Poster #72

MIDWEST ORTHOPAEDICS AT RUSH

Evidence-Based Machine Learning Algorithm to Predict Failure Following Cartilage Procedures in the Knee

Ron Gilat, MD; Ben Gilat, BS; Sumit Patel, MD;
Kyle Wagner, BS; Eric D. Haunschild, MD; Tracy Tauro, BS, BA;
Jorge Chahla, MD, PhD; Adam B. Yanke, MD, PhD; Brian J. Cole, MD, MBA

HALL OF FAME HEALTH

JOFFREY ★ BALLET CHICAGO

Disclosures:

Ron Gilat, MD; Ben Gilat, BS; Sumit Patel, MD; Kyle Wagner, BS; Eric D. Haunschild, MD; Tracy Tauro, BS, BA: Nothing to disclose

Jorge Chahla, MD, PhD has received consulting fees from Arthrex, Inc CONMED Linvatec, Ossur, and Smith and Nephew.

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Purpose:

1. Develop machine learning algorithms to predict failure

2. Detect the most valuable features associated with failure

3. Compare risk of failure of specific patient-procedure combinations

Methods:

- A single institution prospectively collected database of cartilage procedures was queried for procedures performed between 2000 and 2018
- **Minimum 2 years follow-up**
- **Failure** was defined as **revision cartilage surgery** and/or **knee arthroplasty**
- **One hundred and one preoperative and intraoperative features** were evaluated as potential predictors

Methods:

- The dataset was randomly divided into **training (70%)** and independent **testing (30%)** sets
- **Four machine learning algorithms** were trained and internally validated
- Algorithm performance was assessed using **area under curve (AUC)** and the **Brier score**
- **Local Interpretable Model-agnostic Explanations (LIME)** was utilized to assess the optimized **algorithm fidelity**

Results:

No. of Patients → 1091

Mean Follow Up → 3.5y

Failures → 18%

Demographics

	Overall (N=1091)
Age at time of surgery years	40.5±15
Gender	
Male	550 (50.4%)
Female	541 (49.6%)
Body Mass Index	28.2±6
Laterality	
Right	569 (52.2%)
Left	522 (47.8%)
Athlete	293 (26.9%)
Worker's Compensation	119 (10.9%)
Traumatic event	439 (40.2%)
Symptoms' duration years	2.7±4.7

Surgical Details

Cartilage Lesion Location	
MFC	554 (50.8%)
MTP	144 (13.2%)
LFC	285 (26.1%)
LTP	145 (13.3%)
Trochlea	293 (26.9%)
Patella	329 (30.2%)
Defect Area (mm^2, mean±SD)	
MFC	17.8±14
MTP	10.2±9.4
LFC	18.7±13.9
LTP	11.7±10.1
Trochlea	16.4±13.8
Patella	16±13.5

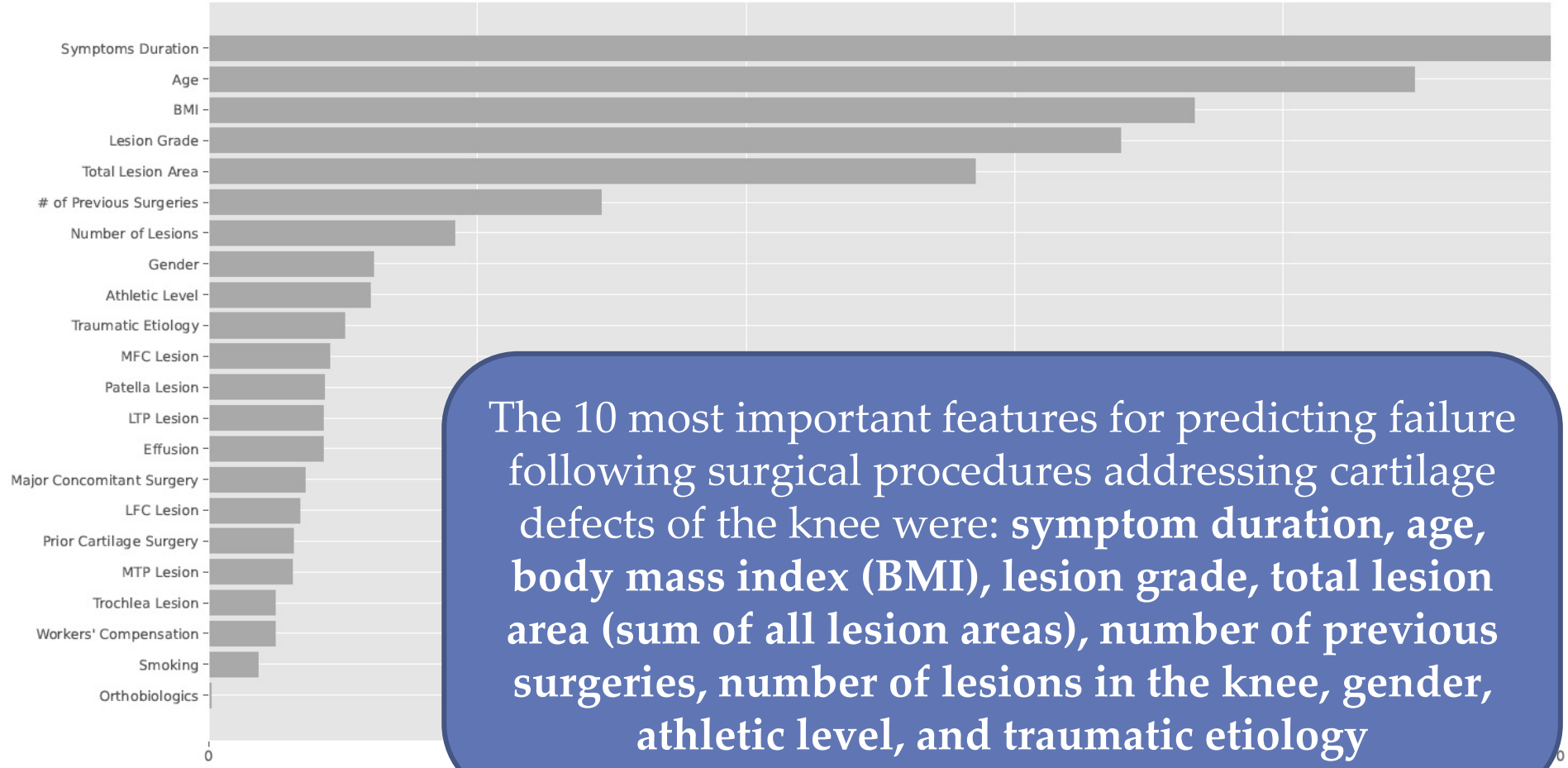
Procedures Performed

Cartilage Procedure	
Chondroplasty	560
Microfracture	150
Osteochondral Allograft Transplantation (OCA)	306
Osteochondral Autograft Transplantation (OATS)	36
Articular Chondrocyte Implantation (ACI/MACI)	39

Concomitant Procedures

Concomitant Procedure	
Medial Meniscectomy	481 (44.1%)
Lateral Meniscectomy	289 (26.5%)
Medial Meniscus Repair	13 (1.2%)
Lateral Meniscus Repair	7 (0.6%)
Medial MAT	53 (4.8%)
Lateral MAT	77 (7.1%)
High Tibial Osteotomy	32 (2.9%)
Distal Femoral Osteotomy	25 (2.3%)
Tibial Tuberosity Osteotomy	51 (4.7%)
ACL reconstruction	157 (14.4%)
Platelet-rich plasma injection	14 (1.3%)
Bone Marrow Aspirate Concentrate (BMAC)	11 (1%)

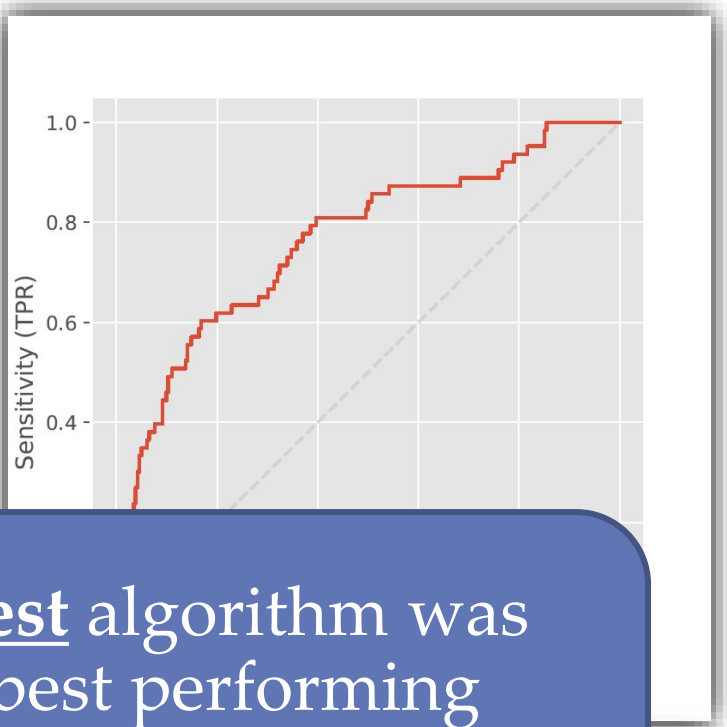
Feature Importance



The 10 most important features for predicting failure following surgical procedures addressing cartilage defects of the knee were: **symptom duration, age, body mass index (BMI), lesion grade, total lesion area (sum of all lesion areas), number of previous surgeries, number of lesions in the knee, gender, athletic level, and traumatic etiology**

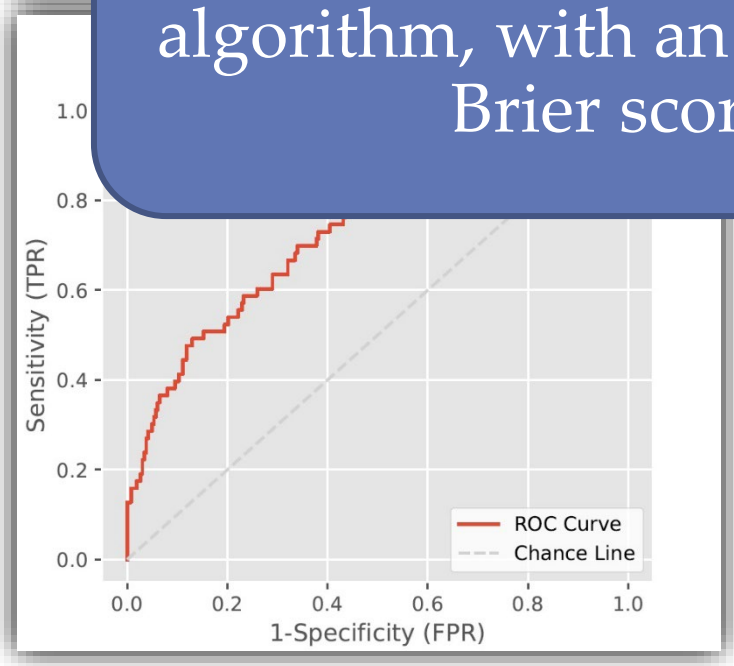
Elastic-net penalized linear regression (ENPLR)

Random Forest

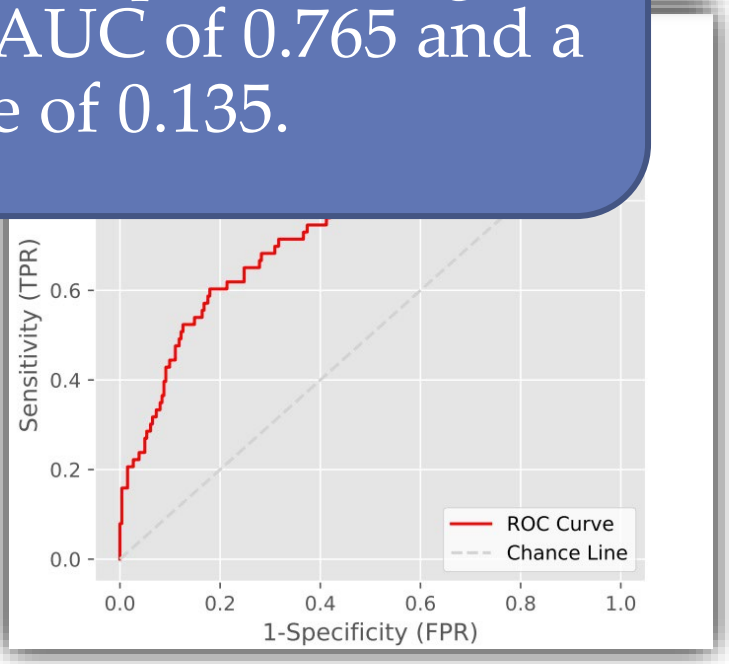


The **Random Forest** algorithm was found to be the best performing algorithm, with an AUC of 0.765 and a Brier score of 0.135.

Neural Network



XG Boost

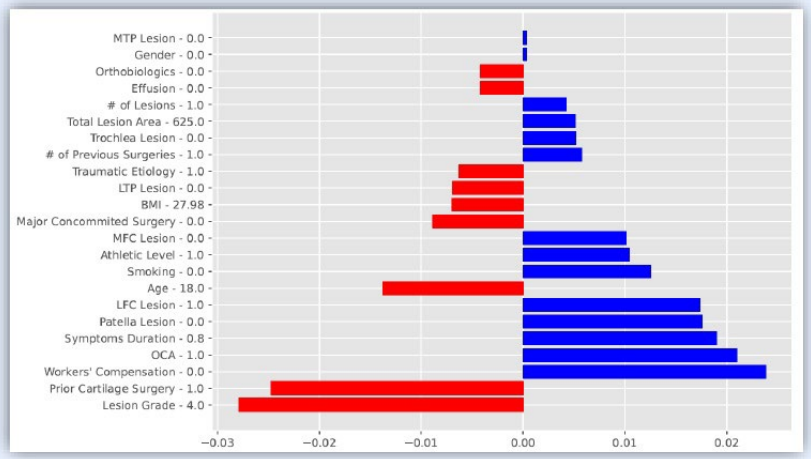


So How Can I Use This to Choose the Best Treatment Modality for My Patient?

These machine learning algorithms may allow **to compare** the risk of failure of **specific patient-procedure combinations** in the treatment of cartilage defects of the knee.

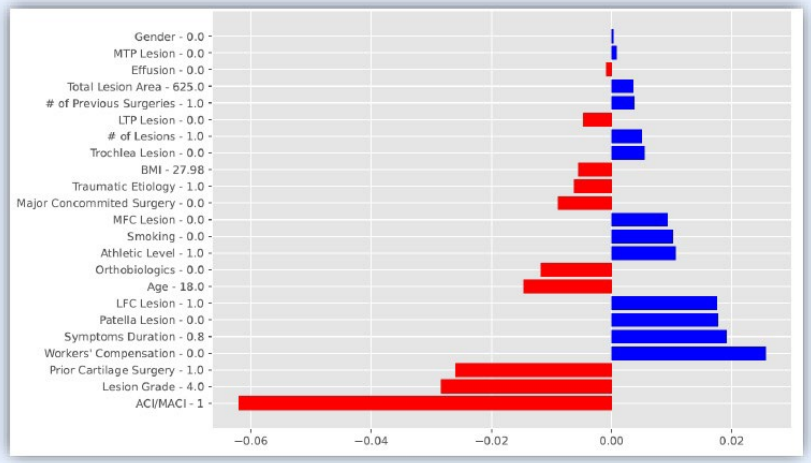
Patient-specific analysis and propensity to succeed for an 18 year-old male, BMI=28, non-smoker, recreational athlete, one prior cartilage procedure, no worker's compensation, 8 months duration of knee pain without effusion following a traumatic injury, and a grade 4, 25mm × 25mm lateral femoral condyle lesion.

OCA



89%

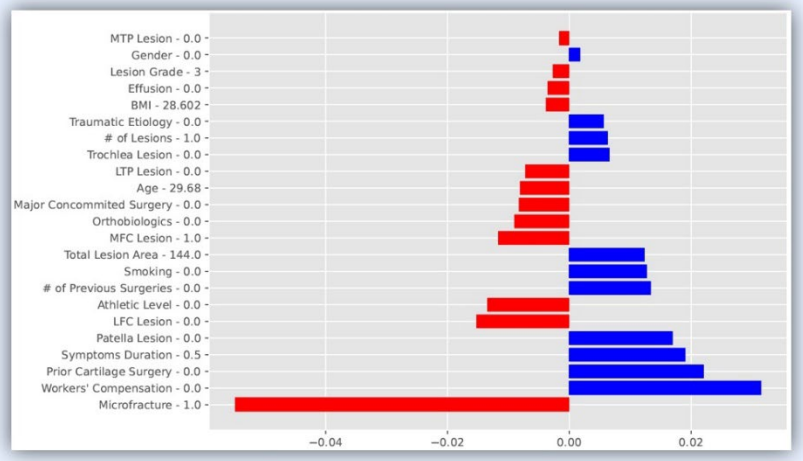
ACI/MACI



75%

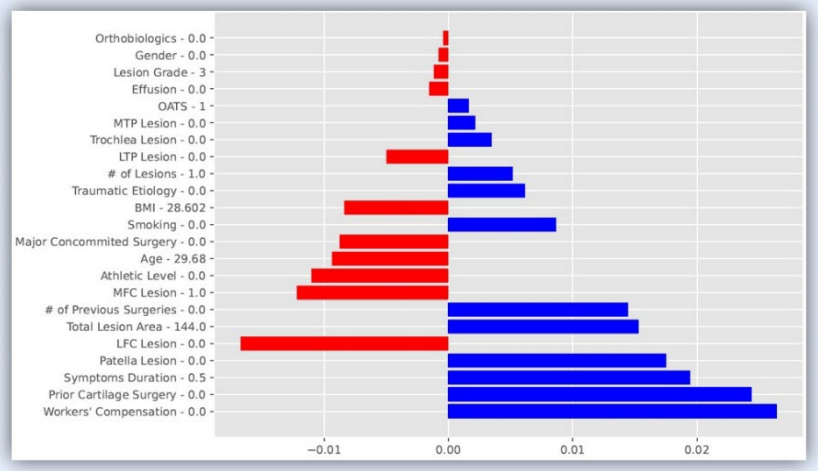
Patient-specific analysis and propensity to succeed for a 29 year-old female, BMI=28, non-smoker, non-athlete, no relevant past surgical history, no worker's compensation claim, with 6 months duration of knee pain without effusion, and a grade 3, 12mm × 12mm medial femoral condyle lesion.

MICROFRACTURE



73%

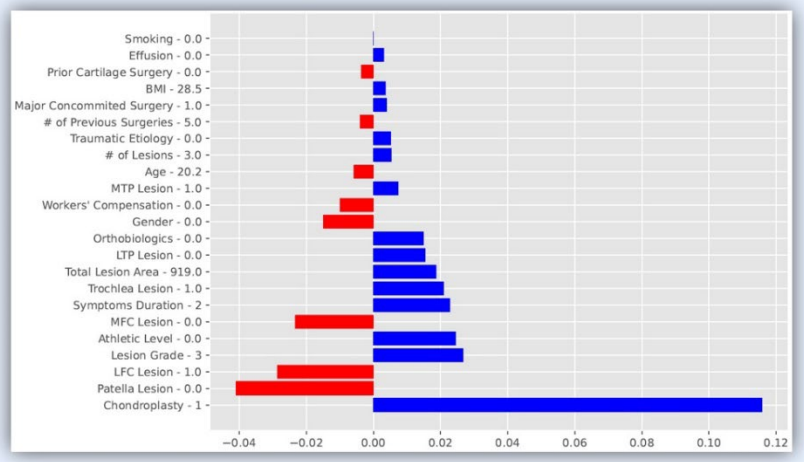
OATS



83%

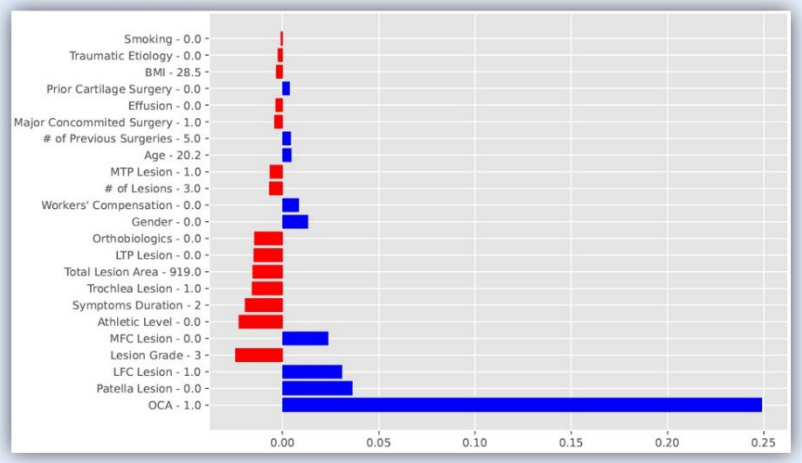
Patient-specific analysis and propensity to succeed for a 40 year-old male, BMI=28.7, non-smoker, non-athlete, six prior procedures, no worker's compensation, two years duration of knee pain without a known traumatic event, without knee effusion, with both a grade 3, 18mm × 18mm medial femoral condyle lesion and a grade 3, 16mm × 16mm trochlea lesion.

CHONDROPLASTY



47%

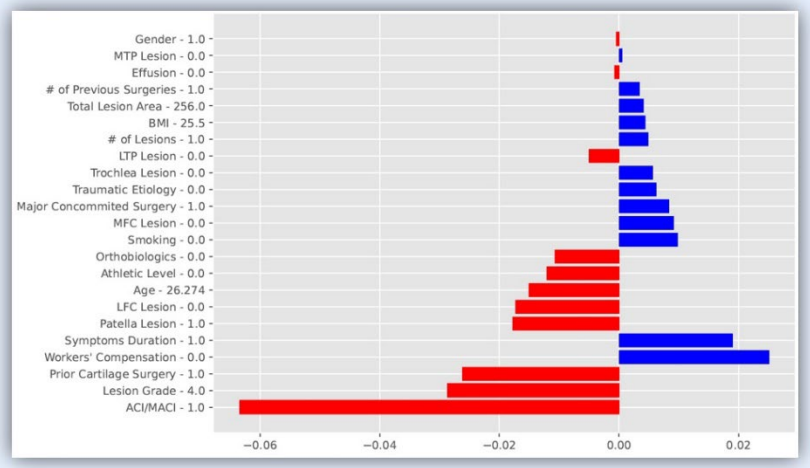
OCA



79%

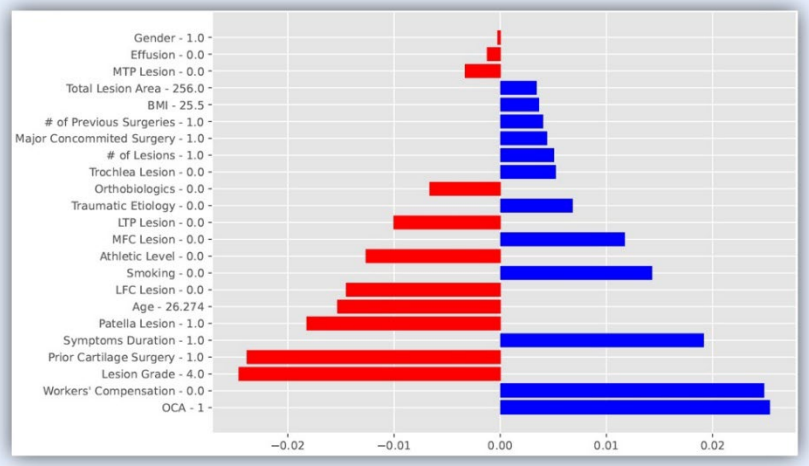
Patient-specific analysis and propensity to succeed for a 26 year-old female, BMI=25.5, non-smoker, non-athlete, one previous knee surgery, no worker's compensation claim, with 1 year duration of knee pain without effusion, and a grade 4, 16mm × 16mm patellar lesion.

ACI/MACI



60%

OCA



81%

Conclusions:

- **Machine learning algorithms were accurate in predicting the risk of failure** following cartilage procedures of the knee, with the most important features in descending order being symptom duration, age, BMI, lesion grade, and total lesion area.

- Machine learning algorithms **may be used to compare** the risk of failure of **specific patient-procedure combinations** in the treatment of cartilage defects of the knee.

- **Integrated human and machine learning decision-making may improve patient selection and bring about the new era of patient-tailored evidence-based clinical care.**