Skeletal Normal Variants

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Disclosure of Commercial Interest

Neither I nor my immediate family members have a financial relationship with a commercial organization that may have a direct or indirect interest in the content.

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Objectives

- The skeleton is visualized on nearly every radiologic image (xray, CT, MR)
- Skeletal variation is commonplace and most are recognizable
- Others are less familiar and may mimic true pathologic condition

Spectrum of Impact

Classic Benign Normal Variant
Normal Variant Mimics Pathology
Pathology Mistaken for Normal Variant
Normal Variant Contributes to Pathology
Axial and Appendicular Skeleton

Less Bone
- Holes
- Clefts
- Notches

More Bone
- Tubercles
- Processes
- Ossicles

Altered Morphology
- Hypertropy
- Atrophy

Axial and Appendicular Skeleton

Sternum
- Develops from somatic mesoderm
  - 2 bars on either side of midline that fuse
- Ossification begins in utero and continues during growth
- Xiphoid process last to appear (childhood)

Adult Sternum
- Manubrium-trapezoidal shape.
  - Articulates with clavicles, 1st ribs, and upper portion of 2nd ribs.
- Body – comprised of 4 segments and twice as long as manubrium.
  - Articulates ribs 3-7.
- Xyphoid – highly variable in size and morphology.
**Bifid Sternum**

- True “Cleft” Sternum
- Rare (sporadic)
- Failure of midline fusion during first 3 months in utero
- Two types:
  - Incomplete
  - Superior > inferior > central
  - Complete

Associated with anomalies of heart, abdomen, diaphragm, omphalocele

**Sternal Foramen**

- Common bone defect
  - Seen in 5% of Chest CTs
- Inferior 1/3 of sternum
- Risk to heart:
  - Sternal aspirations
  - Acupuncture

**Sternal Bands**

- Fused vertically oriented midline mesenchymal bands
- Shallow clefts – coronal images
- Only in manubrium or body

**Xyphoid Foramen and Forks**

- Foramen 25% MDCTs
- Spiked/Forked 33% MDCTs
Hypersegmented Sternum

- Down Syndrome

Suprasternal/Episternal Ossicles

- Relatively common
- No clinical significance
- Locations
  - Above (suprasternal)
  - Adjacent (episternal)
- May mimic fracture

Pectus Excavatum

- Incidence 1:400-1000 live births.
- Most common deformity of the sternum (45% are familial).
- Causes central depression of the sternum.
  - Excessive growth of cartilage from lower most region of thorax
  - Ribs protrude anteriorly
- Pectus index = transverse diameter/AP diameter.
  - Normal ratio is 2.56 +/- 0.35

Radiographic findings:

- Reduces prevertebral space
- Leftward cardiac displacement and axial rotation
- Reduction of left thoracic volume (left lung capacity reduced)
Pectus Carinatum

- Incidence – 1:1500 live births.
- 4X more common in men.
- 25% are familial
- 30% associated with scoliosis.
- Clinically – SOB and exercise intolerance.
- 2 types of protrusion:
  - Chondromanubrial deformity (upper sternum)
  - Chondrogladiolar deformity (middle/lower sternum)

Clavicle

- Clavicular Pseudoarthrosis
  - Mimics nonunion
  - Assoc. with:
    - Cleidocranial dysostosis
    - Not Neurofibromatosis
  - Arrested development <8th embryologic wks
  - Failure of Med and Lat ossification centers
  - Right > Left

- Rhomboid Fossa of the Clavicle
  - Inferomedial concavity
  - Costoclavicular lig insertion
  - 4-10 times M>>F
  - Bilateral in 30% of men but only 2.9% of women
  - R > L when unilateral
  - Forensically, left sided fossa indicates 92% prob skeleton is male
  - DDx-erosion/infiltration
Irregular Ossification Center

- First bone to ossify
- No medullary cavity
- Primarily intra-membranous ossification but ends undergo endochondral ossification

Med ossifies 12-19 yrs/fuses at 22 yrs
Lat ossifies and fuses 19 yrs

Ossification of Superior Transverse Lig.

- Suprascapular notch
  Concavity in superior border just medial to base of coracoid
- Suprascapular nerve
- Ossification of STL
  3% to 13% - genetic?
  Thin layer to thick constricting bone
  +/- Entrapment of nerve

Scapula

- Uncommon
- Most common in the body
  Interruption in IM ossification in utero
- Incidence <6%
- DDx – multiple myeloma, mets, infiltrative process
Acromion Process Ossification

- 8% of population
  - Reported range 1%-15%
- Bilateral 60%
- Most asymptomatic
- W/ stepoff, RCT inc.
- Fusion range from 18-25 yrs
- DDx
  - Acromion fx
  - Apophysiolysis

Acromial Apophysiolysis

Os Acromiale

Humerus
Deltoid Tubercle Striation
- Usually smooth
- Occasionally
  - Irregular
  - Hypertrophied
  - Striated periosteal rx
  - Bone scan

Supratrochlear Foramen

Sacrum/Pelvis

Sacral Hiatus
- Midline defect
- Below the S4/5 segment
  - Represents failure of fusion in the posterior wall
  - No defect in CSF sac
  - Normal anterior surface
- DDx-myelocele, myelomeningocele, lipomeningocele
Paraglenoid Sulcus

- Pre-auricular groove
- Insertion of anterior SI lig
- Prevalence-14%
- Only in females
- Increased incidence with aging
  Increased stress on lig from obesity, strenuous exercise or activity, pregnancy

Patella

- Largest sesamoid in skeleton
- Arises from single ossification center 4-6 yrs
  Accessory ossification appear between 9-12 yrs

Bipartite Patella

- Occurs 2-3% of pop.
- Bilateral 50%
- Etiology-
  Direct trauma or repeated trauma
  Lack of arterial penetration to the sec. ossification
- Intact hyaline cartilage

Dorsal Patellar Defect

- Well-marginated lesion
  Dorsal surface-SL quad
  Occasionally central
- Incidence – 1-4%
- No gender preference
- Cause unknown but likely failed ossification
- Sometimes heals and disappears
Cervical Spine

Table 1. Radiographic Development of the Pediatric Cervical Spine

<table>
<thead>
<tr>
<th>Age</th>
<th>Developmental Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 months</td>
<td>Body of C1 not visible, only synchondrosis open</td>
</tr>
<tr>
<td>1 year</td>
<td>Body of C1 now visible</td>
</tr>
<tr>
<td>2 years</td>
<td>Synchondrosis of posterior occipital bone begins to fuse</td>
</tr>
<tr>
<td>3-6 years</td>
<td>No ossification begins to fuse</td>
</tr>
<tr>
<td>Palatine</td>
<td>Secondary synchondrotic centers appear at the top of the spinal process, superior and inferior synchondroses appear, upper synchondrosis center of odontoid fuses</td>
</tr>
<tr>
<td>26 years</td>
<td>Secondary synchondrotic centers at the tip of spinous processes fuse, superior and inferior synchondroses fuse in the axis</td>
</tr>
</tbody>
</table>

Os Odontoideum

- Normal variant-ossicle above a hypoplastic odontoid process
- Assoc. with:
  - Hypoplasia of post arch
  - Hypertrophy of ant arch
- Congenital-overgrowth of os terminale (small % could be post-trauma)

Two Types

Orthotopic Type

Moves with C1 anterior arch.

Dystopic Type

Moves with clivus.

Absent Pedicle

- Rare
- Anomaly assoc. w/ other deformities
  - Incomplete transverse foramen
  - Dorsal displacement of lateral mass
- Probably caused by delayed neural arch formation.
- DDx- neural tumor
Os Odontoideum

Conclusion

• There are many variations to the skeleton. **Reviewed a few of the 206 bones**
• Remember potential pitfalls, resist temptation to call something normal as abnormal and pathology as normal.
• Even normal variants can have clinical implications so don’t ignore them.