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EVALUATION OF WRIST CARTILAGE WITH AND WITHOUT SCAPHOLUNATE LIGAMENT INJURY IN PRE AND POST OPERATION SUBJECTS

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INTRODUCTION

Hand and wrist injuries commonly occur and can be debilitating. Scapholunate dissociation generally requires surgery, and if left untreated, can lead to scapholunate advanced collapse (SLAC wrist) and associated osteoarthritis [1]. The overall goal of this research is to make a positive impact on the assessment and treatment of wrist injuries and on prevention of osteoarthritis as a result of injury.

The objective of this study was to evaluate changes in the status of the cartilage in the wrist following scapholunate ligament injury, pre-operation and post-operation (pre-op and post-op, respectively), by analyzing the T2 relaxation time in the cartilage of human subjects. The T2 relaxation time increases with tissue hydration and is sensitive to biochemical composition, changes in which are markers for cartilage degeneration [2]. Our first hypothesis was that the calculated T2 values would be lower in the contralateral (uninjured) wrist than the injured wrist both pre-op and post-op. Our second hypothesis was that even though surgical treatment may restore the wrist to a more normal state of function, the calculated T2 relaxation time would be higher in the cartilage of injured wrists post-op than in that of the same wrist pre-op due to continued cartilage degradation.

METHODS

The study protocol was approved by the University of Kansas Medical Center's Human Subjects Committee. Data was collected from magnetic resonance imaging (MRI) of the radiocarpal joints in 7 human subjects who were diagnosed with unilateral scapholunate dissociation pre-op. Three of these subjects have returned for a follow-up scan after surgery. Prior to both pre-op and post-op scanning the subject's pain levels associated with completing a maximum grip strength task were recorded. Pain levels were measured on a 0-10 visual-analog scale (zero no pain, increasing numbers with increased pain, and 10 unbearable pain).

Data collection consisted of MRI scans of the wrist using a Siemens Allegra 3T scanner. The scan series included a set of 4 spin echo scans (0.39 x 0.39 x 0.6 mm/pixel) with varying echo times (20, 40, 60, and 80 ms) to allow the calculation of cartilage T2 relaxation times. These scans were taken with the patient's wrist in a relaxed state. The imaging protocol and analysis were performed on both the injured and contralateral wrist during both the pre-op and post-op scan sessions.

The four image sets obtained from the spin echo scans were first registered to minimize the effects of any position changes over the set of 4 scans. The regions of radiocarpal cartilage on the radius and lunate bones in the wrist were then defined manually on the 60 ms image set. Only the central portion of the cartilage was template, to avoid partial volume effects at the cartilage edges. After this, the data was analyzed by a custom Matlab code to calculate the T2 time for each pixel of cartilage via regression to an exponential decay curve. Individual pixel regressions that produced negative T2 times were dismissed. Only pixel regressions with a correlation coefficient (R^2 value) of 0.6 or greater were considered to have reasonable goodness of fit for inclusion of the T2 data. Pixels with outlier T2 times (outside the range of mean ± 3 standard deviations), were omitted in an iterative fashion until all remaining pixels were within the acceptable range.

Once the evaluation pixels were defined, the average intensity of the pixels was computed for each of the four echo times. A single, averaged T2 time was calculated from these four values and recorded. Descriptive statistics were calculated for the image set and the mean T2 times for each bone were compared between the control and injured wrists for both the pre-op and post-op scan image sets.

RESULTS

Results (Fig. 1-2) indicate a consistent trend towards higher mean T2 time in the injured wrist. Significance was defined as $p<0.05$. Using repeated-measures ANOVA with Fisher's PLSD post-hoc analysis, we found significant differences between injured pre-op and injured post-op T2 values, as well as between uninjured and injured post-op wrists. The pre-op uninjured scan was also significantly different than the post-op injured wrist, as expected.

Although there was not a significant difference between the pre-op uninjured and injured T2 values, the trend towards higher T2 values in the injured wrist is present, corresponding to our hypothesis. Pain levels (Table 1) during grip task are generally higher in the pre-op injured wrists, than post-op. Pain does not consistently correspond to time from injury.

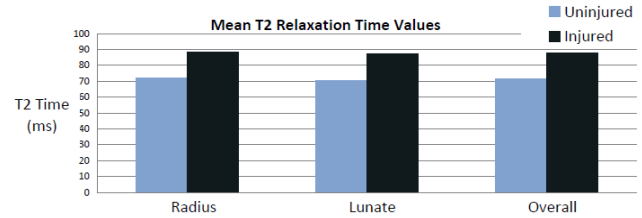

Figure 1. Mean T2 Values from all uninjured and injured wrists pre-operation (7 subjects).

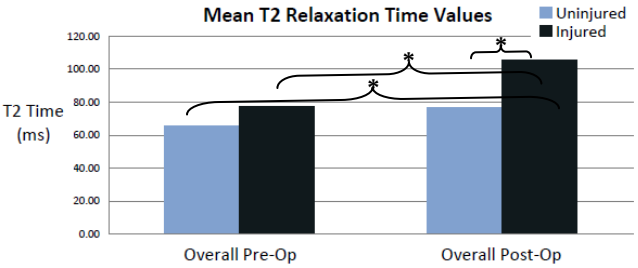

Figure 2. Mean T2 values from uninjured and injured wrists pre and post-operation (3 subjects).

Table 1. Pain level and time elapsed since injury for all subjects and all scans.

Subject Number	Pain From Grip Test	Time Elapsed From Injury to Scan
Pre-Operation		
20100304_01	1/10	25 months
20100311_01	6/10	1 month
20100416_01	2/10	22 months
20100702_01	7.8/10	1 month
20100720_01	9.4/10	69 months
20100726_01	0/10	11 months
20100920_01	1.6/10	≈60 months
Post-Operation		
20100304_01B	1/10	28 months
20100416_01B	0.3/10	25 months
20100720_01B	0.5/10	72 months

DISCUSSION

Mosher reported T2 values of normal cartilage range from 15 ms to 60 ms [3], which is comparable to values found in this study. Dunn et al. found significantly higher T2 values in knee cartilage in subjects who have arthritis when compared to healthy subjects in all but one knee compartment [4].

Our hypothesis that the calculated T2 values would be lower in the contralateral (uninjured) wrist than the injured wrist for all cases is supported by the trends in the current data and a significant difference in the post-op data. All data showed the mean T2 value increasing in the cartilage of the injured wrist of pre-op and post-op scans. Although the 7 pre-op subjects only showed a trend in increasing T2 values from the uninjured to injured wrist, a power analysis ($p<0.05$, and 80% power) indicates that significance should be found with 18 subjects in each group: uninjured and injured.

The secondary hypothesis, that even as surgery repaired the wrist to a more normal state of function the calculated T2 relaxation time would be higher in the cartilage of injured post-op wrists than in the same wrist pre-op, is supported by the current data. The data showed the mean injured T2 value increasing after operation.

Inflammation due to the injury and/or surgery may be occurring in the wrist, and may alter the results of the T2 time calculation. The effect of inflammation on T2 times has not been precisely quantified, likely due to difficulty quantifying inflammation. However, it is expected that inflammation would increase the T2 time.

This study had a number of limitations, including the limited number of subjects. The high amount of variability in the mean T2 times calculated may be due to a number of factors. Motion artifact is always present to some degree in the images due to the nature of the human subject scans. Pixels may also experience some partial volume effects that, when exacerbated by motion, would alter the pixel intensity. Error in the image registration may also lead to error in the mean T2 time calculated for the human subjects. In one case, 20100304_01 injured, the 80 ms image was discarded from the data set due to inconsistencies in the pixel intensities in the images attained from the scanner. Central cartilage from the uninjured lunate of Subject 20100702_01 proved too difficult to clearly identify, and no T2 times were calculated for this particular case.

In conclusion, T2 relaxation time appears to be a promising indicator of cartilage degeneration in this wrist model, with higher values seen in injured wrists than uninjured wrists in both pre-op and post-op scans. The increase in injured T2 times from pre-op to post-op scans suggests that the T2 relaxation time increases after surgery. Continued data collection and analysis is ongoing with enrollment of additional subjects.

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