

# The Elbow UCL Injury Prognosis Score

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**INTRODUCTION:** No model exists to predict which patients with elbow ulnar collateral ligament (UCL) injuries will successfully return to play (RTP) with non-operative treatment. The reported rates for successful RTP after non-operative management of UCL injuries are limited and vary widely. Furthermore, patient and UCL injury characteristics that influence failure of non-operative treatment have not been established.

## METHODS:

205 patients with prospectively collected data after being evaluated by the senior author for a UCL injury from 2010 to 2020 were enrolled in a longitudinal REDCap database that was then retrospectively reviewed. Of these patients, 130 underwent a trial of non-operative treatment and were either cleared for RTP (n= 46) or eventually underwent surgical intervention (n= 84) after a minimum one-month trial of non-operative management. The Elbow UCL Injury Prognosis Score is a close approximation of a logistic regression model which was developed by recursively selecting features using a combination of backward stepwise and best subset methods. The criteria considered for feature selection included p-values from Fisher exact tests, variable importance from intermediary logistic models, and accuracy and sensitivity of the final model. The final logistic model was tested and validated using 5-fold cross-validation, and the score was validated against the logistic model.

## RESULTS:

The Elbow UCL Injury Prognosis Score provides an individualized prediction of each patient's need for surgery based on age, MRI characteristics and 5<sup>th</sup> digit paresthesias. The final model achieved an average accuracy of 78.7% and consistently perfect sensitivity and negative predictive value on the test set. The area under the ROC curve was 0.86. A simplified score to allow for calculation at the bedside was created by standardizing the weights from the logistic equation. The lower the score, the more likely patients could successfully RTP without surgery.

## DISCUSSION AND CONCLUSION:

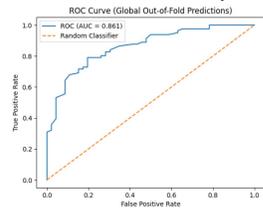
The Elbow UCL Injury Prognosis Score was created to predict who will succeed with non-operative management and avoid unnecessary surgery, while simultaneously identifying patients for whom non-operative management would delay the inevitable need for surgical intervention. Patients with a score greater than 8 have an over 80% chance of requiring surgery. Overall, the Elbow UCL Injury Prognosis Score is a statistically rigorous and practical tool that can be used at the bedside to help counsel patients on their chances of needing surgery.

The probability of  $p = 1$ , or the patient requiring surgery, is:

$$P(p = 1) = \frac{1}{1 + \exp(-(-1.7644 + 0.6033x_1 + 1.8883x_2 + 2.1718x_3 + 0.9913x_4 + 0.8390x_5))}$$

$x_1 = \text{Age} > 37 \text{ years}$   
 $x_2 = \text{MRI Full Thickness Tear (yes = 1, no = 0)}$   
 $x_3 = \text{MRI Partial Tear (yes = 1, no = 0)}$   
 $x_4 = \text{MRI Chronic Changes (yes = 1, no = 0)}$

**Equation 1: The Elbow UCL Injury Prognosis Probability Model**



**Figure 1: Five-fold cross-validation and ROC curve of our Elbow UCL Injury Prognosis Probability Model.** We achieved an average accuracy of 78.7% on the test set. The area under the ROC curve was 0.86, and the model consistently achieved perfect sensitivity and negative predictive value on the test dataset. AUC, area under curve; ROC, receiver operating characteristic.

Variable	Points
Age	1
Tear severity	2
Full thickness	3
Partial thickness	2
Sprain	0
Chronic ligament changes	2
Sign of FRP	3

**Table 2: The Elbow UCL Injury Prognosis Score.** The Elbow UCL Injury Prognosis Score was created to provide a simple calculation for surgeons to use to determine a patient's probability of requiring surgery to help guide shared decision making. This score was developed by standardizing the weights of the predictor variables from the logistic equation of the final model. The score was validated against the results of the logistic model with 100% accuracy and can be expected to have as much accuracy as the logistic model.

Test Score	Probability of Requiring Surgery
0	0.0%
1	36.80%
2	46.90%
3	76.80%
4	88.0%

Patient Characteristics	Total	Non-Op	Operative
<b>Total n (%)</b>	130 (100)	46 (35.4)	84 (64.6)
<b>Gender, n</b>			
Male	130 (100)	46 (100)	84 (100)
Female	0	0	0
<b>Mean age at injury, years (range)</b>	34.1	31.2	34.2
(1) 0-27.4	(12.0-37.4)	(11.7-28.4)	(11.7-38.4)
(2) 27.4-34.1	(34.1-37.4)	(34.1-37.4)	(34.1-37.4)
(3) 34.1-37.4	(37.4-37.4)	(37.4-37.4)	(37.4-37.4)
<b>Level of play, n (%)</b>			
Amateur	120 (92.3)	40 (87.0)	80 (95.2)
Professional	10 (7.7)	6 (13.0)	4 (4.8)
<b>Position, n (%)</b>			
Pitcher	112 (86.2)	37 (80.4)	75 (89.3)
Other	18 (13.8)	9 (19.6)	9 (10.7)
<b>UCL condition, n (%)</b>			
UCL intact	100 (76.9)	46 (100)	54 (64.3)
UCL torn	30 (23.1)	0	30 (35.7)
<b>5<sup>th</sup> digit paresthesia, n (%)**</b>			
Present	22 (16.9)	4 (8.7)	18 (21.4)
Absent	108 (83.1)	42 (91.3)	66 (78.6)
<b>Tear Severity**</b>			
Full Thickness	27 (20.8)	0 (0)	27 (32.1)
Partial Thickness	45 (34.6)	22 (47.8)	23 (27.5)
Sprain	38 (29.2)	24 (52.2)	14 (16.7)
Chronic Changes, n (%)**	39 (30.0)	9 (19.6)	30 (35.7)
<b>Location of Tear, n (%)**</b>			
Proximal	63 (48.5)	21 (45.6)	42 (49.8)
Mid-substance	20 (15.4)	7 (15.2)	13 (15.5)
Distal	41 (31.5)	11 (23.9)	30 (35.7)
<b>Use of FRP, n (%)**</b>	57 (43.9)	36 (78.3)	21 (25.0)

**Table 1: Patient demographics, exam findings, and tear characteristics.** \*\* indicates variables that were significantly different between operative and nonoperative management.