ANSWERS AND ADDITIONAL INFORMATION FOR ORTHOPAEDIC CLINICAL QUIZ

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Question 1

a. Bilateral anomaly of the tibia with the left tibia is not visualized and only the proximal part of the right tibia is present. Both feet appear to have polydactyly.
b. The diagnosis is bilateral tibial hemimelia.
c. Severe flexion contracture of the knee occurs due to the absence of the knee extensor mechanism secondary to agenesis of the tibia.

TIBIAL HEMIMELIA

Tibial hemimelia, also known as tibial deficiency or longitudinal deformity of the tibia, is a rare congenital anomaly with an incidence of 0.1 per 100 000 births. Two-thirds of children with tibial hemimelia also had associated anomalies which include polydactyly, syndactyly and femoral hypoplasia. Accompanying non-skeletal anomalies include cardiac defects, varicocele and cryptorchism.

Kalamchi and Dawe (1985) identified three types of tibial hemimelia. Type-I anomaly features absence of the tibia, an inverted and adducted foot, and absence of the medial ray of the foot. Tibial hypoplasia in the absence of the distal half of the tibia, but with a normal knee joint characterizes type-II hemimelia. In type-III hemimelia, the distal tibia is dysplastic and the foot is in varus position with prominence of the lateral malleolus and diastasis of the tibiofibular syndesmotic joint.

Treatment of tibial hemimelia is principally based on the type of the deformity. Orthotic prescription is the first line of treatment. Centralization of the fibula is the best option for type-1 deformity if there exists sufficiently good quadriceps function and adequate distal femur. With a deformed distal femur and flexion contracture of the knee, a through the knee amputation is advisable before the child starts to walk. Arthrodesis of the femur and fibula is an alternative option with subsequent risk of adverse effect on growth plate.

Type-II hemimelia can be treated with side-to-side tibio-fibular fusion and fibulo-talar arthrodesis along with forefoot amputation as part of a modified Boyd procedure. For type-III hemimelia, cranial migration of the talus through the diastasis and protruding lateral malleolus are the key problems. External fixation can be used to reduce the talus underneath the tibia followed by tibio-talar transfixation with a medullary nail and distal tibio-fibular fusion.

Question 2

a. Pulled elbow or nursemaid elbow.
b. The underlying cause remains unclear. Either capsular interposition or annular ligament entrapment following longitudinal traction and pronation of the elbow has been implicated.
c. Reduction should be undertaken by supinating the forearm and flexing the elbow. A snap is usually felt and is typically followed by immediate return of full range of active motion. Post-manipulation immobilization is not necessary. If unsuccessful, repeat the same maneuver after 15 minutes.

PULLED ELBOW

Pulled elbow occurs in approximately 1% of children, with toddlers being particularly at-risk. Nearly 50% of patients have no obvious history of pull or trauma. The child typically presents with pseudoparalysis of the forearm with the elbow held in slightly flexed, pronated position and with guarding.

The underlying cause of pseudoparalysis in pulled elbow is thought to be due to mechanical blockage by either an interposed joint capsule between the annular ligament and the radial head or annular ligament entrapment following a longitudinal pulling of the upper limb in pronation. This explains the normal appearance of elbow radiographs. Radiographs are necessary to exclude occult fracture especially when the initial manipulation fails to obtain normal active range of elbow motion. The purpose of reduction is to free the interposed capsule or entrapped annular ligament. Passive rotation of the forearm through 180 degrees will usually produce a snap, indicating a successful reduction which is further supported by renewed ability to actively pronate and supinate the forearm without or with minimal pain.

Question 3

a. Physeal separation of the distal humerus.
b. This should be treated similar to supracondylar fracture of the humerus by closed manipulative reduction and percutaneous Kirschner wiring under general anaesthesia.
c. Cubitus varus deformity.

DISTAL HUMERAL PHYSEAL SEPARATION

Transphyseal fracture-separation of the distal humerus epiphysis usually occurs in infants and young children. It is frequently misdiagnosed and treated as an elbow dislocation. As such, complication of improperly treated separation may result in cubitus varus deformity.

High index of suspicious is needed when dealing with young children with plain radiographs showing posteromedial displacement of the proximal radius and ulna relative to the humeral shaft. In infants the fracture is basically a Salter-Harris type-I injury. Salter-Harris type-II injury is frequently seen in toddlers (3 to 7 years old). Suspect of non-accidental injury (NAI) by taking a good history and proper examination of the child as the whole.

In principle, this injury is treated as supracondylar fracture of the humerus. Closed manipulative reduction and percutaneous Kirschner wiring is usually adequate.

Question 4

a. Excessive valgus deformity of the left elbow and supinated forearm as compared to normal carrying angle of the right elbow. Typical ulnar claw hand deformity, characterized by hyperextension of the metacarpophalangeal joint and flexion of the proximal interphalangeal joint of the ring and middle fingers, and ulnar-sided wrist flexion.
b. Differential diagnoses of a malunited humeral supracondylar fracture and a non-union of lateral humeral condyle fracture should be considered.
c. Tardy ulnar palsy.

TARDY ULNAR PALSY

A child with cubitus valgus is at-risk of development of ulnar nerve compression at or just proximal to the medial humeral epicondyle. Non-physiological valgus deformity of the elbow (excessive carrying angle) commonly occurs secondary to an old epiphyseal injury to the lateral humeral condyle or a malunited supracondylar humeral fracture. Ulnar nerve compression developing late after a distal humeral fracture was first described by Mouchet in 1914 and

commonly referred as 'maladie de Mouchet' in European literature. The term 'tardy ulnar palsy' was introduced in English literature by Hunt.

Question 5

a. The diagnosis is non-union fracture of the lateral condyle of the humerus.
b. This complication is usually caused by failure to diagnose type-2 lateral humeral condyle fracture and inadequate primary treatment of either type-1 or type-2 lateral humeral condyle fracture.
c. There is no consensus on the treatment of these complications. Recommendations include osteosynthesis for non-union and corrective osteotomy of the distal humerus after malunion for significant deformity. Early non-union (less than 6 months) can be treated similarly to an acute fracture by fixing the posteriorly based Thurston-Holland fragment to the distal humerus with the caveat to avoid posterior dissection or stripping of soft tissue attachments to the fragment in order to preserve blood supply and prevent avascular necrosis. Late non-unions with 10mm displacement or more should be fused in-situ to the metaphysis as the fragments remodel and anatomical reduction would not be possible. Screw fixation is optional. For cases of asymptomatic late non-unions with less than 10mm displacement, leaving the non-union alone has been recommended. Ulnar nerve palsy is addressed by either decompression in-situ or anterior transposition in combination with corrective osteotomy.

NON-UNION OF LATERAL HUMERAL CONDYLE FRACTURES

Lateral humeral condyle fractures are the most common physeal injuries around the elbow. They account for 10% to 15% of all elbow fractures in children aged 6- to 10-years-old. The mechanism of injury involves a varus stress with the elbow in extension. The fracture is basically a Salter-Harris type-4 injury. It may occur during elbow dislocation. A child with pre-existing cubitus varus is at-risk to develop fracture of the lateral condyle.

The main problem related with the development of non-union is failure to differentiate between the stable type-1 fracture with an intact central cartilage hinge (incomplete fracture) and the unstable type-2 fracture (complete fracture). Standard anteroposterior and lateral radiographs are not helpful as the cartilaginous part is not visualised. Internal oblique view shows the fracture best. The best clue is by measuring the displacement or widening of the central fracture section at the cartilage-bone junction. Any widening or displacement of less than 2mm indicates an incomplete or a relatively stable fracture (type-1) with an intact cartilage hinge. Treatment of type-1 fracture requires immobilization in a long-arm cast with the elbow in 80-90 degrees of flexion for four weeks and regular cast-free radiographic follow-ups to assess maintenance of reduction. Any displacement requires re-reduction and internal fixation to prevent re-displacement.

Unstable type-2 or type-3 (displacement of more than 5mm and rotated fracture fragment) fractures are unique for the risk of non-union and are thus indicated for open reduction and internal fixation. Fixation from metaphysis-to-metaphysis using screws or epiphysis-to-epiphysis using smooth pins or Kirschner wire is recommended. Inadequately treated fractures are at risk for malunion and non-union with subsequent deformity, loss of motion and tardy ulnar palsy.

Question 6

a. A chronic stable slipped capital femoral epiphysis (SCFE) based of more than 2 weeks symptoms of ability to walk and referred pain.
b. Chronic SCFE of mild grade based on the appearance of metaphyseal corner resorption and slip angle of less than 30 degree on true lateral radiographic view. Hip ultrasonography is helpful to verify metaphyseal corner roundness, filling defects in the epiphyseal plate and calcification of the fibrocartilage ligaments.
c. Referred pain through the obturator nerve. The motor branch, which supplies the muscle that moves the hip and knee, also supplies the skin over the joints. This rule is known as the Hilton law.
d. Treatment for mild chronic SCFE consists of, epiphysiodesis by *in-situ* pinning to prevent further slippage during acute-on-chronic slip episodes. This can be achieved by using a single reverse-cutting cannulated screw inserted percutaneously according to Canale technique.
e. Femoroacetabular impingement (FAI) is a commonly encountered complication in cases such as this.

SLIPPED CAPITAL FEMORAL EPIPHYSIS

Emphasizing *'primum none nocere'* by preventing avascular necrosis and chondrolysis is the current standard of treatment for SCFE. In addition to the standard classification of SCFE into acute, chronic and acute-on-chronic types based on the duration of symptoms, classification based on physeal stability as determined by walking ability (Loder et al.1993) and hip ultrasonographic features (Kallio et al. 1993) helps to guide surgical decision making.

In chronic stable SCFE, percutaneous *in-situ* single screw fixation remains the gold standard for treatment option, as the risk of avascular necrosis is low. The concepts of treatment for acute unstable SCFE with high risk of avascular necrosis continue to evolve with an enormous body of evidence appear to suggest that early decompression of associated hip effusion, gentle reduction and fixation with two screws reduces the risk of avascular necrosis. Reduction of slip may occur spontaneously from positional manipulation or from gentle traction while the affected limb is being positioned on the operating table for screw fixation.