SURGICAL IMPACTION DAMAGES OSTEOCHONDRAL GRAFTS: A CONTROLLED LABORATORY STUDY OF THE BIOLOGIC EFFECTS OF REPEATED AND VARYING LOADS ON OSTEOCHONDRAL GRAFTS

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INTRODUCTION:
Osteochondral autograft or allograft transplantation procedures have garnered significant attention because of their ability to replace the lesion with true hyaline cartilage and allow for a relatively short recovery period. However, surgical impactation of the osteochondral plug to anchor it into the defect site can be traumatic and subsequently lead to cell death and cartilage degeneration. We studied these effects in a controlled laboratory setting and hypothesized that increasing load magnitude has deleterious effects on cell viability, sulfate uptake, and histological appearance.

METHODS:
Phase 1: To determine the necessary impulse for successful anchorage in the clinical situation, 23 articular cartilage samples were taken from 6 fresh bovine trochleas. 8 mm diameter plugs were removed and surgical hammer. The impaction profile was recorded and the impulse was calculated.

Phase 2: Using a pneumatic impaction device, consistent loads and loading rates were delivered to trochlear plugs that were held in unconfined compression. The loads chosen were 37.5 N (0.75 MPa), 75 N (1.49 MPa), 150 N (2.98 MPa), and 300 N (5.97 MPa). The number of impactions at each load was adjusted to keep the impulse constant. Not impacted plugs served as control. Biologic assays included cell viability (Live/Dead Cytotoxicity Kit, Molecular Probes) detected with a confocal microscope, sulfate uptake (a measure of cartilage metabolism), and histology. Cell viability was performed on days 0, 4, and 8; while the other endpoints occurred on days 4 and 8. Statistical analyses were based on Mann-Whitney pairwise comparisons. Significance was set at p < 0.05. Grubbs’ test was used to identify outliers using a 90% confidence. We targeted 10 samples for each load and day group.

RESULTS:
Phase 1: The impulse was 6.98 ± 5.10 Ns to insert a single plug. During insertion the impaction loads ranged from 49 N to 154 N. Based on the determined impulse, the number of hits for each of the above load levels was 74 (37.5 N), 37 (75 N), 21 (150 N), and 11 (300 N).

Phase 2, Cell Viability: For all days, the percent of live cells decreased with increasing load. Compared to control, all of the loaded plugs showed significantly fewer percentages of live cells (p<0.05). (Figure 1)

Zonal variation in cell viability with or without load was apparent in our study. Zones were determined by dividing the cartilage into quartiles starting with Zone 1 (superficial) down to Zone 4 (deep). Generally, we found a load dependent depth of cell viability loss. (Figure 2)

DISCUSSION:
We have found that the resulting cell viability and histologic appearance of osteochondral grafts is indeed dependent on the load magnitudes, whereas sulfate uptake is not. Limitations included not measuring strain, not studying allograft sized samples, and conducting an in vitro rather than an in vivo study.

Ultimately, it is our goal to determine the ideal loading parameters to surgically impact osteochondral grafts. As we have found larger drops in cell viability with higher loads, we recommend using the lowest load magnitude possible to insert the osteochondral grafts. The initial findings of our study along with future studies may help refine the surgeon’s approach to impacting the grafts. There is also potential for the development of a surgical tool that can deliver impaction loads at pre-set parameters.

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