The Cervical Spine

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Anatomy

The cervical spine consists of 7 cervical vertebrae, intervertebral discs beginning at the C2–C3 interspace, a complex network of supporting ligaments, and neurovascular structures. The cervical vertebrae are smaller than their thoracic or lumbar counterparts and the transverse processes possess a foramen transversarium for the passage of the vertebral artery (Note that the vertebral artery passes through the transverse process of C1–C6 and not through C7).

The first two cervical vertebrae have exceptional anatomic features.

The first cervical vertebra is called the *atlas* because it supports the head. Distinct from all other vertebrae, the atlas has no body and no spinous process; it is a ring-like structure with anterior and posterior arches. It has a lateral mass on each side [1]. The superior surfaces of the lateral masses articulate with the occipital condyles, forming the atlanto-occipital joint. Functionally, this joint allows 50% of neck flexion and extension (nodding movement takes place at atlanto-occipital joint).

The second cervical vertebra, the *axis*, forms the surface on which the atlas pivots to allow lateral rotation of the head. The axis has a peglike odontoid process also called dens is the cranial extension of the body of the axis into the ring of the atlas; it is the most characteristic feature of C2 (Fig. 1). The dens articulates with the posterior aspect of the anterior ring of C1 and is stabilized by the transverse ligament. This articulation provides stability as the atlas pivots during rotation. Half of neck rotation occurs at this atlanto-axial joint (movement for saying "no" takes place at atlanto-axial joint). There is no intervertebral disc at either the atlanto-occipital or the C1–C2 joints, predisposing them to inflammatory arthritis [2].

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© Springer Nature Singapore Pte Ltd. 2019
S. S. Dhatt, S. Prabhakar (eds.), *Handbook of Clinical Examination in Orthopedics*, https://doi.org/10.1007/978-981-13-1235-9_3

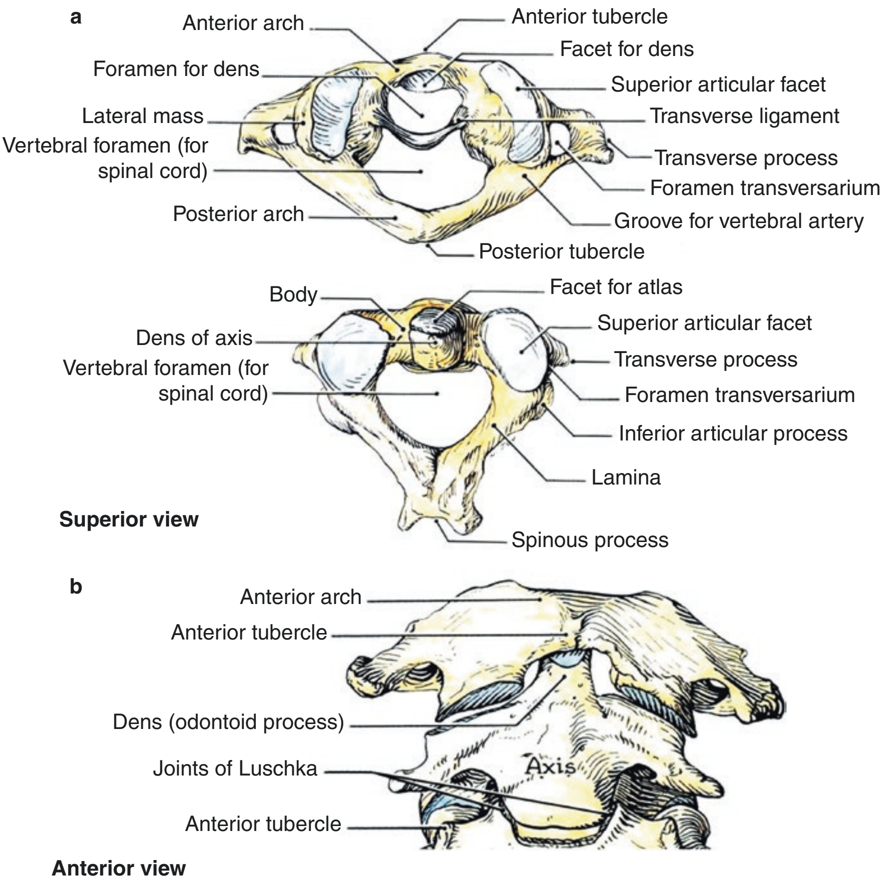

Fig. 1 (**a**, **b**) Cervical vertebra one and two: atlas and axis. (**a**) Superior view (**b**) anterior view

There are 14 facet (apophyseal) joints in the cervical spine. The upper four facet joints in the two upper thoracic vertebrae are often included in the examination of the cervical spine. The uncovertebral joints or Joints of Luschka (Fig. 2) are unique to the cervical spine. The uncus gives a "saddle" form to the upper aspect of the cervical vertebra, which is more pronounced posterolaterally. Extending from the uncus is a "joint" that appears to form because of a weakness in the annulus fibrosus. The portion of the vertebra above, which "articulates" or conforms to the uncus, is called the echancrure, or notch.

Although there are seven cervical vertebrae, there are eight cervical nerve roots. This difference occurs because there is a nerve root exiting between the occiput and C1 that is designated the C1 nerve root. In the cervical spine, each nerve root is named for the vertebra below it. *As* an example, C5 nerve root exists between the C4 and C5 vertebrae (Fig. 3). In the rest of the spine, each nerve root is named for the vertebra above; the L4 nerve root, for example, exists between the L4 and L5

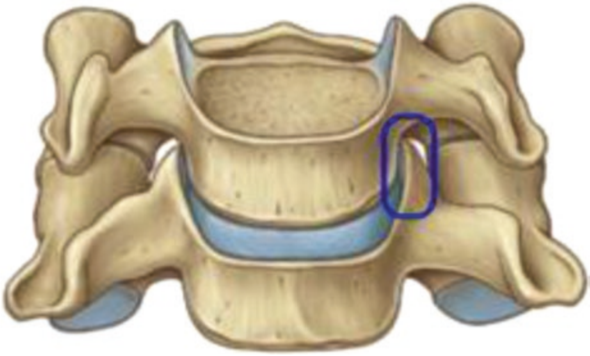

Fig. 2 Joints of Luschka

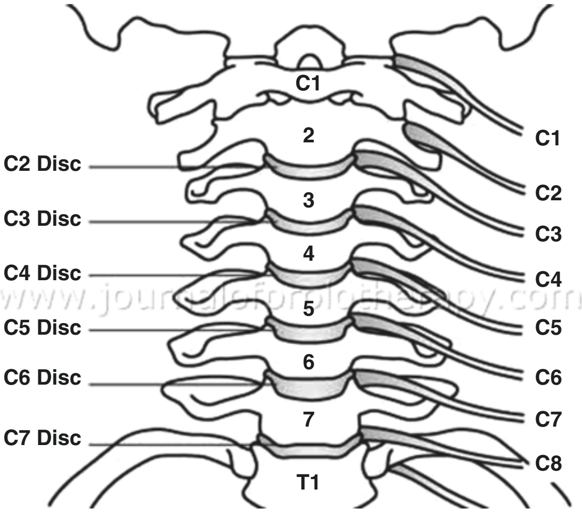

Fig. 3 Cervical spine nerve root anatomy

vertebrae. The switch in naming of the nerve roots from the one below to the one above is made between the C7 and T1 vertebrae. The nerve root between these two vertebrae is called C8, accounting for the fact that there are eight cervical nerve roots and only seven cervical vertebrae.

Patient History

Age

Age may be important because some disorders do not occur or do typically occur at a certain period of life. Torticollis in a baby is probably congenital whereas acute torticollis in a 5-year old child is more likely to be caused by contraction of the sternomastoid muscle after, for example, glandular swelling or abscess formation. And sudden torticollis during adolescence is probably the result of disc protrusion.

Spondylosis is often seen in patients older than 30 or 40 years. 60% of those older than 45 years and 85% of those older than 65 years have spondylosis [3]. Radicular pain in a young person can be due to a neurofibroma,while in the elderly its usually due to compression by a osteophyte or invasion of spine by secondary deposits.

Pain

Pain is the most common symptom. Its localisation may give an idea about the site of the lesion.

Onset

Where???

Pain of cervical origin often starts at the cervical spine but frequently spreads to another region, so that the cervical origin may pass unnoticed.

Interscapular onset is typical of lower cervical disc lesions which compress the dura.

Pain that starts in the region of arm in a young patient may be due to neurofibroma.

When???

Pain of cervical origin usually occurs in discrete attacks especially when a disc lesion is responsible. So patient may give a waxing and waning history.

How???

The origin may be spontaneous, either acute or chronic or due to an injury. In the latter, details about the type of injury should be sought afer (e.g., fall or whiplish).

Localization

Pain that spreads and expands over a larger area is typical of an expanding lesion and should always arouse suspicion. On the other hand, pain that shifts from scapular region to the upper limb is highly indicative of a cervical disc lesion. The fragment of disc substance first displaces postero-centrally and compresses the duramater, which results in central, bilateral or unilateral scapular pain; it then moves laterally and impinges on the dural investment of a nerve root. The scapular pain disappears and is replaced by a radicular pain down the upper limb.

Headache

If headache is of cervical spine origin, patient will usually mention an association between symptoms and certain posture or movements (Table 1).

Cervical radiculopathy or injury to the nerve roots in the cervical spine, presents primarily with unilateral motor and sensory symptoms in the upper limb, with muscle weakness (myotome), sensory alteration (dermatome), reflex hypoactivity and sometimes focal activity being the primary signs [4, 5].

Table 1 Signs of headache having a cervical origin

1. Occipital or suboccipital component to headache
2. Neck movement alters headache
3. Painful limitation of neck movements
4. Abnormal head or neck posture
5. Suboccipital or nuchal tenderness
6. Sensory abnormalities in occipital and suboccipital areas

Cervical Myelopathy or injury to the spinal cord itself, is more likely to present with spastic weakness, parasthesia, and possible incoordination in one or both lower limbs, as well as proprioceptive or sphincter dysfunction [6].

Pain in the trapezioscapular region is the most common pain reference for cervical lesions. Majority of pain in the trapezius or scapular area have a cervical origin and must be considered as a multisegmental reference of a discodural conflict.

Duration

Most of the benign cervical disorders are having intermittent pain. If pain progressively worsens, then the presence of an irreversible lesion such as metastases should be considered, particularly in the elderly. Root pain caused by a disc protrusion lasts for a variable but limited period and then ceases as spontaneous remission takes place.

Paraesthesia

Patients most often complain of numbness, tingling or 'pins and needle' sensations in the extremities of cervical spine lesions. The moment the patient mention such symptoms, the examiner should carefully examine how proximal they are because the point of compression always lies proximal to that of the paraesthesia.

Spinal Cord

External pressure on the spinal cord is characterized by painless paraesthesia in the upper and/or lower limbs felt distally and in a multisegmental distribution. The paraesthesia comes and goes in a wholly irregular way, most marked by day. Neck flexion usually increases the symptoms, or Lhermitte's sign (Fig. 4) may be present: an electric shock sensation in the trunk and/or upper limbs following forceful passive flexion of the cervical spine.

Nerve Root

When a nerve root is affected paraesthesia with pins and needle sensations may occur in the corresponding dermatome level. Pins and needles can come and go in an erratic fashion and usually do not last for more than an hour at a time.

Fig. 4 Lhermitte's sign

Inspection

For a proper observation, a patient should be suitably undressed. The examiner should make it point to see the patient when he/she enters the examination rooms and when the patient undresses. This can give vital information regarding the patient's condition.

Ideally patient must be in a standing posture when examination is done.

Examination should be done while standing in front, back and by the side of the patient (Fig. 5).

Head and Neck Posture

The head should be in midline with the chin above the manubrium. In torticollis the head may be tilted towards the side of the lesion with the chin pointing the opposite direction. Normal neck shows a slight lordotic curve. In whiplash injuries, there may be loss of lordosis with the head fixed in flexion.

Short neck may be seen in a person with Klippel-Feil syndrome [7] due to fusion of cervical vertebra and in a girl with Turner's syndrome [8] one may notice webbing of neck.

Shoulder Level

Usually the shoulder on the dominant side will be slightly lower than the non-dominant side. In a child with sprengel's shoulder the affected side is usually at a higher level.

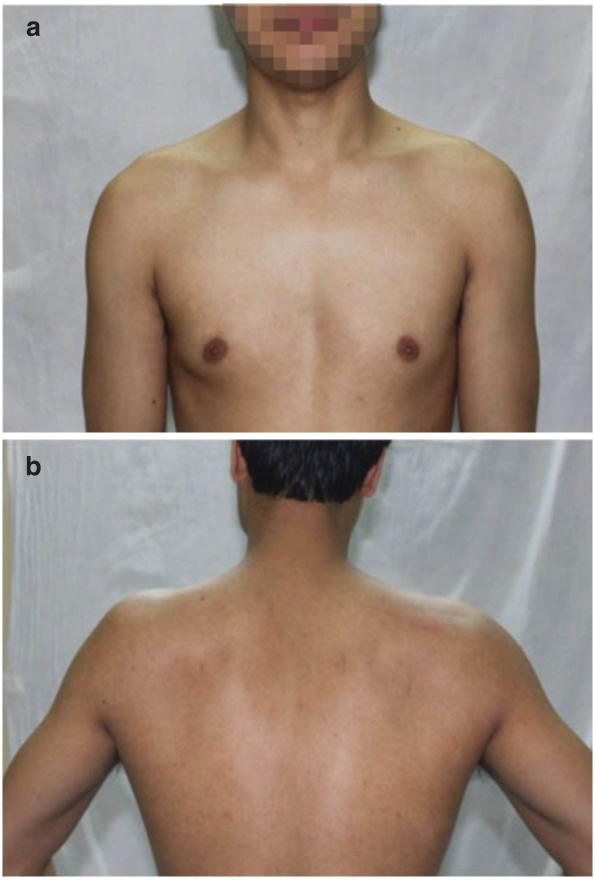

Fig. 5 (**a**) Cervical spine. Inspection infront. (**b**) Cervical spine. Inspection from back

Muscle Wasting or Asymmetry

The scapular and deltoid regions should be surveyed to rule out muscle wasting (e.g., deltoid wasting in axillary nerve palsy). A tight and prominent sternomastoid muscle may be seen in torticollis.

Palpation

Spinous Processes

Palpation of cervical spine begins at the inion, located at the base of the skull. The palpation should proceed distally to identify each spine process, the most prominent being that of C7. Tenderness at a particular level may indicate a localized injury to the region.

Normally all the spinous process should be aligned in a perfectly linear fashion and regularly spaced. An acute lateral shift of a spinous process may be due to unilateral facet joint dislocation or fracture.

Posterior Cervical Musculature

The main muscle in this region is the trapezius. Localized mass or spasm may indicate a hematoma or injury to the muscle itself. Tenderness at the base of the skull, deep to the trapezius may be due to occipital neuritis (greater occipital nerve) or C1–C2 instability in rheumatoid patients.

Anterior Aspect

Three prominent structures are to be identified in the anterior aspect of the neck mainly to orient the examiner to the corresponding vertebral level of spinal pathology.

The hyoid bone lies just caudal to the angle of mandible and it lies at the level of C3 vertebral body.

Inferior to the hyoid bone is the thyroid cartilage or the Adam's apple which lies at the level of C4–C5 vertebral bodies.

Lying inferior to the thyroid cartilage at the level of C6 vertebral body is a mobile ring called the cricoids cartilage (Fig. 6).

Movements

With the patient seated active movements of the cervical spine are tested first. The examiner must look for differences in range of motion (ROM) and patient's willingness to do the movements. The range of motion usually decreases with age, except rotation at C1–C2, which increases with age [9, 10].

Fig. 6 Palpation of cricoid cartilage

Active Movements

Flexion: The maximum ROM is 80–90° (Fig. 7). In rheumatoid arthritis patients with C1–C2 instability, one can notice a posterior bulge of the spinous process of C2 when the patient is flexing his neck.

Extension: Normal ROM is 70° (Fig. 8).

Rotation: Normal rotation is 70–90° to the left and right (Fig. 9).

Lateral flexion: Side or lateral flexion is approximately 20–45° to the right and left (Fig. 10).

Passive Movements

The movements done actively previously are done passively. Pain, limitation and the end-feel are assessed while doing passive movements.

Fig. 7 Cervical spine: flexion

Fig. 8 Cervical spine: extension

Fig. 9 Cervical spine rotation-right

Fig. 10 Cervical spine right lateral flexion

Normal end-feel is capsular. Muscle spasm, bone-to-bone, crisp, empty, soggy and elastic rebound are some of the abnormal end-feels.

Resisted Movements

Lateral Rotation

The sternocleidomastoids function as rotators as well as flexors of cervical spine. They are supplied by spinal accessory nerve.

To test a given sternocleidomastoid muscle, the examiner places the palm of one hand on the opposide side of the patient's head or face and instructs the patient to attempt to rotate the head to that side as strongly as possibly. The tension in the sternomastoid being tested should be quite visible and can be palpated as well (Fig. 11).

Fig. 11 Assessing right lateral rotation strength

Fig. 12 Assessing flexion strength

Flexion

The principal flexors are the sternocleidomastoids. To test flexors, the examiner places a resisting palm against the patient's forehead with the other hand stabilising the patient's thorax (Fig. 12).The patient is asked to flex the neck against resistance and the contraction of sternocleidomastoids should be visible.

Extension

The main extensors are the posterior intrinsic neck muscles and the upper portion of trapezius (Fig. 13). The examiner places a resisting hand on the patient's occiput and asks the patient to extend the neck against resistance.

Motor Examination

C5 Nerve Root

C5 nerve root is best assessed by testing deltoid function. The examiner makes the patient to sit in an upright position and asks him to abduct the arm with the elbows

Fig. 13 Assessing extension strength

Fig. 14 Assessing C5 motor function (deltoid strength)

flexed. The examiner exerts downward pressure on the elbow while the patient tries to resist with a pure abduction force (Fig. 14). In a normal patient, the examiner is unable to overcome the patient's abduction power.

C6 Nerve Root

C6 nerve root can be assessed by testing for biceps brachii and wrist extensors. To test the biceps, the examiner asks the patient to flex the elbow to 90° (in supination). With one hand the examiner supports the patient's elbow and with the other hand he holds the patient's wrist and tries to extend the elbow while the patient tries to flex (Fig. 15). In a normal patient, the examiner will find it difficult to extend the elbow.

To test the wrist extensors, the patient is asked to keep his elbows flexed, and the examiner applies a downward pressure on a dorsiflexed wrist (Fig. 16).

Fig. 15 Assessing C6 motor function (biceps)

Fig. 16 Assessing C6 motor function (wrist extensors)

C7 Nerve Root

C7 nerve root can be assessed by testing the wrist flexors, long finger extensors and triceps brachii.

To test the wrist flexors, the examiner first asks the patient to make a fist and then asks the patient to flex the wrist while he tries to extend it (Figs. 17, 18, and 19).

To test the long finger extensors, the examiner stabilises the patient's wrist in one hand and asks the patient to extend the fingers while he applies downward pressure to flex to metacarpo-phalangeal joint.

To test for triceps, the patient is asked to flex to elbow to 90°. Now with one hand the examiner stabilises the elbow and with the other hand grasping the wrist, the examiner tries to flex to elbow while the patient tries to extend it.

C8 Nerve Root

This is assessed by testing for long finger flexors. The examiner places his index and middle finger in the patient's palm and asks the patient to squeeze his hand (Figs. 20 and 21).

Fig. 17 Assessing C7 motor function (wrist flexors)

Fig. 18 Assessing C7 motor function (long finger extensors)

Fig. 19 Assessing C7 motor function (triceps)

An alternative method is for the examiner to place his 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 while he attempts to do so.

Fig. 20 Assessing C8 motor function (long finger flexors)

Fig. 21 Assessing C8 motor function (alternative technique)

T1 Nerve Root

T1 nerve root is assessed by testing the interossei muscles which play a vital part in finger abduction and adduction (Figs. 22, 23, and 24).

To test for finger abduction, the patient is asked to keep his hands on a table and spread his fingers as far apart as possible. Now the examiner grasps the patient's fingers between his index finger and thumb and tries to push them back together while the patient tries to spread them apart.

To test for finger adduction, the examiner places a card between the spread index and long fingers of the patient. Now the patient is asked to squeeze the two fingers together while the examiner tries to pull the card out. Normally the card can be pulled out by the examiner but with some difficulty.

To test the first dorsal interossei, the patient's hand is kept on a table and the examiner places the index finger of his hand against the radial aspect of the patient's index finger. Now the patient is asked to press his index finger against that of the examiner's while the examiner tries to bring the patient's finger medially. The muscle can be seen contracting and can be palpated as well.

Fig. 22 Assessing T1 motor function (finger abduction)

Fig. 23 Assessing T1 motor function (finger adduction)

Fig. 24 Assessing T1 motor function (first dorsal interosseous)

Reflex Examination

The reflexes are tested and it is observed whether they are normal, diminished, absent or inverted. It should be noted that the reflexes is always compared with the other side when in doubt.

Biceps Reflex (C5)

The patient's elbow is at right angle with his forearm resting on the examiner's forearm. With the examiner's thumb over the biceps tendon in the antecubital fossa, hammer is tapped on the thumb. The examiner will be able to see the contraction of the biceps muscle (Fig. 25).

Brachioradialis Reflex (C6)

With the patient's elbow at 90° flexion and his midprone forearm in a relaxed position over that of the examiner's hand, the examiner taps the radial aspect of the forearm 4–8 cm proximal to the radial styloid. The examiner is usually able to see the contractions of brachioradialis muscle (Fig. 26).

Triceps Reflex (C7)

With the patient in 90° shoulder abduction and 90° elbow flexion, and with the examiner supporting the patient's arm, the examiner strikes the triceps tendon just proximal to olecranon, which results in visible contraction of triceps and extension of the elbow (Figs. 27 and 28).

Fig. 25 Biceps reflex (C5)

Fig. 26 Brachioradialis reflex (C6)

Fig. 27 Triceps reflex (C7)

Fig. 28 Triceps reflex (alternative technique)

Plantar Reflex

The patient is asked to sit comfortably in a chair with his feet dangling. The examiner grasps the patient foot in one hand and stroking the sole of the patient's foot, starting at the lateral aspect of the heel and moving along the lateral border of the foot to the base of the fifth metatarsal and then curves towards the base of the great toe at the medial aspect of the foot. The normal reaction, as described by Strümpell, is flexion of the toes and withdrawal of the foot. The pathological reflex—Babinski's sign—is a slow extension of the big toe, combined with fanning of the other toes and flexion of knee and hip. The presence of Babinski's sign in adults indicates an upper motor neuron lesion (Figs. 29, 30, and 31).

Hoffmann's Sign

The hand is supported and pronated so that wrist and fingers fall into slight flexion. The middle finger is firmly grasped and partially extended. The terminal phalanx of the patient's middle finger is flicked downwards. In states of hypertonia, the thumb flexes and adducts and the other fingers flex (Fig. 32).

Fig. 29 Eliciting plantar reflex

Fig. 30 Normal plantar reflex response

Fig. 31 Babinski's sign

Fig. 32 Hoffmann's sign

Grading of Reflexes

Grade 0: Absent
Grade 1: Present
Grade 2: Brisk
Grade 3: Very brisk
Grade 4: Clonus

Clonus

Clonus is a state of exaggerated deep tendon reflex where repetitive contractions of the muscle being tested occurs after a single stimulus.

Ankle Clonus

With the patient lying supine,the examiner flexes the hip and knee to 90°. With one hand supporting the leg, and the other holding the forefoot of the patient, the examiner gives a dorsiflexion stimulus at the ankle.In cases of upper motor neuron lesions, repeated plantar flexion movements can be seen (Fig. 33).

Fig. 33 Eliciting ankle clonus

Fig. 34 Eliciting patellar clonus

Patellar Clonus

With the patient lying supine with hip in neutral and knee in extension, the examiner holds the superior pole of patella with his fingers and gives a single stimulus by pushing the patella distally. In upper motor neuron lesions, there will be repeated pulling of patella upwards by the quadriceps tendon (Fig. 34).

Sensory Examination

Sensations and the corresponding tracts

1. Pain (superficial and deep)—lateral spinothalamic tract.
2. Temperature-lateral spinothalamic
3. Touch-anterior spinothalamic tract, posterior column
4. Proprioception-posterior column
5. Vibration sense-posterior column
6. Two point discrimination-posterior column

7. Stereognosis-posterior column
8. Graphaesthesia- posterior column

Pain

All sensory testing should be done with the patient's eyes closed. Superficial pain can be tested using a sharp pin and it should be noted that the examiner should always move from the area of impaired sensation to the normal site.

Deep pain can be tested by squeezing muscles of calf and tendo-achilles. Deep pain is increased in subacute combined degeneration of cord, infective polyneuritis. In syringomyelia and tabes dorsalis sensation of deep pain is decreased (Figs. 35, 36, and 37).

Temperature

Test tubes containing hot (110 °F) and cold (45 °F) can be used to test temperature sensation (Fig. 38).

Sensory Examination

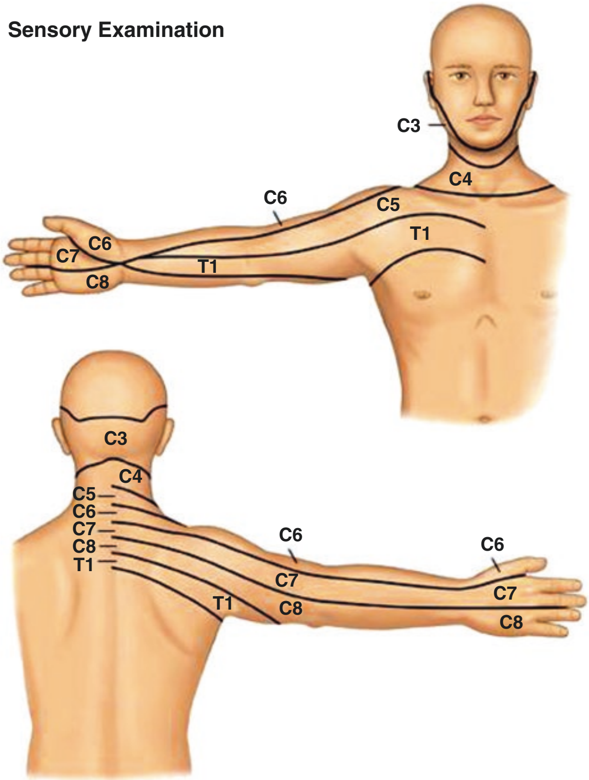

Fig. 35 Cervical dermatomes

Fig. 36 Testing for superficial pain

Fig. 37 (**a**, **b**) Testing for deep pain

Touch

Cotton wool is shaped to a point and the skin is touched lightly in dermatome areas, tell the patient to shut his eyes and to say "yes" if he feels anything. Dermatomal mapping done. Fine hair brush can also be used to test. Do not stroke hairy areas.

Vibration Sense

Vibration sense can be tested using a tuning fork of 256 Hz over bony prominences such as olecranon, humeral epicondyles, radial styloid, medial malleolus. The examiner places the base of the tuning fork after striking on the bony prominence and ask the patient to report when the vibration stops. The examiner then suddenly stop the vibration with the free hand. Normally the patient identifies the cessation of vibration quite readily (Fig. 39).

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. The patient should be able to identify whether the digit ends the manoeuver in extension or flexion (Fig. 40).

Fig. 38 Testing for temperature

Fig. 39 Testing for vibration sense

Fig. 40 Testing for proprioception

Two Point Discrimination

A person with normal sensation will be able to distinguish two points 5 mm apart on the fingertips. The points are initially apart and are approximated till the patient starts making mistakes.

Stereognosis

It is the ability to recognize an object purely from the feel of its size and shape with the eyes closed. When other forms of sensation are normal, presence of astereognosis should indicate a parietal lobe lesion.

Graphaesthesia

It is the ability to recognize letters, shapes written on the skin with a blunt object.

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