EFFECT OF GAMMA IRRADIATION ON THE MECHANICAL PROPERTIES OF MORSELISED ALLOGRAFT

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INTRODUCTION:
Impaction grafting is a common procedure in the reconstruction of cavity defects. Concerns regarding sterility of the graft material may require gamma irradiation prior to implantation. The grafts’ mechanical properties play an important role in surgical handling and in-vivo response. Gamma irradiation adversely affects the mechanical properties in a dose dependent fashion in cortical bone from human femurs [1] as well as in cylindrical specimens of porcine cancellous bone [2]. However, Zhang et al., [3] reported no effect of gamma irradiation on the mechanical properties of iliac crest wedges. Bavadekar et al., [4] using morselised femoral head allografts reported the presence of cartilage remnants decreased the stiffness, while the inclusion of cortical bone from the femoral neck did not affect the impaction and stiffness. The effect of gamma irradiation on the mechanical properties of morselised allograft has not been well studied. The effect of gamma irradiation dose on the stiffness and compaction of morselised bone grafts from the femoral heads of human donors was examined in this experiment.

METHODS:
Twelve femoral heads (mean age 68 years old; range 39-92 years old) were morselised by the Queensland Bone Bank using a Tracer Bone Mill. Care was taken not to include any articular cartilage in the preparation. Bone from each femoral head was allocated to 3 groups: Control (no irradiation), 15 or 25 kGy. All samples were stored at -20°C prior to mechanical testing. Samples were tested in a blinded fashion using an aluminium testing apparatus that allowed expulsion of any fluids during impaction [4]. Loading was performed in 0.5mm stages at 1mm/min up to 12mm (Figure 1) using an MTS 858 Bionix Testing machine (MTS Corporation, MN). A relaxation period of 30 seconds between each compaction was allowed. The stiffness for each compaction level was determined at the densification portion of loading for all samples. The load versus displacement data was reduced to stress versus strain for the final compaction. The compressive force was normalised by dividing the maximum force at each step with the initial linear portion as well as in the densification region. The compressive force was increased with increasing compaction for all samples. The 25 kGy treatment resulted in the highest stiffness compared to other groups in the mechanical properties of intact specimens of cortical [1] or cancellous bone [2, 3] may not necessarily translate to morselised allograft specimens. No mechanical differences were found in the current study on the compressive properties of control, 15 or 25 kGy treated morselised femoral head samples. The compressive stiffness and modulus continued to increase even after 12 mm of impaction. The results of this study agree with the data from Bavadekar et al., [4] using a similar testing setup. Gamma irradiation did not significantly alter the compressive properties of morselised human femoral heads. However, the power of the study is low (0.43) even with a sample size of n=12 per group. While the mechanical properties of bone are known to decrease with age, no relationship with age was found with respect to the properties of morselised allograft. The in-vivo effects of gamma irradiation and morselised allograft are beyond the scope of this study but are another important variable to consider.

RESULTS:
The force versus displacement curves was typical for porous materials with an initial linear region followed by a collapse and finally densification. The irradiated groups demonstrated a more non-linear response compared to the controls during loading. Stiffness (N/mm) increased with increasing compaction for all samples. The 25 kGy treatment resulted in the highest stiffness compared to other groups in the initial linear portion as well as in the densification region. Normalizing the force data, by dividing the maximum force at each step with the maximum force for all steps, revealed similar responses for the controls, 15 kGy and 25 kGy samples (Figure 2). Figure 3 presents the elastic modulus of the final compaction for each femoral head sample in control, 15 and 25 kGy groups. No statistical differences were noted in the compressive properties with gamma irradiation of the morselised femoral heads. Specimen age did not correlate with the mechanical properties of the morselised allograft.

REFERENCES:

Queensland Bone Bank, Holy Spirit Hospital, Brisbane, QLD Australia.