BONE BLOOD FLOW IN RESPONSE TO SURGICAL TRAUMA

INTRODUCTION
The pathogenesis of implant induced osteopaenia remains controversial with impairment of vascular outflow, redistribution of mechanical forces (stress protection) or a combination thereof all implicated.

Using strontium labeled microspheres, blood flow has been measured in both intact and osteotomized canine tibiae into which various fixation devices had been implanted. Common levels of structural changes were observed in all forms of fixation methods (plating, external fixation and intramedullary nails) in the face of differing levels of blood flow. A later study reported that increased blood flow observed in the early post-operative period was due to the trauma of drilling holes. The development of implant induced osteopaenia, it was concluded, showed a regional orientation as evidenced by the different histomorphometric appearance of bone following implant fixation.

The research presented involves an evaluation of the effect of surgical trauma (drilling and tapping screw holes) on the relative flow and distribution of blood through diaphyseal bone. This was accomplished using dynamic acquisition of radionuclide angiographic images and static images of Disulphine blue distribution in intact sheep tibiae.

MATERIALS AND METHODS
Five mature female Border Leicester sheep were used. A catheter was positioned in the aorta distal to the renal arteries and proximal to the bifurcation of the femoral arteries to allow radionuclide and intravascular dye administration. The hypothesis tested was that surgical intervention does not result in changes to blood flow or distribution in the immediate post-intervention period (30 minutes).

Unlike radiolabelled microspheres or intravascular dyes, the use of radionuclide angiography is repeatable, non-invasive and inexpensive. The principle that blood flow is proportional to the area under a first pass curve has been refined to measure relative flow and distribution of blood through diaphyseal bone. This was accomplished using dynamic acquisition of radionuclide angiographic images and static images of Disulphine blue distribution in intact sheep tibiae.

Blood flow in bone varies according to region whilst changes in blood flow produced by physical events do not display uniformity throughout the bone; regional changes are manifest and are most apparent in areas immediately adjacent to the traumatized bone. This was certainly the appearance in tibiae perfused with Disulphine blue following the surgical trauma of drilling and tapping screw holes. A ‘segmental ischaemia’ was observed in these bones, most apparent in the region immediately adjacent to the drilled screw hole. It appears that bones immediate response to surgical trauma is a reduction in blood perfusion, certainly in the areas surrounding the screw holes. The segmental ischaemia was observed in the absence of bone plates nor where there screws inserted.

The segmental ischaemia apparent in the Disulphine blue perfused tibiae, following the drilling and tapping of screw holes, is supported qualitatively and quantitatively by the radionuclide angiographic images obtained. Qualitatively, a similar pattern of segmental ischaemia was observed in the images obtained for all tibiae. ‘Gaps’ appeared in the angiographic images which were directly related to the location of drilled and tapped screw holes. When the gap regions were quantitated in a comparison with the immediately proximal and perfused region, it was confirmed (p<0.005) that the region of each screw hole had a relative rate of blood flow less than that in bone immediately proximal which had not undergone direct trauma.

Interestingly, quantitative assessment of the relative rate of blood flow through the distal femoral/proximal tibial region reference organ (p<0.0306) and the entire operative tibia (p<0.0099) showed significantly higher rates of blood flow than the non-operative contralateral control. This apparent overall increase in the rate of blood flow in the operative tibiae compliments the findings of Daum and Simmons.

We have shown that a substantial ischaemic event occurs in the acute period (30 minutes) directly after the drilling and tapping of screw holes. The segmental ischaemia observed has developed in the total absence of bone plates. Moreover, the inconsistencies cited earlier, which have confused the development of a clear picture of the pathogenesis of implant induced osteopaenia, may have some relationship with our findings described above and the regional acceleratory phenomenon of Frost.

DISCUSSION
Blood flow in bone varies according to region whilst changes in blood flow produced by physical events do not display uniformity throughout the bone; regional changes are manifest and are most apparent in areas immediately adjacent to the traumatized bone. This was certainly the appearance in tibiae perfused with Disulphine blue following the surgical trauma of drilling and tapping screw holes. A ‘segmental ischaemia’ was observed in these bones, most apparent in the region immediately adjacent to the drilled screw hole. It appears that bones immediate response to surgical trauma is a reduction in blood perfusion, certainly in the areas surrounding the screw holes. The segmental ischaemia was observed in the absence of bone plates nor where there screws inserted.

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The values of relative blood flow for operative and non-operative tibia over all five individuals were compared using a paired t-test. A probability of p < 0.05 was considered significant.