

Embryonic periosteum is relaxed

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Embryonic periosteum is relaxed

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Bone & Orthopedic Biomechanics

Introduction

- Inappropriate loading of the immature skeleton is associated with the development of severe growth-related skeletal deformities (scoliosis & Blount's disease) [1]. Longitudinal growth of long bones occurs through the expansion of cartilage, and can be up to 25%/day [2]. As a result, the surrounding fibrous periosteum (PO) is strained to 15% in 4 - 14 weeks old chicks [3] and 50% in chick embryos [4]. This straining is thought to mechanically restrict bone growth through compression of growing cartilage [5].

Aims

- To assess PO force at *in vivo* length and at failure of day 15 - 17 embryonic chicks.
- To determine stresses in chick embryo cartilage, induced by straining of the PO during growth.

Materials & Methods

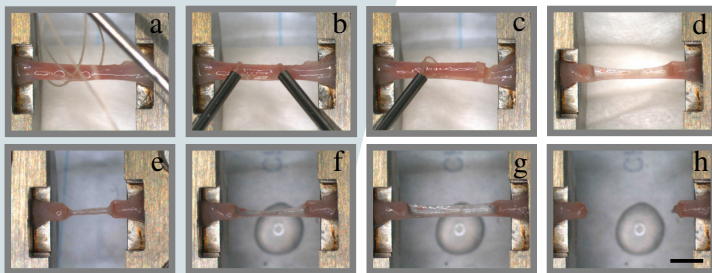


Fig 1a-h. Tibiotarsi from e15 - e17 chicks are fixed in a Enduratec tensile tester. Suture wires, placed between bone and PO (a & b), are used to cut the proximal and distal metaphyseal cartilage (c). Bone tissue is removed with PO held at *in vivo* length (d). Force is measured while PO is shortened from *in vivo* length to -15% strain (e) and then strained at 0.1 %/s to failure (f - h). Scale bar 5 mm.

Results

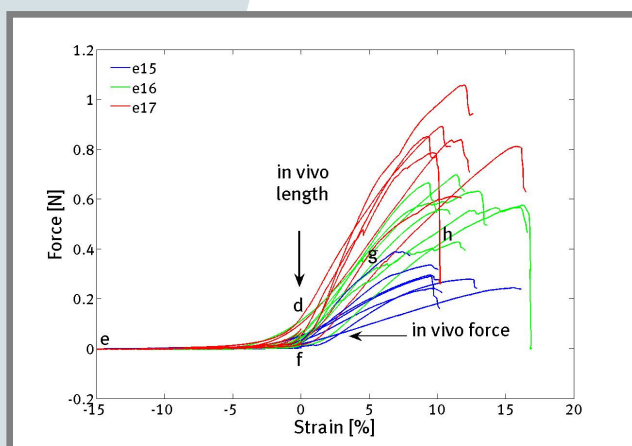


Fig 2. Force-strain curves of e15 - e17 PO. Indices e - h correspond to fig 1e - h.

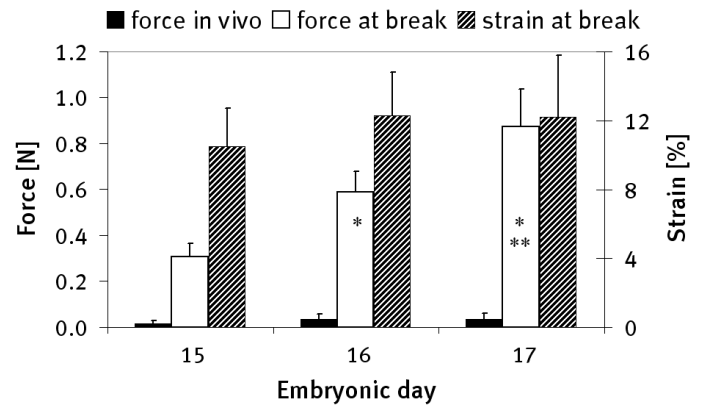


Figure 3: Results of PO tensile tests. * compared to day 15 ($p < 0.01$); ** compared to day 16 ($p < 0.01$). $n=7$

- Force at break significantly increases with age.
- *In vivo* force and failure strain are age independent.

Discussion

- The strong development of PO within a 24-hour time period is shown by the increase in force at break.
- Strain in PO at *in vivo* length is in the toe-region of the force-strain curve (Fig 2). At this length, collagen fibers are straight (fig 3a).
- After dissection, PO contracts to 70% of the original length (fig 3c) and collagen is curled (fig 3b).

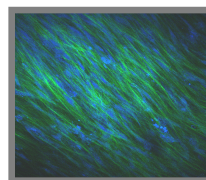


Fig 3a: Collagen network in PO at *in vivo* length.

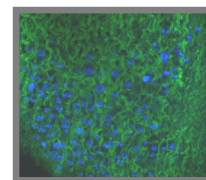


Fig 3b: Collagen network in PO after dissection.

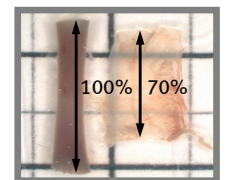


Fig 3c: Bone (left); dissected PO, 70% contracted (right)

Conclusion

- At *in vivo* length, PO is marginally loaded but collagen fibers are straightened (fig 2 & 3a).
- PO strength increases with age, *in vivo* force and failure strain are age independent.
- From the low *in vivo* PO load, the rapid bone growth, and the increasing PO strength with age, it is concluded that PO is a quickly remodeling tissue.

Future work

- Calculate the stress distribution imposed on the cartilage using finite element analysis.

References

- [1] Stokes *et al*, Bone 2007 [2] Foolen *et al*, JOR 2007 [3] Bertram *et al*, Bone 1998 [4] Chen *et al*, 53rd ORS meeting 2007 [5] Crilly, J Anat 1972.