**Introduction:** Cartilaginous defects that do not penetrate to the subchondral bone have a poor capacity for repair and may lead to joint dysfunction and osteoarthritis. Recently, radiofrequency energy (RFE) has gained popularity for the treatment of partial thickness cartilage defects. Using in vitro and in vivo studies, Kaplan et al.¹ and Turner et al.² reported that RFE delivered through bipolar devices appeared to be safe for use on chondromalacic and abraded articular cartilage with better histologic outcomes than traditional methods such as mechanical shaving. However these studies used insensitive methods for determining chondrocyte viability. The purpose of this study was to evaluate chondrocyte viability with a sensitive and specific analysis technique following thermal chondroplasty with bipolar RFE (bRFE) as recommended by Kaplan et al.¹ Confluent laser microscopic (CLM) was used to determine the extent of chondrocyte death. We hypothesized that CLM would demonstrate significant chondrocyte death that is not apparent with standard light microscopy (LM) techniques.

**Materials and Methods:** Following IRB approval, twelve fresh femoral condyles or patellas from 12 patients undergoing total or partial knee arthroplasty were used for this study. Chondromalacia was graded using a modified Outerbridge system. Each specimen was placed on a custom designed jig with an inflow pump maintaining a constant flow (100 ml/min) of saline at 37°C. Under arthroscopic visualization, an ArthroCare 2000™ bRFE System coupled with right angle ArthroWand™ (3.0 mm 90°, ArthroCare, Sunnyvale, CA) or CoVac™ 50° angle probe (ArthroCare, Sunnyvale, CA) was used to deliver RFE in a 10-mm linear pass, non contact mode (1 mm above cartilage surface) at one of three settings: 2, 4, or 6 (S2, S4, S6). For each setting/probe combination, six independent treatments were performed (total, 36 treatments). The total treatment time for each pass was 3 seconds. After RFE treatment, each treated area was processed for analysis by LM (H&E, Safranin-O) and CLM. The depth and width of chondrocyte death were determined for each RFE treated region using previously reported techniques employing ethidium homodimer and calcine.³ Repeated measures ANOVA was used to evaluate differences among groups with Duncan’s post hoc analysis when indicated. P-values less than 0.05 were considered significant.

**Results:** There were no differences in the age, sex, or chondromalacia grade between treatment groups (age 62±7 years, male 6, female 6). All specimens were either Grade 2, softened, fibrillated cartilage or grade 3, softened, fibrillated cartilage with pitting to subchondral bone. The RF treated cartilage changed color from white to light yellow and opaque and some areas became concave (Fig. 1A). H&E staining demonstrated smoothing of the cartilage surface. Chondrocyte nuclei were present and not significantly different in appearance than chondrocytes within adjacent untreated cartilage (Fig. 1B). Safranin-O staining was weaker within the superficial layer of treated cartilage with a clear demarcation visualized between treated and untreated regions. CLM demonstrated that both the ArthroWand™ and CoVac™ probes created immediate chondrocyte death (Fig. 2). The depth of chondrocyte death for the two probes were: ArthroWand: 1512 ± 323 µm (S2), 1886 ± 311 µm (S4) and 2268 ± 232 µm (S6), and CoVac: 1928 ± 611 µm (S2), 2193 ± 439 µm (S4), and 2445 ± 531 µm (S6). Penetration to subchondral bone occurred in 2 samples (ArthroWand) and 3 samples (CoVac) for the two probes, respectively. There was a strong trend for the CoVac™ to kill chondrocytes to a greater depth than ArthroWand™ (p = 0.08). Overall, each increase in setting caused increased depth of chondrocyte death (p=0.05).

**Discussion:** The purpose of this project was to compare LM and CLM for determining chondrocyte viability. While thermal chondroplasty performed with bRFE can smooth the articular surface of chondromalacic cartilage, it resulted in immediate chondrocyte death and a reduction in proteoglycan staining. For the limited time and single linear pass utilized in this project, the fine fronds of fibrillated cartilage were melted, but thickened fronds were minimally modified. The results of this study contradict reports by Kaplan et al.¹ and Turner et al.² because of the more sensitive method utilized for assessing chondrocyte viability in this study. Chondrocyte viability cannot be accurately assessed by LM. CLM utilizes fluorescence stains dependent on functional cell membranes and metabolic pathways to determine cell viability, verified by previously reported work by our laboratory.² Based on the results of this study, we conclude that (1) bRFE delivered through the probes investigated creates significant chondrocyte death in human articular cartilage with naturally occurring chondromalacia, and (2) bRFE poses a great danger for creating full thickness cartilage death up to and including subchondral bone when used clinically.

**Reference:**

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