IRRADIATION DOES NOT INFLUENCE INCORPORATION OF IMPACTED MORSELIZED BONE

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Introduction:
In revision surgery bone defects can be filled with impacted bone grafts. The use of graft material carries a potential but well-established risk of disease transmission. Gamma irradiation of the graft material is gaining more popularity for prevention of disease transmission. Due to changes in mechanical properties of bone by gamma irradiation, it has been used with some caution in clinical practice. Irradiated bone is known to be less strong, less stiff and significantly more brittle than fresh frozen controls when tested in compression models. Recently, it was shown that irradiated freeze-dried impacted grafts provide a more stable femoral reconstruction than fresh-frozen grafts, when tested in a hip simulator [1]. However, the higher compactness caused by impaction of irradiated bone may reduce the speed of remodeling.

Of major concern is the biological performance of irradiated bone used in impaction grafting. Formation of free radicals during sterilization of bone grafts using gamma irradiation might have a detrimental effect on the osteoinductive activity of BMPs. Therefore, we performed a bone chamber study with impacted morselized processed and non-processed allografts. We studied the effects of irradiation on the incorporation of impacted morselized allografts.

Methods:
Cancellous allografts were obtained from the sternum of six donor goats. One third of the grafts were not processed. From the remaining two thirds, blood and marrow were removed macroscopically, by rinsing the grafts with saline for approximately one minute, leaving only a white bone structure. Rinsing was done using a high-pressure pulsatile lavage system (SurgiLav® Plus, Stryker). Grafts were in a sieve during rinsing. Half of the rinsed cancellous allografts were irradiated (gamma irradiation) with a minimal dose of 25Gy (2.5MRad). Irradiation was carried out at a temperature of 4°C by a commercial facility (Isotron B.V., Ede, The Netherlands NL) using a 60Co gamma-ray source.

We used a modified model of the bone conduction chamber (BCC) which is a model for membranous ossification [3] [Fig. 1]. This model consists of a titanium screw with a cylindrical interior space. It is made up of two threaded half cylinders held together by a closed screw cap. The chamber has four openings allowing bone and tissue ingrowth.

Impaction was performed by gradually filling the chamber followed by impaction of the material by a constant force of 40N for 2 minutes. The applied pressure was calculated to be 12.5MPa.

We tested four groups, empty (EMP), allograft (ALL), rinsed allograft (RIN) and both rinsed and irradiated allograft (IRR).

Twelve goats were operated under general anesthesia. Each goat received four implants. The chambers were placed in the tibia of the goat, two chambers per tibia [Fig. 2].

The implantation position of the four chambers was randomized. After 12 weeks the goats were killed and the content was carefully removed from the chambers. Each specimen was embedded in PMMA and 5µm sections were made. In order to get a tissue and bone penetration distance, the area of the total tissue and the ingrown bone were divided by the width of the specimen, to yield the mean ingrow distance [4]. The mean of the three sections at 0, 300 and 600 µm from the center yields a value for each specimen.

Furthermore, BCT-scan was made from chamber content in order to compare BV/TV of the remnants. Statistical analysis was performed using One Way Repeated Measurements ANOVA and Tukey post hoc tests.

Results:
Histologic examination of the specimens revealed cancellous bone in all chambers. Distally, a zone containing vascularized fibrous tissue was observed, followed by a zone with woven-fibered bone more proximally. No difference in osteoclastic resorption between the tested group could be found. New bone was formed by intramembranous ossification, growing upwards to the top of the chamber. If the resorption of the graft remnant was not complete, new bone was apposed on these remnants.

No difference in amount of fibrous tissue ingrowth between the ALL, RIN and IRR groups was found. Bone ingrowth was lowest in the non-processed group (ALL), but only significantly lower compared with the empty chambers (EMP) [Fig. 3]. In the non-processed group significantly more graft remnant was found. No difference in amount of remnant between rinsed (RIN) and both rinsed and irradiated. From our BCT-data a higher, but not significantly higher, compactness of the remnant was found in the both rinsed and irradiated group compared with the other groups.

Discussion:
In the present paper, we studied whether there is a difference in incorporation and remodelling between non-processed, rinsed and both rinsed and irradiated bone. Possible harmful effects of irradiation procedure on the osteoinductive/conductive properties of the graft could not be found. Non-processed bone showed, although not significantly, less bone ingrowth, whereas, significantly more graft remnants were found in this group. No difference between rinsed and both rinsed and irradiated bone ingrowth was found. Similarly, comparing fresh-frozen bone and irradiated bone in bone impaction grafting of the acetabulum, no difference in clinical performance after 6 and 13 months was found, using radiologic criteria to determine allograft incorporation and remodeling [5]. The increase in compactness, as measured with µCT, of the irradiated bone did not seem to influence the incorporation of the grafts. We conclude that sterilization with gamma irradiation does not influence the incorporation of impacted bone allografts, and that gamma irradiation can be used for sterilization of bone grafts for clinical purposes.

References:

52nd Annual Meeting of the Orthopaedic Research Society
Paper No: 1741