A NEW ANIMAL MODEL OF FEMORAL HEAD OSTEONECROSIS, ONE THAT PROGRESSES TO HUMAN-LIKE BONY MECHANICAL FAILURE

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INTRODUCTION

Orthopaedic management of femoral head osteonecrosis (ON) remains a major surgical challenge, since most cases progress inexorably to mechanical collapse of weight-bearing cancellous bone [1]. Total hip replacement has an alarmingly high rate of late prosthesis loosening in this generally young and active patient group. Various head-preserving surgical procedures have been advocated, but remain controversial, owing substantially to the lack of controlled prospective clinical trials. Several existing animal models (sheep, pygmy goats, horses, rabbits, rats, piglets, mature miniature swine, and various canine breeds) reasonably replicate the pathogenesis of early ischemic bone repair [2]. But, none of these animal models progresses to the all-important end stage of frank mechanical collapse for which orthopaedic intervention is required in humans. We reasoned that a key limitation of existing animal osteonecrosis models, all of which are in quadrupeds and therefore capable of limited or non-weightbearing, might be their relatively undemanding biomechanical environment, as compared to the situation prevailing in the human hip. We hypothesized that an active bipedal animal model might therefore achieve bony collapse. We here report development of such a model: surgically induced femoral head osteonecrosis in the emu (dromaius novaehollandiae), a flightless, ostrich-like bird native to Australia.

PROCEDURES

Since the emu is a little-studied species, a pilot series (19 birds) was first necessary to document the bony and vascular anatomy, to develop reliable anesthesia and recovery protocols, to explore the feasibility of alternative surgical approaches, and to document the efficacy of various insults in achieving focal bony ischemia. The procedure which evolved was to first sedate with Telazol® (7.5 mg/kg, IM) and xylazine (7.5 mg/kg, IM). Sedation was delivered by via blowpipe, since the birds were hazardous to handle when alert. Induction to anesthesia was performed with diazepam (1 mg/kg, IV). Following intubation, anesthesia was maintained with isoflurane in oxygen, and perioperative antibiotics (Cefazolin, 25mg/kg, IV) were started. The surgical procedure required approximately one hour, working through a ventral approach. Using careful blunt and sharp dissection, the iliacus muscle was reflected to expose the antero-medial aspect of the hip joint capsule. The capsule was incised, and a periosteal elevator was used to ablate all accessible capsular attachment to the neck. The medial circumflex femoral artery and vein (all major branches) were ligated with hemoclips. A 4.5mm serrated-tip drill guide was then used to access the infero-medial aspect of the head through a large, serendipitously located transcortical foramen. An approximately 20-second stream of pressurized liquid nitrogen was then delivered through this portal into the metaphyseal and epiphyseal cancellous bone, followed by a saline flush in order to thaw the frozen, visibly whitened bony bed.
Three repetitions of this internal freeze/thaw cycle were performed, interspersed with three episodes of delivering 20-second liquid nitrogen streams extracortically to the femoral head/neck junction. The foramen was then sealed with bone wax.

RESULTS AND DISCUSSION

Most animals were able to ambulate within 1 to 2 hours after recovery. After 2 weeks of postoperative stall confinement, they were moved to a free-roaming fenced outdoor enclosure. Both in postoperative confinement and especially in their outdoor enclosures, the birds were impressively active. No animals were lost from infection. In 16 subsequent survival birds, onset of lameness in the operated limb occurred at 11 to 16 weeks postoperatively in 13 birds, and at 21 weeks in a 14th. At necropsy, trabecular collapse and fracture were grossly evident throughout the freeze-killed region. Histologically (Fig. 1), normal marrow (NM) was replaced by fibrotic marrow (FM), with many trabeculae showing intense osteoclastic activity (scalloping), culminating in resorption and microfracture (R/Fx). On higher magnification (lower panels), empty lacunae (EL) are seen instead of the osteocyte-filled lacunae (OFL) normally present.

SUMMARY

The observed functional impairment and histological changes strongly support the hypothesized progression to collapse in this novel bipedal model of osteonecrosis. This success opens the way for systematic investigation of surgical interventions advocated to arrest collapse in human ON.

REFERENCES
