Skeletal Development in a Broiler Chicken Dietary Study: Histopathology Correlates of Clinical Findings

F.J. Hoerr, F.D. Wilson, S. Dougherty, C. Wyatt and T. York
### Bone Histopathology Surveys

<table>
<thead>
<tr>
<th>Pre &amp; Post – In Ovo</th>
<th>All Aspects of Processing and Holding</th>
<th>Transport &amp; Placement</th>
<th>Normal &amp; Lame Birds to ~7 days of age</th>
<th>Normal &amp; Lame Birds at 35 days of age</th>
</tr>
</thead>
</table>

- 10+ years ago, looked at lame birds at 6 weeks and followed traumatic lesions in bone back to the hatchery
- More recently started at ~2 weeks and worked deeper into hatchery
  - Then went intensively into hatchery
- Now, we start in the field at about 2 weeks, and go into the hatchery if needed
- The focus is microscopic lesions and all lesions are scored for severity
- Legs with obvious diagnosis at necropsy are scored but not processed for histopathology
Lessons Learned

• Between in-ovo processing and 7 days of age, trauma, developmental defects, and inflammation are established
  • Correlating to gait score increases, if not overt clinical lameness
• Production complexes have different patterns of skeletal disease
• Euthanasia creates acute skeletal hemorrhage that must be differentiated from acute trauma
  • Cervical dislocation and pentobarbital
• Ongoing assessment of growth plate of proximal femur and tibia, particularly the “cutback zone” that remodels diaphyseal bone for growth
  • Normal osteoclastic activity
  • Buckle or greenstick fractures
  • Understanding the development of avian “focal cortical defects” from greenstick fractures
• FCD occur in children, Males > Females
• Defining FCD in broilers and turkeys
• Microfractures
Embryonal cartilage (resorbed by 7 days of age)
Radiographic Differential Diagnosis of Skeletal Diseases of Young Dogs

Dalmatian, four months old, lateral radiograph of distal radius and ulna showing normal bone density and growth areas. (A) bone cortex, (B) diaphysis, (C) cut back zone, (D) metaphysis, (E) growth plate, and (F) epiphysis.

The diameter of the bone decreases at the cut back or remodeling zone when resorption of primary and secondary trabeculae occurs in the diaphysis.
Children, Males > Females

Normal Cutback Zone, Fibrous Cortical Defect & Non-Ossifying Fibroma

Normal Cutback Zone (few mm)  Fibrous Cortical Defect (< 1 cm)  Non-Ossifying Fibroma (> 1 cm)
Study Outline & Methods

• Broiler chickens, males, pen trial to 35 days of age
  • Clinically normal, gait score 0 (one bird score 1) no gross lesions
• Six dietary treatments, variable Ca and AvP
• Femurs and tibias examined (hips and stifles)
• Bones were collected and routinely processed with decalcification for histopathology
  • Proximal femur, sectioned through the center of the femoral head
  • Stifle joint: distal femur, joint structures, and proximal tibia, sectioned through the median plane, cranial to caudal
• Histologic lesions were identified and scored semiquantitatively for severity on a scale of 0 (normal) through 5 (severe)
• Histomorphometric evaluations were also done on the physis for the femur as ongoing background data collection
  • Measurement of the width of the zone of proliferation (hyperplasia)
  • Measurement of the width of the zone of maturation (hypertrophy) or embryonic cartilage zone
  • Calculation of the ratio of the maturation zone to proliferative zone
Fibrous components of the epiphyseal plate

Femur with no apparent gross defect. Arrow shows the typical location of "cut back zone"

Tibia with apparent gross defect (arrow)
Normal Femur
Microfractures or Focal Cortical Defects
• Expanded zone of osteoclastic activity and fibroplasia
• Disrupted boney spicules
• Raised or mild irregularity periosteal surface at cutback zone
• Variable hemorrhage
Microfractures or Focal Cortical Defects
Greenstick or buckle fractures
Traumatic disruption of periosteum

Microfracture
Fibrous Cortical Defects ↔ Microfractures

Lesion Scores

<table>
<thead>
<tr>
<th>Feed Group</th>
<th>Feat 1</th>
<th>Feat 2</th>
<th>Feat 3</th>
<th>Feat 4</th>
<th>Feat 5</th>
<th>Feat 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severy Score</td>
<td>0.0</td>
<td>0.5</td>
<td>1.0</td>
<td>1.5</td>
<td>2.0</td>
<td></td>
</tr>
</tbody>
</table>

Table Analyzed: Femur Score Fracture (Individual Data)

- Kruskal-Wallis test: 0.2493
- Exact or approximate P value?: Approximate
- P value summary: ns
- Do the medians vary signif. (P < 0.05)?: No
- Number of groups: 6
- Kruskal-Wallis statistic: 6.835

Incidence

<table>
<thead>
<tr>
<th>Feed Group</th>
<th>Feat 1</th>
<th>Feat 2</th>
<th>Feat 3</th>
<th>Feat 4</th>
<th>Feat 5</th>
<th>Feat 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Occurrence Fractures</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Table Analyzed: Femur % Fracture

- Kruskal-Wallis test: 0.0111
- Exact or approximate P value?: Approximate
- P value summary: *
- Do the medians vary signif. (P < 0.05)?: Yes
- Number of groups: 6
- Kruskal-Wallis statistic: 14.83
<table>
<thead>
<tr>
<th></th>
<th>Calcium (%)</th>
<th>Available Phos (%)</th>
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<tbody>
<tr>
<td></td>
<td>Starter 0-10d</td>
<td>Grower 11-24d</td>
</tr>
<tr>
<td>Global advice</td>
<td>0.96</td>
<td>0.87</td>
</tr>
<tr>
<td>Global advice + phytase (500 ftu)*</td>
<td>0.96</td>
<td>0.87</td>
</tr>
<tr>
<td>Marginal Av P control</td>
<td>0.88</td>
<td>0.79</td>
</tr>
<tr>
<td>Marginal Av P + phytase (500 ftu)*</td>
<td>0.88</td>
<td>0.79</td>
</tr>
<tr>
<td>Low Av P control</td>
<td>0.80</td>
<td>0.71</td>
</tr>
<tr>
<td>Low Av P + phytase (500 ftu)*</td>
<td>0.80</td>
<td>0.71</td>
</tr>
</tbody>
</table>
Figure 4

**Femur M/P Ratio**

![Bar graph showing Femur M/P Ratio for different feed groups.](image-url)
Summary

• Developmental and traumatic lesions occur in the proximal femur and tibia
  • *Microscopic* lesions in clinically normal and lame chickens (and turkeys)
• Site of remodeling of trabecular bone to cortical bone for long bone growth
  • Most common on medial aspect
• Resemble focal cortical defects associated with pain and lameness in children
• This site is susceptible to traumatic *folding* or *buckle* fractures – all microscopic
• The lesion severity and incidence *can be* influenced by nutrition
  • Preliminary evidence points to available phosphorus
  • Lesions occur in the absence of rickets
Possible implications for conformation, gait and lameness
Acknowledgements

- Marty Hoerr
- Mary Ford and Staff, Alabama Pathology Associates