Surgical Incisions-Their Anatomical Basis
Part V - Approaches to spinal column

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Abstract. The present paper is a continuation of the previous one by Patnaik et al (2001). Here the anatomical bases of various incisions used for the exposure of different parts of vertebral column are discussed. Brief steps of dissection & important anatomical landmarks to be taken care are delineated. Since this part of the body falls in the domain of not only orthopaedician, & neurosurgeon but also otolaryngologist & oral & maxillofacial surgeon, an emphasis has been laid on a multidisciplinary approach. For the same reasons, the authors feel that the article would be of help, apart from the anatomists to the disciples of other specialities mentioned above.

Key words : Surgical incisions, spine, vertebral column.

Introduction :

The spine is composed of 33 vertebral segments of which 7 are cervical, 12 thoracic, 5 lumbar, 5 sacral and 4 are coccygeal. The sacral and the coccygeal vertebrae are fused as single masses, separately. A typical vertebra consists of a body that lies anteriorly, and a posterior arch that further consists of 2 pedicles, 2 laminae that are joined together and give rise to the spinous process. The posterior complex also consists of 2 transverse processes and a pair each of superior and inferior articular facets. In the intervening spaces between any two adjacent vertebral bodies are the intervertebral discs, which have outer fibrous portion, called annulus fibrosus and an inner gelatinous, nucleus pulposus. The normal spine is lordotic at cervical and lumbar levels and kyphotic at dorsal and sacral levels. The segmental nerves and vessels pass through the intervertebral foramina formed by superior and inferior borders of pedicles of adjacent vertebrae.

Surgical approaches to spine :

Spine may be approached by any of the following routes :

(A) Anterior approaches :

I. Anterior approach from occiput to C3 vertebra
   1. Trans oral approach
   2. Anterior retropharyngeal approach
   3. Subtotal maxillectomy
   4. Extended maxillotomy

II. Anterior approach from C3-C7
   1. Southwich & Robinson (1957) technique

III. Anterior approach to cervico thoracic junction
   1. Low anterior cervical approach
   2. High transthoracic approach
   3. Trans-sternal approach

IV. Ant. approach to thoracic spine

V. Ant. approach to thoracolumbar junction

VI. Ant. approach to lumbar spine
   1. Ant. retroperitoneal approach (L1-L5)
   2. Ant. Transperitoneal approach to L5S1

B. Posterior approaches :

I. Post. approach to cervical spine (occiput to C2)

II. Post. approach to cervical spine (C3-C7)

III. Post. approach to thoracic spine (T1-T12)
   1. Midline approach
   2. Costo tranversectomy

IV. Post. approach to lumbar spine (L1-L5)
   1. Midline approach
   2. Paraspinous approach

V. Post approach to lumbosacral spine (L1-sacrum)

A. Anterior approaches to spine : With the posterior approaches for correction of spinal deformity well established, in recent years more attention has been placed on the anterior approach to the

**Indications** : In general, anterior approaches to the spine are indicated for decompression of the neural elements (spinal cord, conus medullaris, cauda equina or nerve roots), when anterior neural compression has been documented by myelography, CT Scan or MRI. Crenshaw (1992) has listed followings as the most accepted indication for these approaches.

A. Traumatic
   1. Fractures with documented neurocompression secondary to bone or disc fragments anterior to dura.
   2. Incomplete spinal cord injury (for cord recovery) with anterior extradural compression.
   3. Complete spinal cord injury (for root recovery) with anterior extradural compression.
   4. Late pain or paralysis after remote injuries with anterior extradural compression.
   5. Herniated intervertebral disc.

B. Infections
   1. Open biopsy for diagnosis
   2. Debridement and anterior strut grafting

C. Degenerative
   1. Cervical spondylitic radiculopathy
   2. Cervical spondylitic myelopathy
   3. Thoracic disc herniation
   4. Cervical, thoracic, and lumbar interbody fusions

D. Neoplastic
   1. Extradural metastatic disease
   2. Primary vertebral body tumor

E. Deformity
   1. Kyphosis - congenital or acquired
   2. Scoliosis - congenital, acquired, or idiopathic

Anterior approaches have the propensity to cause significant morbidity as potential dangers include iatrogenic injury to the visceral and neurovascular structures. Injury to specially the neural structures is irreversible and may defeat the very purpose for which the surgery was planned for; therefore, a thorough knowledge of anatomy is essential.

The choice of approach depends upon:
(a) preference and experience of the surgeon.
(b) Patient’s age,
(c) Medical condition of the patient,
(d) Segment of the spine involved,
(e) Underlying pathological process,
(f) Presence or absence of signs of neural compression.

Various anterior approaches are described below:

I. Anterior approach from occiput to C3.
   1. **Trans oral approach (Spetzler, 1983)**
      The patient is placed supine and the head is stabilized either by skull traction tongs or by May-Field head holding device. Uvula and the soft palate are retracted by tying a rubber catheter, which is passed from each nostril, and pulling it. The endotracheal tube required for general anaesthesia is retracted to one side using special retractors. Anterior arch of C1(atlas) can be palpated in the depth of posterior wall of pharynx. A midline longitudinal incision is chosen to expose the anterior aspects of C1 and C2 as the midline is relatively avascular. Retracting the flaps laterally can further increase the exposure. After the wound is closed, it is desirable to keep the endotracheal tube in situ for a further period of 12-24 hours to maintain adequate airway. This approach is commonly used for caries involving the anterior arch of C1 or vertebral bodies of C2, C3 and also for transoral odontoidectomy.
   2. **Anterior retropharyngeal approach (McAffee et al, 1987)**
      This approach is extra-mucosal and avoids all the complications associated with transoral approach. One of the common indications is caries involving C1, C2 region. The technique has been
described by Mc Affee et al. (1987) A thorough understanding of anatomical tissue planes and fascial spaces as described by Singh et al (2000) is mandatory before undertaking this approach. A T-shaped incision is given in right submandibular region (Fig. 1). The platysma muscle is cut and its flaps mobilized. The marginal mandibular branch of 7th nerve is identified and protected. The retromandibular vein is ligated at its junction with the internal jugular vein. This brings the sternomastoid muscle in view with its overlying superficial layer of deep cervical fascia; this layer is cut and the sternomastoid muscle is retracted. Next pulsations of the carotid artery are felt and it is protected. Submandibular gland is resected and its duct is ligated to prevent formation of a salivary fistula. Tendon of digastric is identified and divided. Tra
tion injury to the facial nerve can be caused by superior retraction on the stylohyoid muscle and one should be careful regarding that. The hyoid bone and hypopharynx are then mobilized medially, preventing exposure of the esophagus, hypopharynx, and nasopharynx out of harm’s way. Next, hypoglossal nerve is identified and retracted superiorly. Dissection is continued to the retropharyngeal space between the carotid sheath laterally and the larynx and pharynx medially. Exposure is increased by ligating branches of the carotid artery and internal jugular vein, which prevent retraction of the carotid sheath laterally. The superior laryngeal nerve is identified and mobilized. Following adequate retraction of the carotid sheath laterally, alar and prevertebral fascial layers are divided longitudinally to expose the longus colli muscles which are erased subperiosteally from the anterior aspect of the arch of C1 and the body of C2, taking care to avoid injury to the vertebral arteries. Next, meticulously debride the involved osseous structures and, if needed, perform bone grafting with either autogenous iliac or fibular bone. During closure it is important to repair the digastric muscle.

The patient is maintained in skeletal traction in the postoperative period with the head end of the bed elevated to reduce swelling. Endotracheal tube is continued until pharyngeal edema subsides, usually by 48 hours.

3. **Subtotal maxillectomy**

Cocke et al (1990) have described an extended maxillotomy and subtotal maxillectomy as an alternative to the transoral approach for exposure and removal of tumor or bone anteriorly at the base of the skull and cervical spine to C5. This approach has been used in a limited number of procedures, and the indications have not yet been firmly established. This procedure is technically demanding and requires a thorough knowledge of head and neck anatomy. It should be performed by a team of surgeons, including an otolaryngologist, a neurosurgeon, an orthopaedist and oral & maxillofacial surgeon.

The maxilla is exposed through a modified Weber Ferguson skin incision (Fig. 2). A vertical incision is made through the upper lip in the philtrum from the nasolabial groove to the vermilion border. Lower end in extended to the midline and then vertically in the midline through the buccal mucosa to the gingivobuccal gutter. Upper lip is divided and labial arteries are ligated. External skin incision is extended transversely from the upper end of the lip incision in the nasolabial groove to beyond the nasal ala and then superiorly along the nasolabial groove to the lower eyelid. Central incisor is extracted and a vertical midline incision is made through the mucoperiosteum of maxilla from gingivobuccal gutter to the central incisor defect and then transversely through the buccal gingiva adjacent to the...
teeth to the retromolar area. Skin, subcutaneous tissue, periosteum and mucoperiosteum of maxilla is elevated to expose maxilla, nasal bone, piriform aperture of nose inferior orbital nerve and zygomatic bone (Crenshaw, 1992). Further steps of dissection are beyond the scope of this article and interested readers are referred to the original article.

4. Extended maxillotomy: Skin incision and initial steps to expose maxilla are same as subtotal maxillectomy with a difference that central incisor tooth is not extracted. For the rest of the steps original article may be consulted.

II. Anterior Approach to C3-C7:

Cervical spine in region of C3 to C7 can be approached through a longitudinal or a transverse incision. The approach is carried out medial to the carotid sheath. A lot of vital structures come in the way, so as thorough knowledge of fascial planes and spaces, as described by Singh et al (2000) allows a safe and direct approach to this area.

Cervical traction is recommended during surgery. Spinal cord monitoring should be used if available to prevent inadvertent injury to the spinal cord. A left sided approach minimizes the risk of injury to recurrent laryngeal nerve as it has a more predictable course than its right counterpart.

III. Anterior approach to cervicothoracic junction

The rapid transition from cervical lordosis to thoracic kyphosis results in an abrupt change in the depth of the wound. Also there is a confluent area of vital structures that are not readily retracted.

The cervicothoracic junction can be approached either by a low anterior cervical approach, which can expose cervical vertebral bodies as well as thoracic spine up to T2 level, or by a high trans-thoracic approach, which is especially suitable in scoliosis involving the cervicothoracic junction, or by trans-sternal approach, which gives exposure from C4 to T4.

1. Low anterior cervical approach:

Enter on the left side by a transverse incision placed 1 finger breadth above the clavicle. Extend it well across the midline, taking particular care when dissecting about the carotid sheath in the area of entry of the thoracic duct. The latter approaches the jugular vein from its lateral side, but variations are not uncommon. Further steps in exposure follow those of the conventional anterior cervical approach.

2. High trans-thoracic approach

A kyphotic deformity of the thoracic spine tends to force the cervical spine into the chest, in which instance a high transthoracic approach is a logical choice. Make a periscapular incision (Fig. 4) and remove the second or third rib; removing the latter is necessary to provide sufficient working space in a child or if a kyphotic deformity is present.
This exposes the interval between C₆ & T₄. Excision of 1st or 2nd rib is adequate in adults.

leaves a slight postoperative enlargement of the left upper extremity that is not apparent unless carefully assessed. This approach provides limited access, and its success depends on accuracy in preoperative interpretation of the deformity and a high degree of surgical precision.

IV. Anterior approach to thoracic spine (Trans-thoracic approach)

The anterior approach to the thoracic spine provides access from T2 to T12. Most of the times a left sided approach is preferred as in right -sided approach presence of liver especially in the lower thoracic area can limit the exposure. Moreover the inadvertent injury to aorta, which lies on the left side, is easier to handle as compared to injury to the inferior vena cava, which has thinner wall.

3. Trans-sternal approach:

Make a Y shaped or straight incision with the vertical segment passing along the midsternal area form the suprasternal notch to just below the xiphoid process (Fig. 5). Next, extend the proximal end diagonally to the right and left along the base of the neck for a short distance. To avoid entering the abdominal cavity, take care to keep the dissection beneath the periosteum while exposing the distal end of the sternum. At the proximal end of the sternal notch take care to avoid the inferior thyroid vein. By blunt dissection reflect the parietal pleura from the posterior surfaces of the sternum and costal cartilages and develop a space. Pass one finger or an instrument above and below the suprasternal space, insert a Gigli saw, and split the sternum. Now spread the split sternum and gain access to the center of the chest. In children the upper portion of the exposure will be posterior to thymus and bounded by the innominate, the carotid arteries and their venous counterparts. Next, dissect the left side of this area bluntly. In patients with kyphotic deformity the innominate vein may now be divided as it crosses the field; it may be very tense and subject to rupture. This division is recommended by Fang et al (1964). The disadvantage of ligation is that it

The patient is placed in lateral position with left side up. Incision is then given over the rib of corresponding or 1-2 level higher vertebra depending on the level and the extent of exposure required (Fig. 6). The rib is dissected subperiosteally by cutting the subcutaneous tissue and the muscles overlying it. The rib is removed by cutting at the costochondral junction and disarticulating the rib from the transverse process. During this process one should be careful not to injure the intercostal nerves. The parietal pleura are then incised in line with the skin incision and the lung and the other contents of mediastinum are retracted by a retractor. The parietal pleura overlying the vertebral bodies is dissected to expose the segmental vessels, which are identified and cut after ligating. The periosteum is elevated from the vertebral bodies to expose the vertebral bodies and the pedicles. The excised rib can be used as a strut graft for fusion of the spine. If extended exposure is required like for scoliosis correction, 2 ribs can be removed either at adjacent levels or at different levels by another skin incision.
V. Anterior approach to thoracolumbar junction

The presence of the diaphragm originating from the upper lumbar vertebrae and the twelfth ribs poses technical problems in exposure. The position is similar as for thoracic exposure. The incision is centered on 10th rib, which allows exposure between T10 and L2. It is made curvilinear with ability to extend either the cephalad or caudal end (Fig. 7).

The diaphragm is identified and is incised after carefully retracting the lung. The incision of the diaphragm should be done at the periphery to minimize the risk of postoperative paralysis of diaphragm as the phrenic nerve supplies it from the center to the periphery. Now take care in entering the abdominal cavity. Since the transversalis fascia and the peritoneum do not diverge, dissect with caution and identify the two cavities on either side of the diaphragm. Incise the diaphragm 2.5 cm away from its insertion and tag it with sutures for later closure. Incise the prevertebral fascia. The rest of the dissection is the same as for anterior thoracic and lumbar exposure.

VI. Anterior approach to lumbar spine.

1. Anterior retroperitoneal approach (L1-L5)

The patient is positioned with right side down. The approach is made most often from the left side to avoid the liver and IVC, which is more difficult to repair then the aorta, should vascular injury occur during the surgery. The skin incision is placed parallel to the 12th rib, in the abdominal region, depending on the level of exposure required (Fig. 8). The subcutaneous tissue, external oblique, internal oblique, transversus abdominus, and the transversalis fascia are all cut in the line with skin incision. At this point care is taken not to enter the peritoneal cavity. The peritoneum is reflected anteriorly using blunt dissection to expose the psoas muscle. The exposure can be widened by applying a Finochitto rib retractor between the costal margin and the iliac crest. The sympathetic chain, which lies between the psoas and the vertebral bodies, and the genito-femoral nerve, which lies anteriorly on the psoas, need to be protected. Also the aorta and the inferior vena cava, which lie anterior on, the vertebral bodies requires to be identified and carefully protected. The appropriate vertebral body is exposed by elevating the psoas muscle from the lumbar vertebral bodies. The lumbar segmental vessels, which come in the way, should be ligated. The pedicles of the vertebral bodies are next identified to locate the neural foramen. The affected bodies and the pedicles can be removed using bone rongeurs to expose the dura. The wound is closed over a drain in the retroperitoneal space.

2. Anterior transperitoneal approach to L5-S1.

Anterior transperitoneal approach is especially useful in lumbosacral junction area as the retroperitoneal approach gives a limited exposure at the level because of presence of the iliac crest. However, this approach has the disadvantage that the hypogastric plexus, which carries sympathetic fibres to the urogenital system can be injured and can cause retrograde ejaculation in males. However, injury to the hypogastric plexus can be avoided by careful opening of the posterior peritoneum and blunt dissection of the prevertebral tissue from left to right and by opening the posterior peritoneum higher over the bifurcation of the aorta and then extending the opening down over the sacral promontory. In addition, electrocautery should be kept to a minimum when dissecting within the aortic bifurcation, and until the anulus of the L5 to S1 disc is
clearly exposed, no transverse scalpel cuts on the front of the disc should be made.

The position is supine and a midline abdominal incision is given (Patnaik et al., 2001). The peritoneum is reached by incising the rectus abdominis sheath in the midline. The peritoneum is opened and the bowel is packed to expose the posterior peritoneum, which lies over the sacral promontory region. The aorta is palpated at its bifurcation and the posterior peritoneum is carefully incised in midline in that region avoiding damage to the great vessels. The dissection is then carried along the right common iliac vessels till its division into external and internal iliac vessels, and then the dissection is curved medially to avoid ureter from being injured, which is identified and protected. The soft tissues are dissected using blunt gauze from left to the right side from the level of left common iliac vessels, which will protect the hypogastric plexus from being injured. The middle sacral artery, which is the terminal branch of aorta, and also the middle sacral vein, needs to be protected during the exposure of L5/S1 disc. Confirmation of L5/S1 disc should be done by intraoperative roentgenograms as L5 body may be frequently mistaken for the sacrum.

B. Posterior approaches:

The posterior approach through a midline longitudinal incision provides access to the posterior elements of the spine at all levels, including cervical, thoracic, and lumbosacral. It is the most direct access to the spinous processes, laminae, and facets and, in addition, the spinal canal may be explored and decompressed over a large area after laminectomy. Under most circumstances the choice of approach to the spine should be dictated by the site of the primary pathological condition. Posterior approaches to the spine rarely are indicated when the anterior spinal column is the site of an infectious process or a metastatic disease. The posterior elements usually are not involved in the pathological process and provide stabilization for the uninvolved structures of the spinal column. Removal of the uninvolved posterior elements, as in laminectomy, may result in subluxation, dislocation, or severe angulation of the spine, causing increased compression of the neural elements and worsening of any neurological deficit.

I. Post. approach to cervical spine (Occiput to C2)

Patient is positioned prone and skull traction tongs are applied. A midline longitudinal skin incision is given from occiput to spinous process of C2. (Fig 9) Deeper dissection is carried out in the midline raphe (nuchal ligament) to minimize the bleeding, as it is avascular.

Fig. 9
Posterior approach to upper cervical spine

One has to be careful in C1/Occiput junction and the dissection should not be carried out more than 1.5 cm from midline to avoid injuring the vertebral vessels. Second cervical ganglion is the landmark taken for the lateral dissection, which lies in the groove for vertebral artery.

The posterior arch of C1 lies deeper in comparison to the spinous process of C2. Care should be exercised while dissecting near to C1 arch because it is thin and vulnerable to fracture during dissection and secondly the dura is also vulnerable to injury at superior as well as inferior aspect of C1.

II. Post. approach to cervical spine (C3-C7)

Patient is positioned prone and skull traction tongs are applied. A midline longitudinal skin incision is given from spinous process of C2 to spinous process of C7, depending on the area to be dissected. Deeper dissection is carried out in the midline raphe (nuchal ligament) to minimize the bleeding, as it is avascular. The exposure can be safely done up to the level of facet joints without endangering any important structure.

III. Post. approach to thoracic spine (T1-T12)

1. Mid line incision: Patient is positioned prone and a midline longitudinal skin incision is given from spinous process of T1 to spinous process of T12, depending on the area to be dissected. Deeper dis-
section is carried out in the midline. The paraspinal muscles are erased from the posterior elements using a Cobb's periosteum elevator. Lateral exposure can be done to the level of transverse processes safely and no important structure comes in the way. This approach is commonly used for posterior spinal stabilization, for scoliosis correction and instrumentation and also for intradural surgery.

2. Costotransversectomy

The thoracic vertebrae may be alternatively approached through a costotransversectomy when direct access to the transverse processes and pedicles of the thoracic spine and limited access to the vertebral bodies are indicated. Costotransversectomy should be considered for simple biopsy or local debridement. It should be noted, however, that this approach does not provide the working operative area or length of exposure to the thoracic vertebral bodies that is afforded by a transthoracic approach or the midlongitudinal posterior approach.

IV. Posterior approach to lumbar spine (L1-L5)

The lumbar spine can be approached posteriorly either by a midline or through the Paramedian approach. Through the posterior midline approach the spine can be easily reached up to the transverse processes, though, it is much easier to reach the more lateral areas by the Para-median approach, the disadvantage is that the latter causes more bleeding. Posterior approach to the spine is commonly used for disc excision in cases of prolapsed intervertebral disc, posterior stabilization in cases of fracture & scoliosis of spine and also for approaching any intra-dural pathology.

1. Posterior midline approach

Patient is positioned prone and a midline longitudinal skin incision is given from spinous process of L1 to spinous process of L5, depending on the area to be dissected. Deeper dissection is carried out in the midline. The spinous processes are reached and the paraspinal muscles are erased from the posterior arch to reach up to the tips of the transverse processes as required. The dissection can be extended proximally to the dorsal or distally to the sacral region if required.

Position the patient prone or lateral. Make a curved incision with its apex lateral to the midline at the desired level (Fig. 10). Deepen the dissection through the subcutaneous tissues and the trapezius and latissimus dorsi muscles and the lumbodorsal fasciae, which are divided longitudinally. Dissect the paraspinal muscles sharply from their insertions on the ribs and transverse processes, and retract them medially. Expose the transverse process and posterior aspects of the associated rib subperiosteally and remove a section of rib 5 to 7.5 cm long at the level of involvement, disarticulating from the rib facet. The rib generally is transected at its prominent posterior angle. Take care to remain subperiosteally and extra pleural during this part of the exposure and to protect the intercostal neurovascular bundle. Anterior to the transverse process is the vertebral pedicle, and above and below the pedicle lie the neuroforamina. Once the pedicles, neuroforamina, and neurovascular structures have been identified, proceed with dissection directly anteriorly on the pedicle to the vertebral body along a path that is relatively free of major vessels or nerves. Carefully dissect the parietal pleura anteriorly to expose the anterolateral aspect of the vertebral body, raising the sympathetic trunk and parietal pleura. Exposure may be increased by removal of the transverse process, pedicle, and facet joints as necessary. After completion of the spinal procedure, check for air leaks in the pleura. Close the wound in layers over a drain to prevent hematoma collection. Should a leak occur, an intercostal chest tube drainage should be used.

2. Posterior paraspinous approach:

Recently, Wiltse and Spencer (1988) refined the paraspinal approach to the lumbar spine, which involves a longitudinal separation of the sacrospinalis muscle group to expose the posterolateral aspect of the lumbar spine. This approach is especially useful in removing far lateral disc...
herniation, posterolateral fusion, and inserting pedicle screws.

Patient is positioned prone and a midline longitudinal skin incision is given from spinous process of L1 to spinous process of L5, depending on the area to be dissected. Dissection is done up to the deep fascia and retraction is done to expose paraspinal muscles on the desired side. Cleavage is then created between the multifidus and the latisimus dorsi muscles by blunt dissection to reach the area of the facet joints. Further exposure can be gained by subperiosteal dissection of the muscles. This approach is commonly used for inter-transverse spinal fusion.

V. Posterior approach to lumbosacral spine (L1-Sacrum).

A longitudinal skin incision is given over the spinous processes of the appropriate vertebrae. The superficial fascia, lumbodorsal fascia, and the supraspinous ligaments are incised longitudinally, over the tips of processes. The ligament is divided longitudinally between the 2 spinous processes in the most distal part of the wound. Keeping a small, blunt periosteal elevator in this opening, and with a scalpel, muscles are stripped subperiosteally from distal to proximal.

Expose the spinous processes from distal to proximal as just described because the muscles may then be stripped from the spinous processes in the acute angle between their insertions and the bone. If exposure in the opposite direction is attempted, the knife blade or periosteal elevator will tend to follow the direction of the fibers into the muscle and divide the vessels, thus increasing haemorrhage.

This approach exposes the spinous processes and medial part of the laminae. Divide the supraspinous ligament precisely over the tip of the spinous processes and denude subperiosteally the sides of the processes because this route leads through a relatively avascular field; otherwise the arterial supply to the muscles will be encountered.

References:


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