Impact Cartilage Injury in a Rabbit Model

INTRODUCTION:
Impact injury to cartilage, a common consequence of joint trauma, is commonly thought to lead to degenerative osteoarthritis. One recent review of 31,516 knee arthroscopies found a 63% incidence of cartilage lesions, with 20% being grade IV lesions. While many treatments currently exist for end-stage cartilage lesions, the results are marginal at best. As a result, there has been increasing interest in preventing traumatic injuries from developing into lesions. Prior to testing of these measures in human clinical trials, they must first demonstrate success in animal studies. For this to be possible, a model for cartilage injury in an animal model must be developed.

Several models for cartilage injury have been developed previously, including direct gouging of cartilage, joint immobilization, sectioning of the anterior cruciate ligament and external impact across the joint. While all of these models are able to create cartilage injury, most have the disadvantage of being unable to control the size or location of the lesion or to not be reflective of in vivo injury mechanisms. The direct impact model involves directly injuring the cartilage with an impactor, either with the use of a pendulum or from a drop tower. This technique has the distinct advantage of allowing control of not only the location and size of the lesion but also allows modification of the stress and stress rate applied. While other authors have successfully created cartilage lesions using a direct impact approach, none have previously controlled for the rate of impact. Controlling the rate of impact may have a great effect in cartilage injury, as several authors have shown increase fissuring and reactive bone changes of the underlying cartilage at higher rates.

The purpose of the current study is to develop a cartilage injury model that is reproducible, consistent, and allows for control of not only the peak pressure delivered but also allows for control of the rate of impact. Our hypothesis was that our method will be a consistent method for creating reproducible cartilage lesions.

METHODS:
A pendulum style impactor device was manufactured based upon the impactor design of Borelli et al. to create the energy necessary for impact. Force data was acquired from a load cell at 5000 Hz (Sensotec, Columbus, OH). This data was used to calculate time to peak, peak pressure, pressure rate, and impulse. Previous experiments from our laboratory have shown in both analogue and cadaveric specimens that our device is capable of delivering a consistent and controllable pressure at a defined pressure loading rate.

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After sacrifice, the medial femoral condyle of each rabbit was harvested and the area of damage was stained using India ink. Histologic sections were obtained through the area of damage and stained with hematoxylin and eosin (H&E) and Safranin-O. Histological analysis was performed by 4 blinded observers using two validated scoring systems (Modified Mankin Score and the ICRS visual histological assessment scale). Inter- and intraobserver reliability were obtained using raw measures of reliability. Differences between histological scores were determined with two-sample student-t-tests.

RESULTS:
Our histology was evaluated by four blinded observers, using two scoring systems, the ICRS visual histological assessment score and the modified Mankin score. The results of the ICRS score are shown in Figure 1. There was a significant difference (p<0.001) between the control and impact specimens only in the surface and cell distribution scores. There was a statistically significant difference between the modified Mankin score of 1.216 ± 2.067 (mean ± SD) for the control group and 3.45 ± 2.81 for the impact group (p = 0.001). There was no significant difference in inter- or intra-observer reliability amongst any of the observers.

DISCUSSION:
The current model provides a reproducible method for creating cartilage defects, while at the same time controlling the peak pressure at the time of impact as well as the rate of impact. We were able to create visible changes that were quantifiable as assessed by 4 blinded observers using 2 validated scoring systems. The importance of controlling the rate of impact has been demonstrated by several studies which have shown that at higher rates of impact, significant damage was imparted at to the cartilage including fissuring as well as increased reactive bone changes.

To our knowledge, this is the first cartilage impact model that controls not only the peak pressure but also the rate of impact.

REFERENCES:

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