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

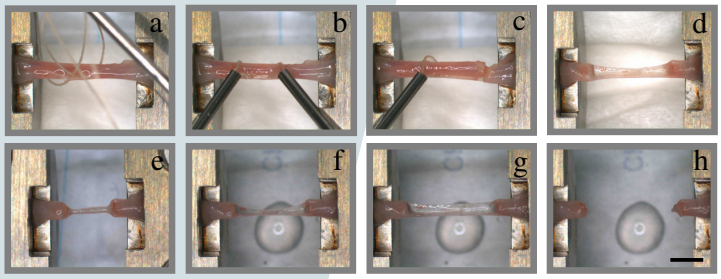

Fig 1a-h. *Tibiotarsi from e15 - e17 chicks are fixed in a Enduratec tensile tester. Suture wires, placed between bone and PO (a & b), are used to cut the proximal and distal metaphyseal cartilage (c). Bone tissue is removed with PO held at in vivo length (d). Force is measured while PO is shortened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

Results

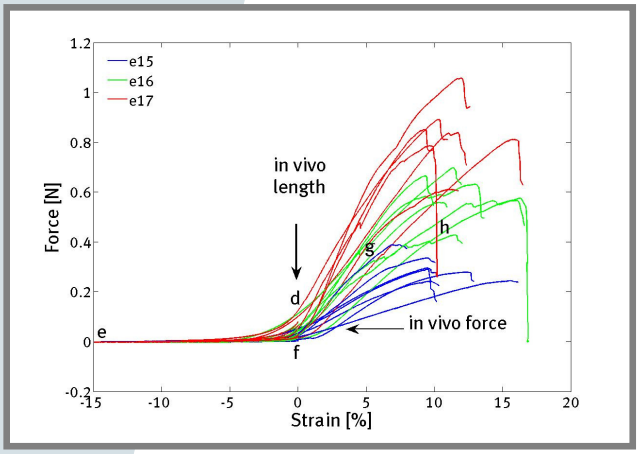

Fig 2. *Force-strain curves of e15 - e17 PO. Indices e - h correspond to fig 1e - h.*

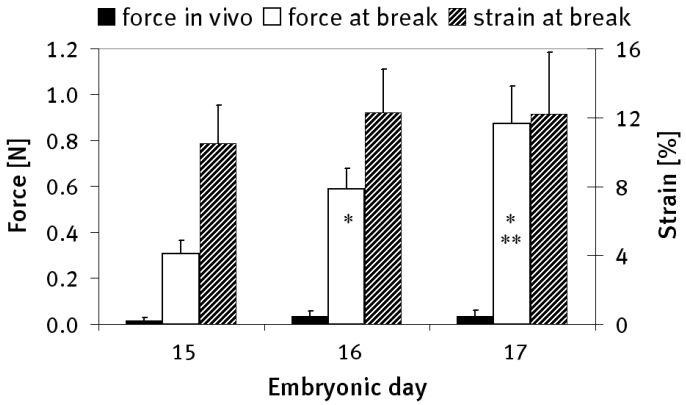

Figure 3: *Results of PO tensile tests. * compared to day 15 ($p < 0.01$); ** compared to day 16 ($p < 0.01$). n=7*

- 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).

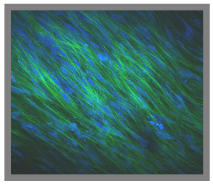

Fig 3a: *Collagen network in PO at in vivo length.*

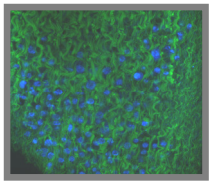

Fig 3b: *Collagen network in PO after dissection.*

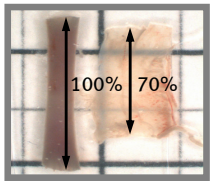

Fig 3c: *Bone (left); dissected PO, 70% contracted (right)*

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.