

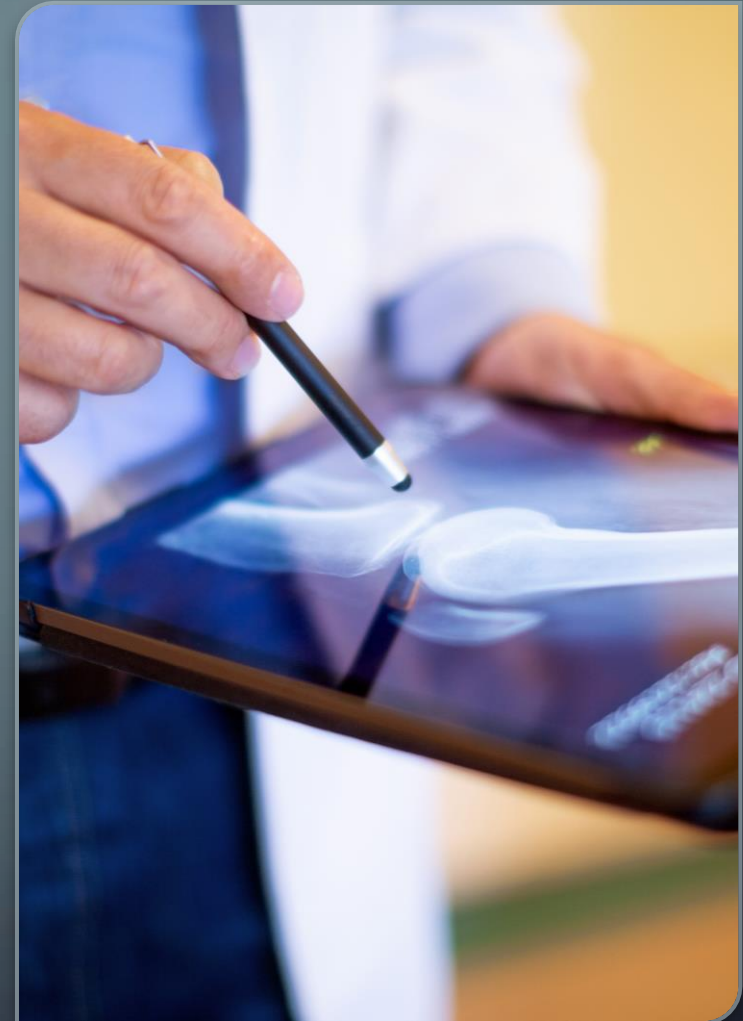
A decorative graphic on the left side of the slide, consisting of a network of white lines and small circles on a dark blue background, resembling a circuit board or a neural network diagram.

# CLASSIFYING KNEE X-RAYS

IDENTIFYING THE SEVERITY OF KNEE OSTEOARTHRITIS IN X-RAY IMAGES

# FAST FACTS ABOUT KNEE OSTEOARTHRITIS (OA)

- Most common type of arthritis
- Impacts quality of life, can be debilitating
- Affects over 32.5 million adults in the USA
- 240 cases per 100,000 adults each year
- Symptoms in 1 in 3 obese adults
- No cure
- Early identification is key to slowing the progression of OA





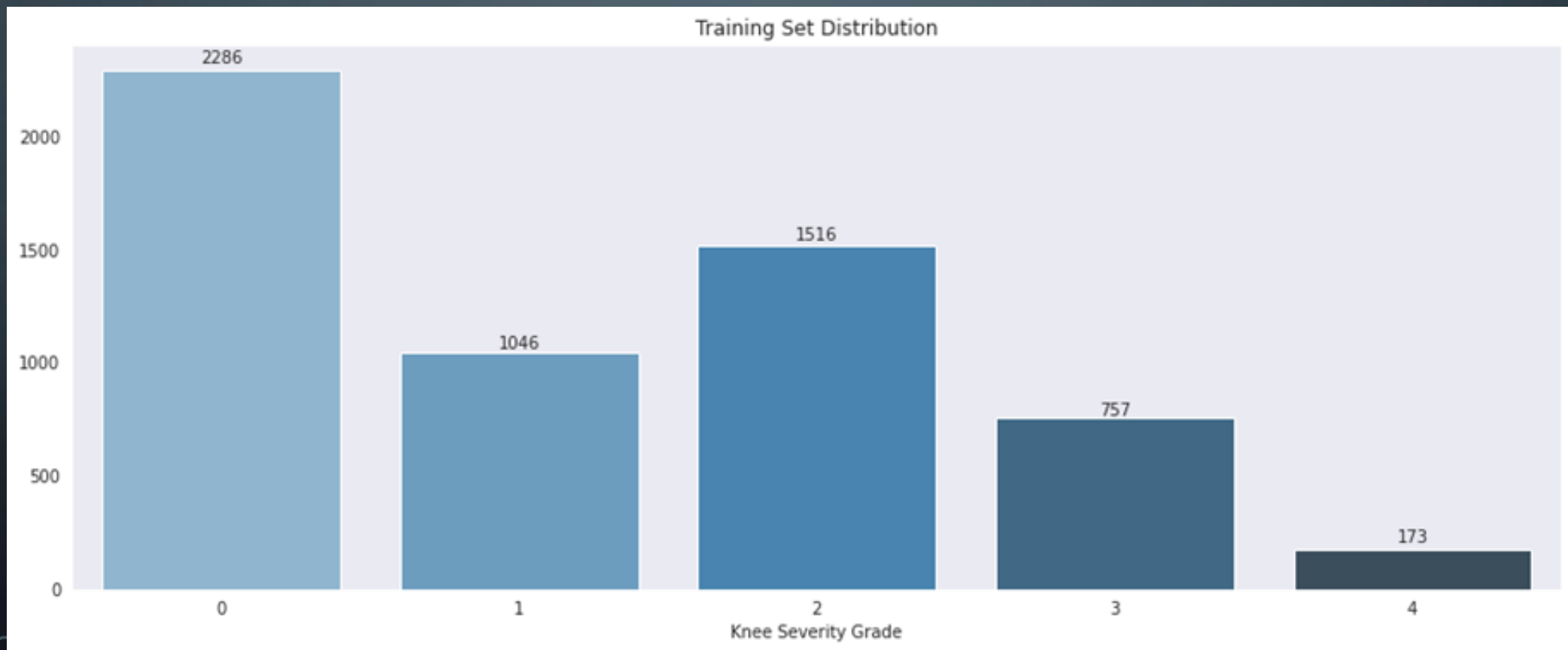
## DATA SOURCE

- Kaggle: [Knee Osteoarthritis Dataset with Severity Grading](#)
- [Mendeley Data](#) (Chen, Pingjun (2018), "Knee Osteoarthritis Severity Grading Dataset", Mendeley Data, V1, doi: 10.17632/56rmx5bjcr.1)

# KELLGREN-LAWRENCE (KL) SCALE

- **Grade 0 (None):** No pathological features, i.e. a healthy knee image
- **Grade 1 (Doubtful):** Doubtful joint narrowing with possible osteophytic lipping
- **Grade 2 (Minimal):** Definite presence of osteophytes and possible joint space narrowing
- **Grade 3 (Moderate):** Multiple osteophytes, definite joint space narrowing, with mild sclerosis.
- **Grade 4 (Severe):** Large osteophytes, significant joint narrowing, and severe sclerosis.

# IMBALANCED DATA





# MODELING

- Keras Image Classification
- Transfer Learning : DenseNet201 initialized with ImageNet weights
- Fine-tuning



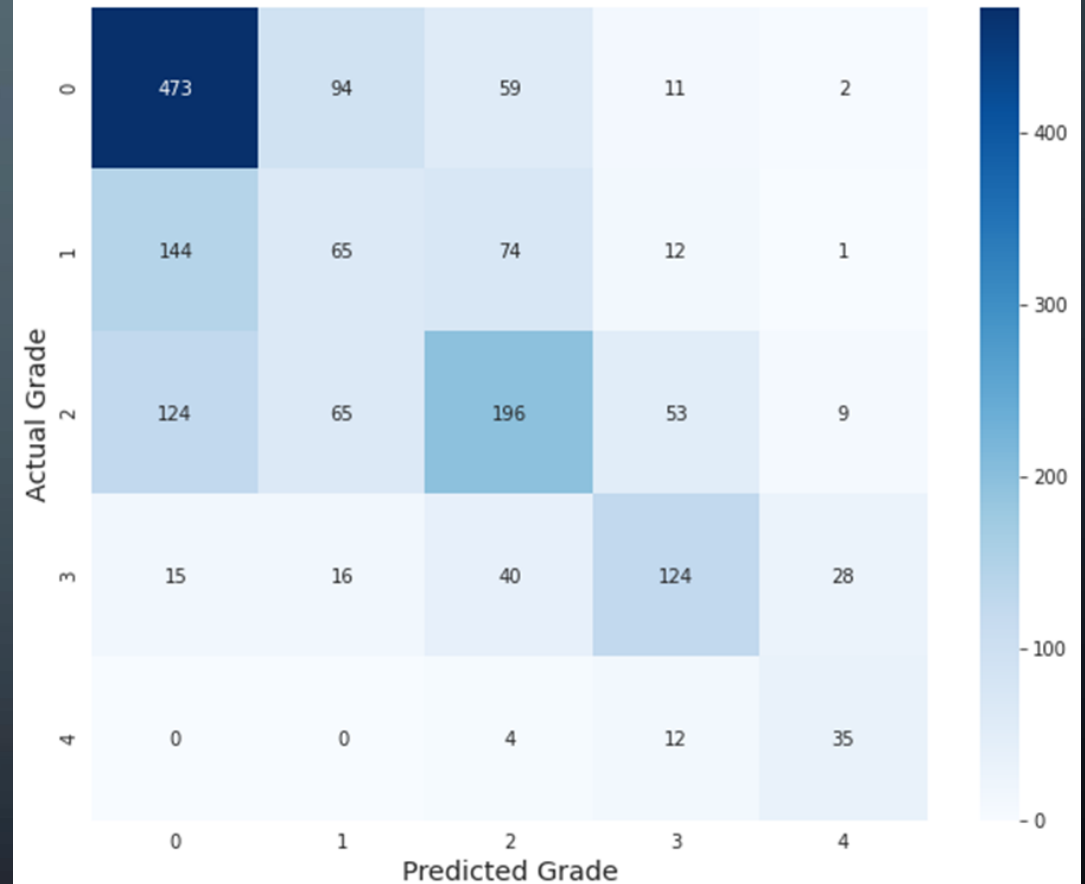
# MODELING – 5 GRADES ON THE KL-SCALE

ACCURACY = 54%

## Fine-tuned model - Classification Report:

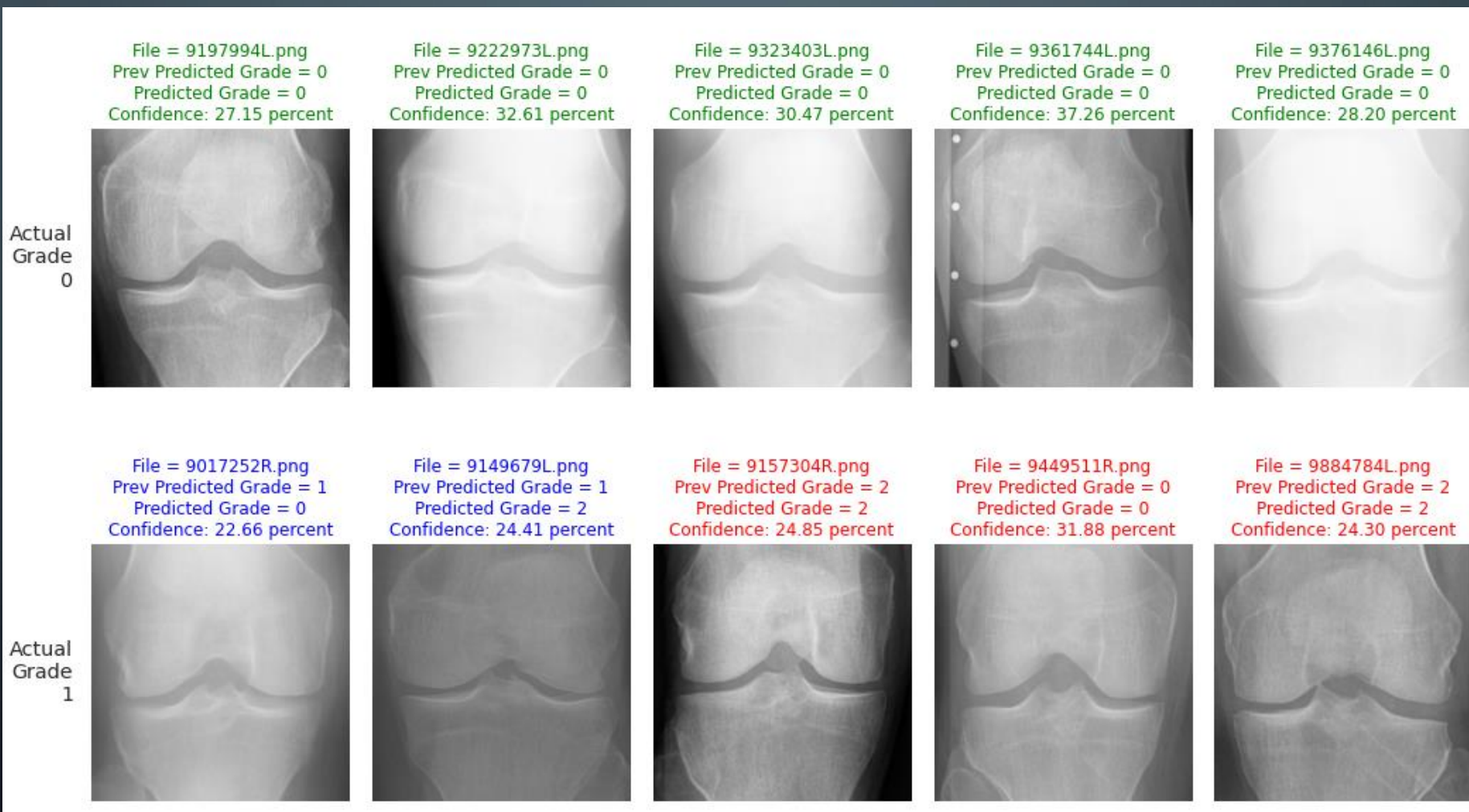
	precision	recall	f1-score	support
0	0.63	0.74	0.68	639
1	0.27	0.22	0.24	296
2	0.53	0.44	0.48	447
3	0.58	0.56	0.57	223
4	0.47	0.69	0.56	51
accuracy			0.54	1656
macro avg	0.49	0.53	0.50	1656
weighted avg	0.52	0.54	0.53	1656

Fine-tuned Model - Confusion Matrix



# SAMPLE KNEE IMAGES FROM TEST SET (GRADE 0-1)

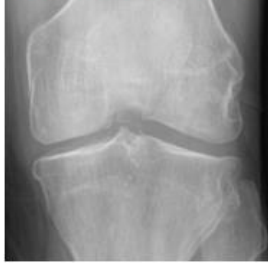
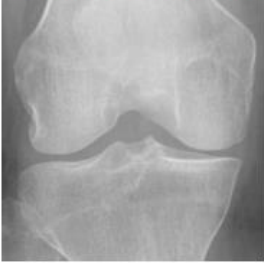
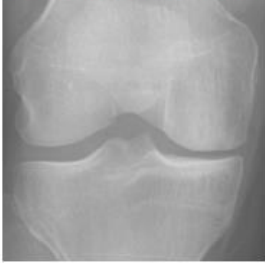

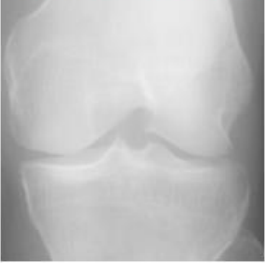
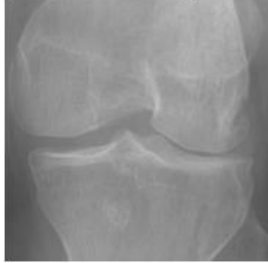
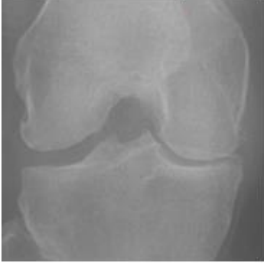

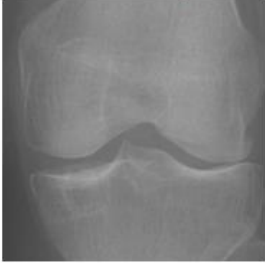
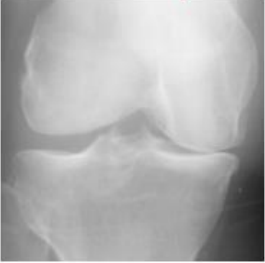





PREDICTION ACCURACY = 44%





# SAMPLE KNEE IMAGES FROM TEST SET (GRADE 2-4)

PREDICTION ACCURACY = 44%

Actual Grade 2	<p>File = 9183590L.png Prev Predicted Grade = 3 Predicted Grade = 3 Confidence: 26.48 percent</p> 	<p>File = 9224061R.png Prev Predicted Grade = 0 Predicted Grade = 0 Confidence: 24.86 percent</p> 	<p>File = 9634146R.png Prev Predicted Grade = 0 Predicted Grade = 0 Confidence: 25.18 percent</p> 	<p>File = 9837371R.png Prev Predicted Grade = 0 Predicted Grade = 1 Confidence: 24.15 percent</p> 	<p>File = 9930588L.png Prev Predicted Grade = 3 Predicted Grade = 3 Confidence: 30.89 percent</p> 
	<p>File = 9556464L.png Prev Predicted Grade = 2 Predicted Grade = 3 Confidence: 23.80 percent</p> 	<p>File = 9660697R.png Prev Predicted Grade = 4 Predicted Grade = 3 Confidence: 34.25 percent</p> 	<p>File = 9664468L.png Prev Predicted Grade = 3 Predicted Grade = 3 Confidence: 34.66 percent</p> 	<p>File = 9809967L.png Prev Predicted Grade = 1 Predicted Grade = 1 Confidence: 23.36 percent</p> 	<p>File = 9870569R.png Prev Predicted Grade = 4 Predicted Grade = 4 Confidence: 27.70 percent</p> 
	<p>File = 9012867R.png Prev Predicted Grade = 4 Predicted Grade = 4 Confidence: 33.90 percent</p> 	<p>File = 9194300L.png Prev Predicted Grade = 3 Predicted Grade = 3 Confidence: 35.42 percent</p> 	<p>File = 9390064R.png Prev Predicted Grade = 4 Predicted Grade = 3 Confidence: 28.90 percent</p> 	<p>File = 9559547R.png Prev Predicted Grade = 4 Predicted Grade = 4 Confidence: 34.57 percent</p> 	<p>File = 9841033R.png Prev Predicted Grade = 4 Predicted Grade = 4 Confidence: 33.42 percent</p> 
	Actual Grade 4				

# SIMPLIFYING INTO 3 CLASSES

- **A** : Grades **0 (None)** and **1 (Doubtful)** : a reasonably healthy knee, patient with knee pain may wish to explore other causes
- **B** : Grade **2 (Minimal)** : patient has minimal OA and should consider lifestyle changes, and possibly medication
- **C** : Grades **3 (Moderate)** and **4 (Severe)** : knee replacement and other procedures and/or surgeries may be an option

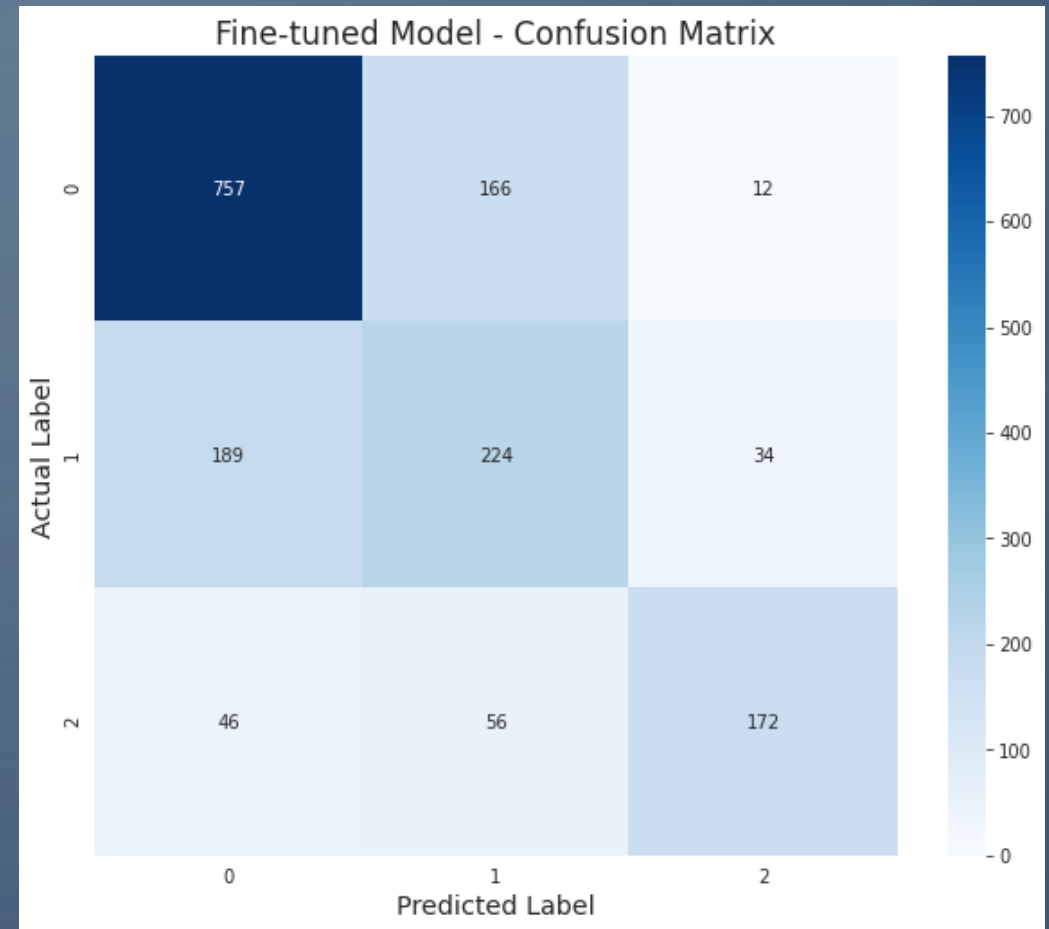
# MODELING – SIMPLIFIED 3 CLASSES

ACCURACY = 70%

```
Fine-tuned model - Classification Report:
              precision    recall  f1-score   support

     0       0.76       0.81       0.79       935
     1       0.50       0.50       0.50       447
     2       0.79       0.63       0.70       274

 accuracy      0.70      1656
 macro avg     0.68      1656
 weighted avg  0.70      1656
```



# SAMPLE KNEE IMAGES FROM TEST SET (CLASS A)

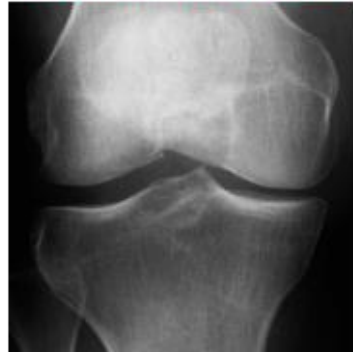
PREDICTION ACCURACY = 73.33 %

Actual  
Label  
A

File = 9024409R.png  
Prev Predicted Label = A  
Predicted Label = A  
Confidence: 53.43 percent



File = 9055038R.png  
Prev Predicted Label = B  
Predicted Label = B  
Confidence: 38.96 percent



File = 9062161R.png  
Prev Predicted Label = B  
Predicted Label = B  
Confidence: 40.71 percent



File = 9115033R.png  
Prev Predicted Label = B  
Predicted Label = A  
Confidence: 40.99 percent



File = 9343691L.png  
Prev Predicted Label = B  
Predicted Label = A  
Confidence: 49.40 percent



Actual  
Label  
A

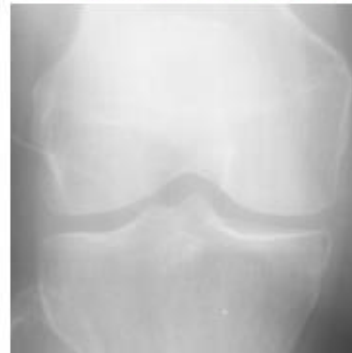
File = 9435145R.png  
Prev Predicted Label = A  
Predicted Label = A  
Confidence: 50.98 percent



File = 9449511R.png  
Prev Predicted Label = A  
Predicted Label = A  
Confidence: 54.35 percent



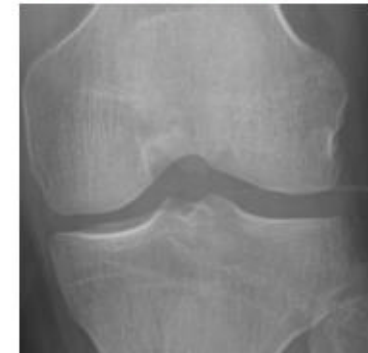
File = 9545822R.png  
Prev Predicted Label = B  
Predicted Label = A  
Confidence: 43.07 percent



File = 9546329R.png  
Prev Predicted Label = A  
Predicted Label = A  
Confidence: 53.92 percent



File = 9909758L.png  
Prev Predicted Label = A  
Predicted Label = A  
Confidence: 56.55 percent





# SAMPLE KNEE IMAGES FROM TEST SET (CLASS B)

PREDICTION ACCURACY = 73.33 %

Actual  
Label  
B

File = 9006407R.png  
Prev Predicted Label = B  
Predicted Label = A  
Confidence: 39.05 percent



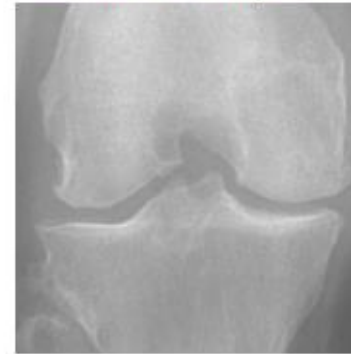
File = 9088866R.png  
Prev Predicted Label = B  
Predicted Label = B  
Confidence: 49.51 percent



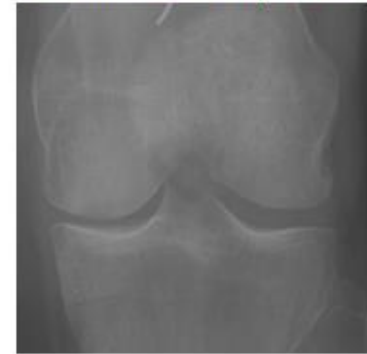
File = 9169499R.png  
Prev Predicted Label = B  
Predicted Label = B  
Confidence: 45.67 percent



File = 9222916R.png  
Prev Predicted Label = B  
Predicted Label = B  
Confidence: 46.67 percent

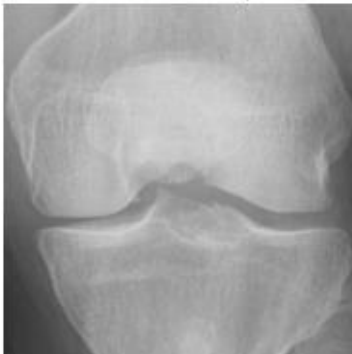


File = 9402978L.png  
Prev Predicted Label = B  
Predicted Label = B  
Confidence: 49.07 percent

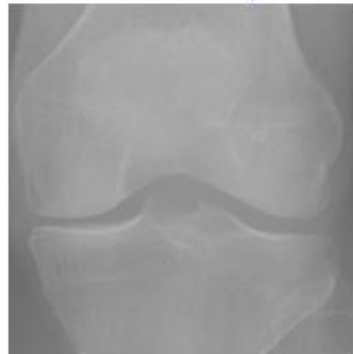


Actual  
Label  
B

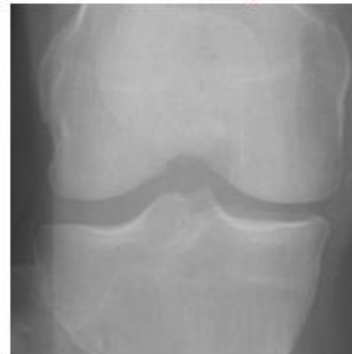
File = 9496443L.png  
Prev Predicted Label = B  
Predicted Label = B  
Confidence: 40.40 percent



File = 9534110L.png  
Prev Predicted Label = B  
Predicted Label = A  
Confidence: 37.52 percent



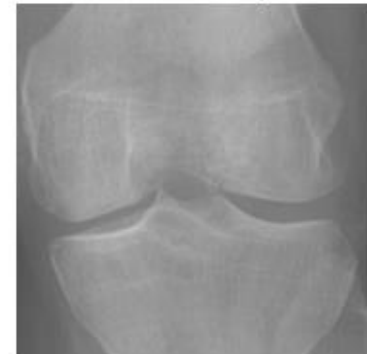
File = 9576694R.png  
Prev Predicted Label = A  
Predicted Label = A  
Confidence: 49.26 percent



File = 9607698R.png  
Prev Predicted Label = B  
Predicted Label = B  
Confidence: 39.85 percent



File = 9627152L.png  
Prev Predicted Label = B  
Predicted Label = B  
Confidence: 47.87 percent





# SAMPLE KNEE IMAGES FROM TEST SET (CLASS C)

PREDICTION ACCURACY = 73.33 %

Actual  
Label  
C

File = 9012867L.png  
Prev Predicted Label = C  
Predicted Label = C  
Confidence: 54.58 percent



File = 9055836L.png  
Prev Predicted Label = B  
Predicted Label = C  
Confidence: 51.13 percent



File = 9087632L.png  
Prev Predicted Label = B  
Predicted Label = A  
Confidence: 42.02 percent



File = 9267247L.png  
Prev Predicted Label = B  
Predicted Label = A  
Confidence: 39.57 percent

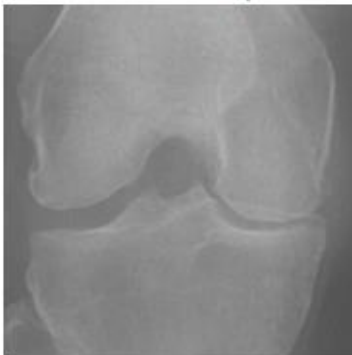


File = 9484333L.png  
Prev Predicted Label = C  
Predicted Label = C  
Confidence: 57.34 percent

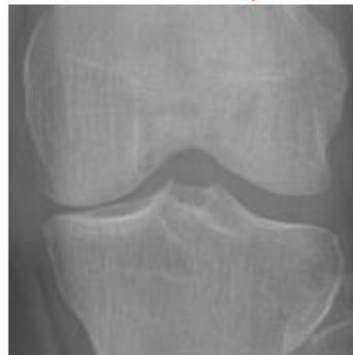


Actual  
Label  
C

File = 9660697R.png  
Prev Predicted Label = B  
Predicted Label = C  
Confidence: 49.37 percent



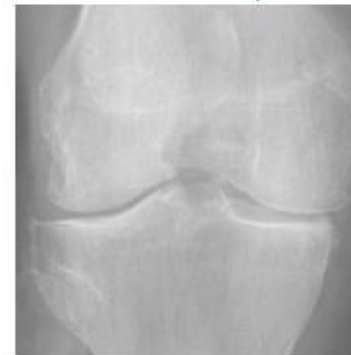
File = 9719748L.png  
Prev Predicted Label = A  
Predicted Label = A  
Confidence: 53.83 percent



File = 9856831L.png  
Prev Predicted Label = C  
Predicted Label = C  
Confidence: 57.30 percent



File = 9872810R.png  
Prev Predicted Label = C  
Predicted Label = C  
Confidence: 55.46 percent



File = 9964731R.png  
Prev Predicted Label = C  
Predicted Label = C  
Confidence: 53.90 percent



# FURTHER RESEARCH

1

Explore other methods of identifying knee OA from X-rays

2

Improve model – add more labeled images to training set

3

Additional fine-tuning, targeting grade 2 / class B classification