

A comprehensive evaluation of a new technology for intramedullary bone graft harvesting: an *in vivo* study

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INTRODUCTION: A new concept for staged harvesting of intramedullary bone graft (Figure 1) with an innovative aspiration device (test group) consisting of the possibility to harvest bone marrow first (first procedure: aspirator) followed by the so-called reaming-aspiration method (R-A method) with iterative reaming with standard intramedullary reamers and aspiration of the morselized endosteal bone chips (second procedure: R-A method) is presented. This study investigated whether this new approach is non-inferior to the Reamer-Irrigator-Aspirator (RIA) 2 system (control group) in terms of harvesting capacity, perioperative complications and osteoinductive capacity of the bone graft.

METHODS: Bone graft was harvested *in vivo* from intact femora of 16 Merino sheep using either the RIA 2 system (n = 8) or the new harvesting concept (n = 8) and bone graft weight was determined. Perioperatively, the effects of bone marrow fat embolism were monitored. For this purpose, fat intravasation was quantified by GURD tests, the coagulopathic response was evaluated with D-dimer blood level concentration and pulmonary fat embolism was evaluated by histological evaluation of the lung tissue. The osteogenic capacity of the bone graft was determined on the one hand *in vitro* by measuring the concentrations of growth factors and inflammatory cytokines relevant for osteogenesis using ELISA (enzyme-linked immunosorbent assay) methods. On the other hand, the direct subcutaneous implantation of the freshly harvested bone graft under sterile conditions in sheep, which was also placed in biodegradable 3D-printed scaffolds, was carried out in an ectopic model in partially immunocompromised rats (n = 2). Ethical approval for this study was obtained from the Queensland University of Technology Animal Ethics Committee (Ethics Approval Number 200000593).

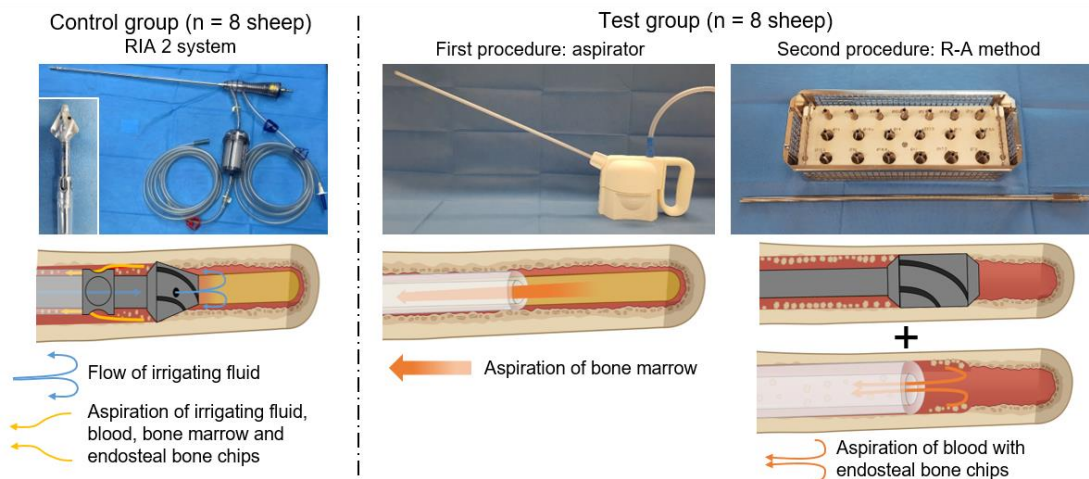
RESULTS SECTION: A similar amount of bone graft was obtained with the aspirator alone (bone marrow collection) in combination with the R-A method (collection of endosteal bone chips) as with the RIA 2 system. The harvested bone graft contained detectable concentrations of growth factors and cytokines in both groups. The GURD test did not detect a difference in the total number and mean size of intravasated fat particles ($p = 0.13$ and $p = 0.98$, respectively). The effects on D-dimer concentrations and the extent of fat emboli in lung tissue did not differ between groups ($p = 0.65$ and $p = 0.17$, respectively). In the *in vivo* rat model, the formation of new (bone) tissue was promoted by the xenografted bone graft of both groups.

DISCUSSION: The prototype aspirator, which does not require irrigation fluid during use and can be used for isolated bone marrow harvesting as well as the R-A method, demonstrated both similar harvesting capacity and similarly low rate of fat embolism complications compared to the RIA 2 system. Furthermore, the bone graft harvested by the innovative intramedullary harvesting technology was not shown to be inferior to the RIA 2 system in terms of bone regeneration capacity in *in vitro* and *in vivo* testing.

SIGNIFICANCE/CLINICAL RELEVANCE: With the comprehensive *in vitro* and *in vivo* testing of the prototype aspirator, which does not require additional irrigation fluid compared to the RIA 2 system and has shown an equally good harvesting capacity and osteogenic capacity as well as low perioperative complications, we have paved the way for the further development of a promising innovative and affordable alternative technology for the harvesting of intramedullary bone marrow and bone chips.

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IMAGE: Figure 1. Depiction of the RIA 2 system for harvesting intramedullary bone graft (mixture of bone marrow and bone chips) and the novel aspirator prototype for bone marrow harvesting as well as for the R-A method (harvesting bone chips). Image adapted from Laubach *et al.* (2023). Partially created with BioRender.com.



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