prominent and palpable. Conversely, when the tibia is externally rotated, the meniscus retracts and cannot be palpated. When the meniscus is torn, the area of the medial joint line becomes tender to touch. Tears are more common in the medial meniscus compared to the lateral meniscus.

Medial Collateral Ligament:

The medial collateral ligament, a broad ligament shaped like a fan, connects the medial femoral epicondyle to the tibia. It consists of a deep and a superficial portion. The deep portion inserts directly into the edge of the tibial plateau and the meniscus, while the superficial portion inserts more distally onto the flare of the tibia. Although the ligament itself is not distinctly palpable, you can locate the region of the medial collateral ligament by identifying the medial joint line. As you move medially and posteriorly along the joint line, you will feel the ligament directly under your fingertips.

The medial collateral ligament is part of the joint capsule and is often torn in valgus stress injuries, such as clipping injuries in football. Palpate the area of the ligament from origin to insertion for tenderness and any interruption in continuity.

The tendons of the sartorius, gracilis, and semitendinosus muscles form a visible ridge on the posteromedial side of the knee. These tendons cross the knee joint before inserting into the lower portion of the medial tibial plateau. They provide support to the knee's medial side, which experiences significant strain during gait due to the valgus angle between the femur and tibia. To palpate these tendons, stabilize the patient's leg and offer resistance against knee flexion. Cup your fingers around the knee and feel the tautness of the tendons. The semitendinosus tendon is the most posterior and inferior tendon, followed by the gracilis tendon, which lies slightly anterior and medial to the semitendinosus.

The gracilis muscle becomes more prominent when you resist internal rotation of the leg. Its tendon, along with the gracilis muscle tendon, is round and should not be confused with the deeper semimembranosus tendon, which remains muscular until its insertion. Above the gracilis tendon, there is a wide, thick band of muscle called the sartorius, which is less tendinous and harder to feel compared to the gracilis and semitendinosus tendons.

The semimembranosus muscle is located deep to this group of tendons on the back of the tibia, and you can feel it by inserting your fingers between the semitendinosus and gracilis tendons. The semimembranosus is rarely affected unless there is significant knee trauma, and it can be used as a muscle transplant to strengthen the knee's medial side. The pes anserine bursa, located at the common insertion of these muscles, can become inflamed and cause pain during movement.

Moving to the lateral aspect, the lateral meniscus is best felt when the knee is slightly flexed, as it tends to disappear when fully extended. It is attached to the edge of the tibial plateau by coronary ligaments, and if these ligaments tear, the meniscus can become detached, causing tenderness upon palpation. By pressing firmly into the lateral joint space with your thumb, you may be able to feel the anterior margin of the lateral meniscus. Unlike the medial meniscus, the lateral meniscus is not attached to the lateral collateral ligament but to the popliteus muscle, making it more mobile. Due to its mobility, the lateral meniscus is less prone to tears. However, when it does tear, the lateral joint line becomes tender, and a cyst may develop at the joint line, which can be felt as a firm, tender mass.

The lateral collateral ligament is a strong cord that connects the lateral femoral epicondyle and the fibular head. It is separate from the joint capsule. To palpate it, have the patient cross their legs so that the ankle rests on the opposite knee. With the knee flexed to 90° and the hip abducted and externally rotated, the iliotibial tract relaxes, making it easier to isolate the lateral collateral ligament. The ligament is located away from the joint itself, along the lateral and posterior aspect of the joint line.

The incidence of tearing in the lateral collateral ligament is not as high as in the medial collateral ligament in certain knee joint injuries. When the lateral collateral ligament is torn, it becomes tender to palpation. In some cases, the lateral collateral ligament may be congenitally absent.

The anterior superior tibiofibular ligament is located in the crevice between the tibia and the fibular head. By moving anteriorly and medially from the head of the fibula, you can feel where the ligament crosses the tibia/fibula joint. Palpating the ligament helps define its anatomy, but it is rarely involved in pathological conditions.

When the knee is flexed, the biceps femoris tendon becomes noticeable as it crosses the knee joint before inserting into the fibular head. It should be palpated near its insertion for any defects. Although the tendon is rarely torn, it can be avulsed from the fibula in cases of severe knee trauma. It's important not to confuse the biceps femoris muscle and tendon with the iliotibial tract.

The iliotibial tract is located more anteriorly on the lateral aspect of the knee. It can be felt where it inserts into the lateral tibial tubercle. The iliotibial tract is not a muscle or tendon but a long, thick band of fascia. It is easier to palpate when the knee is extended and the leg is raised or when resistance is applied during knee flexion. The portion immediately lateral to the superior pole of the patella is the most accessible for palpation. Contractures in the iliotibial tract can contribute to knee deformities in conditions like poliomyelitis and meningomyelocele.

The common peroneal nerve can be felt where it crosses the neck of the fibula. It can be gently rolled between your finger and the neck of the fibula, slightly below the insertion of the biceps femoris muscle. Care must be taken when palpating the common peroneal nerve to avoid excessive pressure, which can cause foot drop.

Zone IV—Posterior Aspect

The popliteal fossa is bordered superiorly by the prominent biceps femoris tendon, medially by the tendons of the semimembranosus and semitendinosus muscles, and inferiorly by the two heads of the gastrocnemius muscles as they emerge from the fossa and enter the calf. Several important structures cross the popliteal area:

1. **Posterior Tibial Nerve:** This nerve, a branch of the sciatic nerve, is the most superficial structure in the popliteal area.

2. **Popliteal Vein:** The popliteal vein lies directly beneath the posterior tibial nerve.

3. **Popliteal Artery:** The deepest structure in the area, the popliteal artery runs adjacent to the joint capsule.

When the knee is extended, the fascia covering the fossa becomes taut, making it difficult to palpate the underlying structures. However, in flexion, the fascia and muscles relax, allowing for easier palpation of the deeper areas of the fossa. Due to the coverage of the popliteal artery by the fascia, nerve, and vein, feeling the popliteal pulse may be challenging. The absence of this pulse could indicate vascular occlusive disease at a higher level in the extremity. A discrete swelling in the fossa may indicate a popliteal cyst, also known as a Baker's cyst, which is typically a painless, movable swelling appearing on the medial side of the fossa. It is more easily palpable when the patient's knee is extended.

The two heads of the gastrocnemius muscle can be felt at their origin on the posterior femoral surface just above the medial and lateral condyles when the patient flexes their knee against resistance. However, the gastrocnemius heads are not as easily palpable as the tendons of the hamstring muscles located just above them. If the gastrocnemius muscle is torn, a small defect may be felt in the muscle belly, although palpation often reveals only slight tenderness.

Tests for Joint Stability

The stability of the knee joint relies on various structures, including the joint capsule, collateral ligaments, cruciate ligaments, and surrounding muscles and tendons. The following tests assess the strength and integrity of these structures.

Collateral Ligaments

To evaluate the medial collateral ligament, instruct the patient to lie supine on the table with one knee slightly flexed to unlock it from full extension. Secure the ankle with one hand and place the other hand around the knee, with the thenar eminence against the fibular head. Apply medial pressure on the knee and lateral pressure on the ankle to create a valgus stress, attempting to open the knee joint on the inside. Palpate the medial joint line for any noticeable gapping, which may even be visible. The presence of a gap indicates inadequate support from the medial collateral ligament. When the stress on the injured joint is relieved, you may feel the tibia and femur "clunk" together as they close.

To assess the stability of the lateral aspect of the knee, reverse the hand positions and apply lateral pressure on the knee and medial pressure on the ankle to create a varus stress, opening the knee joint on the lateral side. Palpate the lateral joint line for any gapping. Similar to the medial side, a palpable and visible gap may indicate instability. Upon releasing the varus stress, the tibia and femur may "clunk" back into position as they close.

If your fingers are not long enough to reach around the knee and palpate the joint lines, you can secure the patient's foot between your arm and body (in the axilla) to free your hands for palpation. This allows your body to act as a lever on the foot, applying varus and valgus stress to the knee joint.

It is important to note that the medial collateral ligament plays a crucial role in knee stability. An isolated tear of this ligament can lead to joint instability, while a similar defect in the lateral collateral ligament may have minimal impact. Most ligamentous injuries around the knee occur on the medial side.

Cruciate Ligaments

The anterior and posterior cruciate ligaments play a crucial role in preventing anterior and posterior dislocation of the tibia on the femur. These ligaments are located within the joint capsule, originating on the tibia and inserting into the inner sides of the femoral condyles.

To assess the integrity of the anterior cruciate ligament, position the patient supine on the examination table with their knees flexed to 90° and feet flat on the table. Sit on the edge of the table to stabilize their foot. Cup your hands around their knee, with your fingers on the area where the medial and lateral hamstrings insert and your thumbs on the medial and lateral joint lines. Gently draw the tibia towards you. If the tibia slides forward from under the femur (positive anterior draw sign), it may indicate a torn anterior cruciate ligament. It is normal to have a slight degree of anterior draw on the opposite side for comparison.

When a positive anterior draw sign is found, it is important to repeat the maneuver with the patient's leg in internal and external rotation. External rotation of the leg tightens the posteromedial portion of the joint capsule. Normally, this should result in reduced forward movement of the tibia on the femur, even if the anterior cruciate ligament is torn. Therefore, if the forward movement with the leg externally rotated is equal to the forward movement with the leg in the neutral position, it suggests damage to both the anterior cruciate ligament and the posteromedial portion of the joint capsule (and possibly the medial collateral ligament).

Internal rotation, on the other hand, tightens the structures on the posterolateral side of the knee. Normally, there should be reduced forward movement when the leg is pulled forward, even if the anterior cruciate ligament is torn. If the amount of forward movement remains the same regardless of internal rotation, it may indicate damage to the anterior cruciate ligament.

while leaving a small gap on the medial side. This slight external rotation of the tibia on the femur allows for full extension of the knee joint.

lachman test

The patient is positioned in supine with the knee flexed to 20-30 degrees. The therapist stabilizes the distal femur with one hand and places the other hand on the proximal tibia. The therapist applies an anterior directed force to the tibia on the femu.r A positive test is indicated by excessive anterior translation of the tibia on the femur with a diminished or absent end-point and may be indicative of an anterior cruciate ligament injury

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Lateral pivot shift test

The patient is positioned in supine with the hip flexed and abducted to 30 degrees with slight medial rotation. The therapist grasps the leg with one hand and places the other hand over the lateral surface of the proximal tibia. The therapist medially rotates the tibia and applies a valgus force to the knee while the knee is slowly flexed. A positive test is indicated by a palpable shift or clunk occurring between 20 and 40 degrees of flexion and is indicative of anterolateral rotatory instability. The shift or clunk results from the reduction of the tibia on the femur.

To assess the integrity of the posterior cruciate ligament, remain in the same position as before and push the tibia posteriorly . If the tibia moves backward on the femur, it is likely that the posterior cruciate ligament is damaged (positive posterior draw sign). It is important to note that the anterior draw sign is more common than the posterior draw sign, as injuries to the anterior cruciate ligament are more prevalent. Isolated tears of the posterior cruciate ligament are rare and are often associated with tears of the medial collateral ligament.

These tests for stability of the anterior and posterior cruciate ligaments are typically performed in one continuous motion, but have been separated here for instructional purposes. It is important to perform these procedures bilaterally and compare the findings.

Posterior sag sign

The patient is positioned in supine with the knee flexed to 90 degrees and the hip flexed to 45 degrees. A positive test is indicated by the tibia sagging back on the femur and may be indicative of a posterior cruciate ligament injury.

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Slocum test

The patient is positioned in supine with the knee flexed to 90 degrees and the hip flexed to 45 degrees. The therapist rotates the patient's foot 30 degrees medially to test anterolateral instability. The therapist stabilizes the lower leg by sitting on the forefoot. The therapist grasps the patient's proximal tibia with two hands, places their thumbs on the tibial plateau, and administers an anterior directed force to the tibia on the femur. A positive test is indicated by movement of the tibia occurring primarily on the lateral side and may be indicative of anterolateral instability. The test can also be performed to assess anteromedial instability by rotating g the patient's foot 15 degrees laterally.

Valgus stress test

The patient is positioned in supine with the knee flexed to 20-30 degrees. The therapist positions one hand on the medial surface of the patient's ankle and the other hand on the lateral surface of the knee. The therapist applies a valgus force to the knee with the distal hand. A positive test is indicated by excessive va1gus movment and may be indicative of a medial collateral ligament sprain. A positive test with the knee in full extension may be indicative of damage to the medial collateral ligament, posterior cruciate ligament, posterior oblique ligament, and posteromedial capsule.

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Varus stress test

The patient is positioned in supine with the knee flexed to 20-30 degrees. The therapist positions one hand on the lateral surface of the patient's ankle and the other hand on the medial surface of the knee. The therapist applies a varus force to the knee with the distal hand. A positive test is indicated by excessive varus movement and may be indicative of a lateral collateral ligament sprain. A positive test with the knee in full extension may be indicative of damage to the lateral collateral ligament, posterior cruciate ligament, arcuate complex, and posterolateral capsule.

Moving on to the range of motion of the knee joint, there are three primary movements: flexion, extension, and internal and external rotation.

Flexion and extension primarily involve movement between the femur and the tibia. Internal and external rotation, on the other hand, involve displacement of the menisci on the tibia and movement between the tibia and the femur. The quadriceps are responsible for extension, while the hamstrings and gravity contribute to flexion. Internal and external rotation occur when the knee is slightly flexed and are performed by the semimembranosus, semitendinosus, gracilis, and sartorius muscles on the medial side, and the biceps muscle on the lateral side.

To quickly assess the range of motion, you can perform the following tests:

1. Flexion: Ask the patient to squat in a deep knee bend and observe if both knees can flex symmetrically.

2. Extension: Instruct the patient to stand up from the squatting position and observe if they can stand straight with both knees fully extended. Pay attention to any reliance on one leg more than the other. Alternatively, you can have the patient sit on the edge of the examination table and extend their knee fully. The motion from flexion to extension should be smooth. In some cases, a patient may have difficulty extending the knee fully, resulting in an extension lag. This is often seen in cases of quadriceps weakness.

It is important to note that the knee joint cannot be fully extended without some degree of external tibial rotation on the femur due to the anatomical configuration of the joint and its cruciate ligaments. The medial femoral condyle is slightly longer than the lateral femoral condyle, causing the tibia to externally rotate as it moves into full extension.

Remember to assess the range of motion bilaterally and compare the findings.

To achieve full extension, the medial side of the tibia must rotate laterally around the lateral femoral condyle, allowing the medial femoral condyle to complete its extension. This rotation, known as the "screw home" motion, locks the knee joint in the fully extended position. This locking mechanism enables the patient to maintain knee extension for prolonged periods without relying on their muscles.

To test the screw home motion, mark a dot on the midpoint of the patella and another dot over the tibial tubercle while the patient's knee is flexed. When the patient extends their leg fully, the tibial tubercle should rotate laterally from under its dot, indicating external rotation of the tibia on the femur. The dot over the tibial tubercle should also be slightly lateral to the dot over the midpoint of the patella. A torn meniscus can impede the screw home motion and limit full extension of the knee.

Next, assess the knee's range of internal and external rotation. Instruct the patient to rotate their foot medially and laterally. Normally, they should be able to rotate the foot about 10° in either direction.

Moving on to passive range of motion, for knee flexion, the patient can lie prone or supine on the examining table or sit on the edge of the table with the popliteal fossa away from it and legs dangling freely. Grasp one leg at the ankle joint and place your other hand in the popliteal fossa to act as a fulcrum and unlock the knee. Then, flex the leg as far as it can go, noting the distance between the heel and buttock. In younger patients, it is relatively easy to achieve full flexion where the heel almost touches the buttock. The normal end point of knee flexion for adults is approximately 135° from an extended position. Repeat the same procedure on the opposite leg and compare the ranges of knee flexion.

To assess the range of motion, position the patient's ankle and knee in a relaxed position and then extend the knee. The movement from flexion to extension should be smooth, and both knees should extend to at least 0°, or even a few degrees of hyperextension.

To test internal and external rotation, place your hand on the patient's thigh just above the knee to stabilize the femur. Grasp the patient's heel with your other hand and rotate the tibia. At the same time, palpate the tibial tubercle to ensure that it is moving. Repeat the test on the opposite leg and compare the findings. Normally, there should be approximately 10° of rotary motion to each side.

Moving on to the neurologic examination, let's assess muscle strength.

For knee extension, stabilize the thigh by placing one hand just above the knee. Instruct the patient to fully extend their knee, and offer resistance just above the ankle joint. Palpate the quadriceps muscle with your stabilizing hand during this test.

For knee flexion, have the patient lie supine on the examining table. Stabilize their thigh just above the knee and instruct them to flex their knee while you resist their motion at the back of the ankle joint. To activate the biceps femoris muscle more, ask the patient to rotate their leg externally during the test. Similarly, to activate the semimembranosus and semitendinosus muscles more, instruct the patient to rotate their leg internally.

INTERNAL AND EXTERNAL ROTATION.

The muscles that allow internal and external rotation in the knee cannot be isolated for clinical testing. However, their strength has been tested earlier, in conjunction with the muscle tests for

flexion and extension.

Sensation Testing

Those nerves taking origin from roots in the lumbar and sacral spines provide sensation to the skin over the knee and surrounding areas. The areas supplied by each particular neurologic level define broad bands, or dermatomes, which cover certain areas of the skin.

Roughly, the sensory dermatomes of the knee region run in long, oblique bands as follows:

1) L4 crosses the anterior portion of the knee, continuing down the medial side of the leg. The infrapatellar branch of the saphenous nerve supplies the skin over the area of the anteromedial flare of the tibial condyle. The saphenous nerve

is the only sensory branch of the femoral nerve that continues into the leg. Its infrapatellar branch is often cut during knee surgery, particularly during the surgical removal of the medial meniscus.

2) L3 spans the anterior thigh immediately at and above the knee joint. It is supplied by the femoral nerve.

3) L2 crosses the anterior portion of the middle of the thigh and is supplied by the femoral nerve.

4) S2 outlines a strip down the midline of the posterior thigh and the popliteal fossa. It is supplied by the posterior femoral cutaneous nerve of the thigh

Reflex Testing

PATELLAR REFLEX: L2, 3, 4. The patellar reflex, or knee jerk, is a deep tendon reflex, mediated through nerves emanating from the L2, 3, and 4 neurologic levels, but predominantly from

L4. For clinical application, the patellar reflex is to be considered an L4 reflex. However, even if the L4 nerve root is pathologically involved, the reflex may still be present, since it is innervated by more than one neurologic level. While the patellar reflex may be significantly diminished, it is rarely totally absent.

To test this reflex, have your patient sit on the edge of the examining table with his legs dangling free, or have him sit on a chair with one leg crossed over his knee. If he is a bed patient, support his knee in a few degrees of flexion. In these positions, the infrapatellar tendon is stretched and primed. Then, to locate the tendon accurately, palpate the soft tissue depression on either side of the infrapatellar tendon.

Elicit the reflex by tapping the tendon with a neurologic hammer at the level of the knee joint, using a short, smart wrist action. If the reflex is difficult to obtain, reinforce it by having the patient clasp his hands and attempt to pull them apart as you tap the tendon. The procedure should be repeated on the opposite leg, and the reflexes graded as normal, increased, decreased, or absent.

SPECIAL T E ST S

McMURRAY TEST. During knee flexion and extension, a torn meniscus may produce a palpable or audible “clicking” in the region of the joint line. Tenderness elicited in palpation of the

joint line on either side suggests the possibility of a torn meniscus. Posterior meniscal tears are difficult to identify, and the McMurray test was originally developed to assist in this difficult diagnosis.

Ask the patient to lie supine with his legs flat and in the neutral position. With one hand, take hold of his heel and flex his leg fully. Then, place your free hand on the knee joint with your fingers touching the medial joint line and your thumb and thenar eminence against the lateral joint line, and rotate the leg internally and externally to loosen the knee joint.

Push on the lateral side to apply valgus stress to the medial side of the joint, while, at the same time, rotating the leg externally

Maintain the valgus stress and external rotation, and extend the leg slowly as you palpate the medial joint line. If this maneuver causes a palpable or audible “click” within the joint, there is a probable tear in the medial meniscus, most likely in its posterior half.

APLEY’S COMPRESSION AND DISTRACTION TESTS

Compression or Grinding Test. This is another procedure designed to aid in the diagnosis of a torn meniscus. Ask your patient to lie prone on the examining table with one leg flexed to 90°.Gently kneel on the back of his thigh to stabilize it

The technique is done by applying pressure on the heel to compress the medial and lateral menisci between the tibia and femur. Afterward, rotate the tibia internally and externally while maintaining firm compression. If the patient experiences pain during this maneuver, it is likely that there is meniscal damage. Ask the patient to describe the location of their pain as accurately as possible. Pain on the medial side suggests damage to the medial meniscus, while pain on the lateral side indicates a tear in the lateral meniscus.

The Distraction Test is used to differentiate between meniscal and ligamentous issues in the knee joint. This test should be performed after the compression test. Stay in the same position as described for the compression test and stabilize the posterior thigh. Apply traction to the leg while rotating the tibia internally and externally on the femur . This action reduces pressure on the meniscus and puts strain on the medial and lateral ligamentous structures. If the ligaments are damaged, the patient will experience pain. However, if only the meniscus is torn, the test should not cause pain.

The Reduction Click procedure is used for patients with a locked knee caused by a torn, dislocated, or displaced meniscus. The positioning is the same as that for the McMurray test, with the patient lying supine on the table. The examiner holds the patient's heel and foot with one hand and their knee with the other, ensuring that the thumb and fingers touch each side of the joint line. The goal of the reduction click procedure is to click the displaced or torn portion of the meniscus back into place. To do this, flex the knee while rotating it internally and externally. Then, rotate and extend the leg until the meniscus slips back into its proper position, accompanied by a characteristic "click" sound. This test can unlock a locked knee caused by a torn meniscus and allow for full extension. The McMurray test can also unlock the knee joint and produce the reduction click.

The "Bounce Home" test is used to assess a lack of full knee extension, often caused by a torn meniscus, a loose body in the knee joint, or swelling within the joint. With the patient lying supine on the table, hold their heel in your palm and flex their knee fully. Then, passively allow the knee to extend. The knee should extend completely and "bounce home" into extension with a sharp end-point. However, if the knee falls short and offers a rubbery resistance to further extension, there is likely a torn meniscus or another obstruction preventing the bounce home motion.

The Patella Femoral Grinding Test is used to assess the condition of the articulating surfaces of the patella and the trochlear groove of the femur. The patient should be lying supine on the examining table with their legs relaxed in a neutral position. First, push the patella distally in the trochlear groove. Then, instruct the patient to tighten their quadriceps while palpating and offering resistance to the patella as it moves under your fingers. The movement of the patella should be smooth and gliding. Any roughness in the articulating surfaces causes a palpable crepitation when the patella moves. If the test is positive, the patient usually experiences pain or discomfort.

Patients commonly complain of pain when climbing stairs or getting up from a chair, which is consistent with this condition as the roughened undersurface of the patella is forced against the trochlear groove. Additionally, chondromalacia patellae, osteochondral defects, or degenerative changes within the trochlear groove itself can cause pain during such activities.

The Apprehension Test for Patellar Dislocation and Subluxation is performed to determine if the patella is prone to lateral dislocation. If you suspect that the patient has a recurrent dislocating patella, you should attempt to manually dislocate it while observing their facial reaction. Ask the patient to lie supine on the examining table with their legs flat and the quadriceps relaxed. If you suspect that the patella may dislocate laterally, press against the medial border of the patella with your thumb. If everything is normal, this will produce little reaction. However, if the patella starts to dislocate, the patient's expression will show apprehension and distress.

The Tinel sign refers to two different scenarios: the elicitation of pain from tapping on the end of a cut nerve for neuromata, or the provocation of pain on the leading edge of a regenerating nerve. In the case of the knee, the focus is on the area around the medial side of the tibial tubercle, where the infrapatellar branch of the saphenous nerve runs. During knee surgery, this nerve is often cut, especially during the removal of the medial meniscus. If a neuroma has formed, tenderness can be felt over the bulbous end of the severed nerve.

The Knee Joint Effusion Tests are used to assess suspected fluid accumulation in the knee joint.

Test for Major Effusion: When the joint is distended by a large amount of fluid, carefully extend the patient's knee and instruct them to relax their quadriceps muscles. Then, push the patella into the trochlear groove and quickly release it. The significant amount of fluid beneath the patella is initially forced to the sides of the joint and then flows back to its original position, causing the patella to rebound. This is known as a ballotable patella.

To test for minor effusion in the knee joint, where there is not enough fluid to ballot the patella, follow these steps:

1. Keep the patient's knee in extension.
2. "Milk" the fluid from the suprapatellar pouch and lateral side into the medial side of the knee.

3. Once the fluid has been forced to the medial side, gently tap the joint over the fluid.

4. This tapping will cause the fluid to traverse the knee, creating a fullness on the lateral side

In a comprehensive examination of the knee joint, it is important to also examine the joints both above and below the knee. This includes assessing for conditions such as a herniated disc in the lumbar spine or osteoarthritis of the hip, which can refer pain to the knee. Additionally, although less common, foot problems like ligamentous sprains or infections may occasionally present with symptoms in the knee.

Brush test

The patient is positioned in supine. The therapist places one hand below the joint line on the medial surface of the patella and strokes proximally with the palm and fingers as far as the suprapatellar pouch. The other hand then strokes down the lateral surface of the patella. A positive test is indicated by a wave of fluid just below the medial distal border of the patella and is indicative of effusion in the knee.

Patellar tap test

The patient is positioned in supine with the knee flexed or extended to a point of discomfort. The therapist applies a slight tap over the patella. A positive test is indicated if the patella

Appears to be floating and may be indicative of joint effusion.

Clarke's sign

The patient is positioned in supine with the knees extended. The therapist applies slight pressure distally with the web space of their hand over the superior pole of the patella. The therapist then asks the patient to contract the quadriceps muscle while maintaining pressure on the patella. A positive test is indicated by failure to complete the contraction without pain and may be indicative of patellofemoral dysfunction.

Hughston's plica test

The patient is positioned in supine. The therapist flexes the knee and medially rotates the tibia with one hand while the other hand attempts to move the patella medially and palpate the medial femoral condyle. A positive test is indicated by a popping sound over the medial plica while the knee is passively flexed and extended.

Noble compression test

The patient is positioned in supine with the hip slightly flexed and the knee in 90 degrees of flexion. The therapist places the thumb of one hand over the lateral epicondyle of the femur and the other hand around the patient's ankle. The therapist maintains pressure over the lateral epicondyle while the patient is asked to slowly extend the knee. A positive test is indicated by pain over the lateral femoral epicondyle at approximately 30 degrees of knee flexion and may be indicative of iliotibial band friction syndrome.