Answers and Additional Information for the Orthopaedic Quiz

Quiz 1

a. A continuous sclerotic lesion posterior to the vertebral bodies and discs of the cervical spine with anterior osteophytes is seen; additionally there is loss of cervical lordosis is seen in this image and the central canal of the cervical spine is stenosed.
b. Continuous type ossification of the posterior longitudinal ligament (OPLL) of the cervical spine, localized type OPLL of the thoracic spine, and ossification of the flavum ligament (OFL) C7-8 and T1-2, myelomalacia C6-7, cord compression C6-7 and T1-2 are seen in this image
c. The diagnosis is cervical and thoracic myelopathy due to f continuous and localized OPLL C2-7 and OFL T1-2 (Tendem ossification of PLL and FL)
d. MR imaging of the entire thoracic spine is necessary to rule out caudal extension of the disease. Decompression with or without fusion and instrumentation will be required depending on the status of instability on dynamic lateral cervical spine seen in radiographs. Posteriorly, laminoplasty is preferred for multilevel disease with laminectomies and posterior instrumentation as an alternative if instability is noted. Anterior corpectomy (either partial or complete) and fusion is an alternative to posterior approaches, but is not advisable in this case due to T1-2 compression. If an anterior approach is used, a modified anterior approach including generation of an anterior 'floating segment' can be used without the need for removal of all ossified elements to obtain adequate decompression without dural violation.

OSSIFICATION OF THE POSTERIOR LONGITUDINAL LIGAMENT (OPLL)
OPLL was first recognized in 1838 and the Asian populations are most commonly affected. It primarily affects the cervical spine (70% - 95% of patients), but the mid-thoracic and upper lumbar spine regions are not spared. Up to 27% of cervical myelopathy cases in Japan are attributed to OPLL. Repetitive ligament strain and genetic susceptibility play significant roles in disease pathogenesis.

Hirabayashi (1981) classified OPLL into four types: continuous, segmental, mixed continuous and segmental, and localized. In nearly 40% of cases, the lesions are continuous. The majority of patients present with gradual onset of neck pain and myelopathy with or without radiculopathy. Less than 30% of patients present with sudden neurological deterioration after minor cervical trauma.

Diagnosis of OPLL is based on true lateral radiographs of the spine coupled with thorough neurological examination. High-resolution CT with sagittal reconstruction is the gold standard for diagnosis. MRI helps to delineate cord compression or oedema and is useful to verify dynamic changes of flexion and extension on canal diameter and cord compression.

Most patients with progressive symptoms require surgery, i.e. decompression with or without fusion and instrumentation, based on co-existing instability. Laminoplasty is the preferred posterior approach for multilevel or long-segment OPLL. Laminectomy is only indicated for single-segment localized disease with lordotic cervical spine. Standard anterior decompression and fusion techniques have drawbacks such as increased intraoperative blood loss, risk of dural tear and CSF fistula, and high rates of pseudo-arthrosis. A new anterior 'floating segment' technique using partial corpectomy without the need for excision of all ossified lesions provides adequate decompression.

Quiz 2

a. Pre-vertebral soft tissue swelling at C1-2 level, fractures involving the anterior and posterior arches of the C1 ring, and lateralization of C1 lateral mass are seen in the radiograph.
b. The diagnosis is three-part variant of a Jefferson fracture.
c. The mechanism of injury involved axial loading transmitted via a direct blow to the head. The occipital condyles were driven caudally into the atlas in a wedge-like fashion causing a C1 ring fracture and lateral mass displacement (LMD).
d. The fracture is unstable because there exists more than 7mm lateralization of the lateral mass. A combined lateral mass displacement (LMD) of more than 7 mm is presumed to be associated with transverse ligament injury.
e. Appropriate treatment consists of halo vest placement for 12 weeks followed by flexion-extension views of the cervical spine. If C1-C2 instability persists, an atlanto-axial (C1-2) fusion is recommended.

JEFFERSON FRACTURE OF THE ATLAS
Fracture of the atlas was first described by Sir Ashley Cooper in 1822 but Jefferson was credited for publishing the classic paper, entitled "Fracture of the Atlas Vertebra". The majority of patients with Jefferson fracture are young adults. These injuries are often caused by motor vehicle accidents, diving injuries or other direct impact to the head. Neck pain and stiffness are the most common presentations. Isolated atlas fractures rarely present with neurological symptoms and the presence of any neurological deficit should alert the physician to associated head or other cervical spine injuries. Signs of a stroke should also be screened as the fracture may cause injury to the vertebral artery.

Diagnosis of atlas fracture requires a high index of suspicion. Standard radiographs for diagnosis include antero-posterior, lateral, and open-mouth odontoid views. With advances in imaging modalities, five types of atlas fractures are recognized based on CT-scanning. Recognition of an unstable fracture is crucial as treatment choices are guided by the extent fracture displacement and integrity of the transverse ligament. A combined LMD of more than 6.9mm (Spence et al.1970) or 8.2mm (Heller et al.1993) based on radiograph magnification factors is used to recognize significant injury to the transverse ligament. CT-scans and MRI have been used with increasing frequency to precisely evaluate bony and soft tissue injuries of the upper cervical spine.

An undisplaced or minimally displaced injury (< 7mm of combined LMD) is treated with a cervical orthosis or halo vest for 12 weeks. A significantly displaced fracture (> 7mm of LMD) is initially treated with halo vest for 12 weeks followed by assessment of C1-C2 instability. C1-C2 posterior fusion is recommended if instability persists. In some spinal centres, immediate C1-C2 fusion is preferred to preclude the initial prolonged immobilization for fracture management and a second period of immobilization is added as needed for treatment of persistent instability.

Quiz 3

a. This is a Jewett hyperextension brace, categorized as a limited contact spinal brace.
b. It works through a three-point fixation principle using two anterior pads at the sternum and symphysis pubis, and a posterior pad placed at the level of injured vertebral segment
c. It works effectively for fractures within the T6-L3 segment
d. The indications for using a Jewett brace include simple osteoporotic vertebral compression fractures (VCFs), pathological fractures (e.g. spinal metastatic lesion or infection), stable traumatic vertebral fractures without neurology, and post spinal instrumentation (suboptimal stabilization)

JEWETT SPINAL ORTHOSIS
The Jewett brace is a light-duty, limited contact spinal orthosis, which applies forces over small areas of the body through a three-point pressure system using one posterior and two anterior pads. The anterior pads produce posterior pressure to the symphysis pubis and sternum. The posterior pad exerts anterior force and opposes the anterior pads to extend the spine. To achieve this, the pad is placed to across the mid-thoracic region.

This orthosis effectively prevents deformity under physiological loading by limiting flexion and extension of the spinal segment with residual stiffness at least 50% of normal. As such, it is mainly indicated for stable compression fractures between T6 and L2-L3, particularly osteoporotic vertebral compression fractures. The brace is ineffective for 2-column injury (loss of spinal stiffness up to 85%).

The brace should be fitted in a high-demand posture such as seated position. This is because it tends to 'ride-up' when the patient is seated. In seated position, the sternal pad should run a half-inch inferior to the sternal notch and the pubic pad crosses a half-inch superior to the symphysis pubis. The brace is adjustable from a lateral bar to which the anterior pads attach. A modified Jewett brace with 'built-in' abdominal support is called a Korsian brace.

Quiz 4

a. Anterior wedging of > 5O affecting more than three adjacent vertebrae, end-plate irregularity and thoracolumbar kyphosis extending from T5 to L1 with a Cobb angle of > 100O are noted. Other findings include Schmorl nodes and disc space narrowing.
b. End vertebrae with respective upper and lower end-plates are referred to as the upper and lower Cobb levels of the deformity
c. Angle 'A' of 102O is the correct measurement of kyphosis.
d. The diagnosis is horacolumbar Scheuermann kyphosis (type-II)
e. Surgical treatment with the goal of preventing further progression of the kyphosis would entail correction of kyphosis via a solid fusion. Limiting the correction to 50% of the original kyphosis is currently recommended. Posterior spinal fusion with instrumentation involving the upper and lower Cobb levels is recommended to avoid junctional kyphosis. This requires a fusion extension to vertebra above the first lordotic disc. Some authors recommend a minimum of eight screws below and above the apex of the kyphosis. Others use a double-rod technique for kyphosis reduction with overlapping parts of the rods brought together and connected with double domino connectors. The connectors are placed near the apex of the kyphosis.
f. The minimal Cobb angle is 75O. A severe curve with rigid deformity may require osteotomy (i.e., a Smith-Peterson osteotomy or pedicle subtraction osteotomy).

SCHEUERMANN KYPHOSIS (SK)

This rigid round back deformity in adolescent was first described in1920. Classically, anterior wedging of 5O with end-plate irregularities affecting at least three contiguous vertebrae confirms the diagnosis of SK. Two curve patterns: thoracic (extending from T1-2 to T12-L1) and thoracolumbar (fromT4-5 to L2-3) are recognized. The second pattern tends to progress into adulthood due to inadequate support from the thoracic cage.

SK typically presents around puberty and patients are referred for cosmetic reasons related to poor posture, disproportionate limb growth and ill-fitting clothes. Adult patients often present with degenerative low back pain secondary to chronic compensation for thoracic kyphosis. Adolescents with back pain typically have pain distal to the apex of the deformity that is aggravated by standing, sitting or strenuous activity and is relieved by rest. Disabling recalcitrant back pain is common when the kyphosis exceeds 60O. Extreme kyphosis of more than 100O is associated with restrictive pulmonary disease.

Non-operative treatment with close follow-up until skeletal maturity is indicated for mild SK of less than 60O with bracing recommended for curves of more than 60O. SK with neurologic deficit is an absolute indication for surgery. Relative indicators for surgery include resistance to brace treatment due to a rigid curve of >75O and non-compliance secondary to progressive pain, and/or respiratory problem related to curves >1000.

Quiz 5

a. Café-au-lait spots, plexiform neurofibroma and kyphoscoliotic deformity of the spine are seen.
b. Signs of kyphoscoliosis with dystrophic changes include vertebral wedging and scalloping, spindling of transverse processes, widened interpedicular distance, enlarged intervertebral foramina, and dysplastic or pencilling ribs.
c. The most likely diagnosis is neurofibromatosis type-1 (NF-1) with dystrophic kyphoscoliosis
d. The diagnosis of NF-1 is based on meeting two out of seven criteria developed by the Consensus Development Conference at the National Institutes of Health in1987:
   - 6 cafe-au-lait spots of at least 15mm (adults) or 5mm (prepubertal children)
   - Two or more neurofibromas of any type or one plexiform neurofibroma
   - Axillary or inguinal freckling (Crowe sign)
   - Optic glioma
   - Two or more Lisch nodules (iris hamartomas)
   - A distinctive bony lesion (dysplasia or sphenoid wing lesion)
   - A1st-degree relative with NF-1 as per the above criteria

NEUROFIBROMATOSIS-1 (NF-1)

This (aka von Recklinghausen disease) autosomal dominant, single gene disorder has a gene locus localized to the long arm of chromosome 17. Spontaneous mutation occurs in about 50% of cases.

NF-1 has two peaks of severe manifestations: from 5 to 10 years of age and from 36 to 50 years of age. Two-thirds of patients have mild-to-moderate disease and one-third suffer serious medical and cosmetic consequences. Musculoskeletal problems include congenital pseudoarthrosis of the tibia and ulna, limb over-growth, spinal deformity and soft tissue tumours.

Spinal deformities include scoliosis, kyphoscoliosis and rarely spondylolisthesis involving soft tissue and bone. Peculiar to NF-1, spinal changes are categorized as dystrophic and non-dystrophic. Non-dystrophic scoliosis has similar behaviour to idiopathic scoliosis except for earlier presentation, worse prognosis and high risk for pseudoarthrosis after fusion surgery. A dystrophic deformity may evolve from a non-dystrophic spine through a process called modulation. A dystrophic curve always progresses when it acquires 3 pencilled ribs or a combination of 3 dystrophic features. Surgery is indicated once the dystrophic curve appears.

Quiz 6

a. C4-C5 anterolisthesis of 50% and C4-5 facet dislocation is seen.
b. Diagnosis is distraction-flexion injury with bilateral C4-5 facet dislocation
c. Emergent management should include neck immobilization with cervical collar, high flow oxygen supplementation, maintenance of systolic BP > 90mm Hg and methylprednisolone infusion if seen within 8 hours after trauma
d. MRI of the cervical spine is indicated to preclude disc prolapse and cord damage before and after attempting any form of reduction
e. Treatment goals for bilateral facet dislocation include reduction of the dislocated segment, as well as restoration of neurologic function and spinal stability. Gradual skull traction with an initial weight of 5 pounds and thereafter 5-pound increments until the facets are perched and reduced is recommended. Serial plain radiographs or fluoroscopic guidance should accompany each attempted reduction. A weight of less than 50 pounds is generally adequate for reduction of cervical facet dislocation. Following successful reduction, reduce the weight and put the patient in a halo vest for early stabilization. Definitive stabilization and fusion is indicated if persistent instability continues after closed reduction attempts or persistent/evolving neurologic deficits present. Posterior instrumented fusion or anterior discectomy and interbody fusion with a plate is an acceptable option for definitive treatment.

DISTRACTIVE-FLEXION INJURIES OF THE CERVICAL SPINE

Distraction-flexion injury accounts for 10% of sub-axial cervical spine injuries. It occur in four stages:

Stage 1 is a failure of the PLC with only < 25% subluxation of facets in flexion and divergence of the spinous processes. Diagnosis is difficult and may require flexion/extension radiographs when pain subsides 3 weeks later.

Stage 2 is unilateral facet dislocation with or without fracture of articular processes or pedicles. This is a distractive flexion injurywith a rotational element and is typically recognized by the presence of < 25% anterolisthesis.

Stage 3 is a bilateral facet dislocation, which usually shows 50% anterolisthesis. The supraspinous and intraspinous ligaments, facet joint capsules, ligamentum flavum, posterior longitudinal ligament and the intervertebral discs are disrupted. Complete neurologic injury is more frequent with bilateral facet dislocation.

Stage 4 is a bilateral facet dislocation with 100% anterolisthesis.

Routine pre-reduction MRI is recommended to identify co-existing prolapsed discs because of the risk of disc fragment displacement during reduction. The timing for MRI depends on whether the patient is awake and co-operative, with or without neurologic deficit, or comatose/semi-comatose with suspected neurology. If a pre-reduction MRI shows prolapsed disc, most surgeons prefer decompression and fusion via an anterior approach.