MONOPOLAR AND BIPOLAR RADIOFREQUENCY TREATMENT OF HUMAN OSTEOARTHRITIC CARTILAGE HAS IMMEDIATE AND DELAYED EFFECTS ON CELL SYNTHESIS AND MATRIX INTEGRITY

+*Cook J L; *Kuroki K; * Kenter K; **Marberry K; *Brawner T; *Geiger T; *Jayabalan P; **Bal B S
+*Comparative Orthopaedic Laboratory, University of Missouri, Columbia, MO

Introduction: Arthroscopically delivered radiofrequency (RF)-generated heat has been used extensively for treatment of fibrillated articular cartilage. RF-treatment is an attractive surgical option because it allows the surgeon to re-create a “smooth” articular surface, and has been reported to allow patients to achieve full range of motion and return to work earlier than patients treated with abrasion arthroplasty. However, no data have been published regarding clinical efficacy, patient satisfaction, disease progression, or long-term effects of RF treatment of osteoarthritic articular cartilage. RF energy can be delivered via monopolar or bipolar devices. Monopolar delivery has the advantages of avoiding heating of the probe itself and the ability to monitor the delivered temperature, while bipolar delivery can achieve the same desired tissue effect using less current than monopolar devices. In vivo data suggest that both monopolar and bipolar RF energy results in immediate chondrocyte death in areas of treated cartilage. To the authors’ knowledge, no studies regarding the temporal effects of RF energy on human osteoarthritic articular cartilage extracellular matrix integrity and function have been reported. Therefore, the purpose of this study was to determine the temporal effects of monopolar and bipolar RF-energy on articular cartilage extracellular matrix using human osteoarthritic articular cartilage.

Methods: All procedures were approved by the Institutional Review Board. After informed patient consent, osteoarthritic femoral articular cartilage was retrieved during total knee replacements (n=30). Eight-millimeter diameter templates (n=150) were created on the surface of the articular cartilage. Each template was given an OA severity grade using the Outerbridge system (grades I-V). The templates were randomly assigned to monopolar RF, bipolar RF, or control groups. Pre-treatment compressive stiffness of each template was measured using a cartilage stiffness testing device (ArtScan 1000). The articular cartilage was immersed in saline maintained at room temperature. RF energy was applied to all templates in the monopolar RF group in a contact mode at a setting of 15 or 30 Watts (using a commercially available generator (ORATEC Vulcan)). RF energy was applied to all templates in the bipolar RF group in a non-contact mode (0.5 mm offset) at a setting of 30 W using a commercially available generator (Mitek VAPR). Group controls received sham treatment (same as RF treatment without the generators being activated). Treatment was standardized by using a computer-driven milling machine to move the probe over the entire cartilage template at a rate of 1 mm/sec. Post-treatment stiffness was measured on the subchondral bone, and again after removal from the bone. The templates were cultured as explants in RPMI 1640 media with 10% fetal bovine serum in 24-well tissue culture plates at 37 °C. At the predetermined harvest time (0, 1, 10, 20, or 30 days after treatment), the explant and the liquid media were retrieved, and compressive stiffness of each explant was measured. After harvest, explants were assessed for matrix and cell morphology, permeability, water content, glycosaminoglycan (GAG) content, collagen content, and matrix metalloproteinase-13 (MMP-13) immunoreactivity. Liquid media samples were assayed for GAG content, collagen content, MMP-13, nitric oxide (NO), and interleukin-1 (IL-1) concentrations. Data from each group were pooled and means±SEM determined. Statistical analyses (ANOVA, t-test) were performed using computer software program (Sigma Stat). Significance was set at p < 0.05.

Results: Cartilage in grades I and IV was significantly (p<0.001) stiffer than cartilage in grades II and III (Fig. 1). There was not a significant difference in pre-treatment compressive stiffness values among groups, nor in immediate post-treatment compressive stiffness values between RF-treated cartilage and controls. There was a significant (p<0.0001), positive (r=0.56) correlation between compressive stiffness values measured on and off the subchondral bone for all samples. There were no significant differences within or between groups for compressive stiffness values measured over time. Radiofrequency thermal chondroplasty using monopolar and bipolar devices at low-wattage settings resulted in visual “smoothing” of fibrillated articular surfaces of human osteoarthritic cartilage.

Figure 1. Compressive stiffness among cartilage of various OA severity grades

Histologically, RF-treated cartilage had a diminished superficial zone with evidence of loss of chondrocyte viability in all groups (Fig. 2).

Discussion: The use of a compressive stiffness tester on human osteoarthritic cartilage was effective in distinguishing clinically-relevant grades of OA. These data provide justification for comparing compressive stiffness values between RF-treated and non-treated cartilage in this model. The significant correlation between on-bone and off-bone compressive stiffness values among all samples in this study helps to validate the compressive stiffness testing of cartilage explants as a suitable representation of biomechanical function of the tissue in vivo. Therefore, the lack of significant differences in compressive stiffness values between RF-treated and non-treated osteoarthritic cartilage in this study suggests that low-energy (< 30 W) RF treatment of human osteoarthritic cartilage may not adversely affect the biomechanical properties of the tissue. However, RF treatment resulted in significant changes in the biochemical properties of the extracellular matrix of human osteoarthritic cartilage. Permeability was decreased in cartilage treated with 30 W of RF. The decrease in permeability is likely the result of molecular changes in collagen fibers in the superficial zone of the cartilage. This is evidenced by the histological appearance of treated explants as well as the data regarding temporal collagen loss. Decreases in cartilage permeability can result in diminished nutrition to the chondrocytes, as well as negative effects on the biomechanical properties of the tissue, if inflow of nutrients and outflow of water are compromised. These effects would be severely detrimental to the cartilage, and the patient, over time. Interestingly, the biochemical effects that are attributable to changes in tissue permeability in this study may have both potentially positive (decreased GAG, IL-1, and NO release) and negative (increased MMP activity collagen loss) effects. However, the clinical effects of these findings have not been determined. Therefore, further in vitro investigation and in vivo studies are warranted before RF can be recommended for clinical use in the treatment of patients with osteoarthritis.

**Dept of Orthopaedic Surgery, University of Missouri, Columbia, MO

49th Annual Meeting of the Orthopaedic Research Society
Poster #0722