In [2]:

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
%matplotlib inline
import seaborn as sns
from sklearn.utils.class_weight import compute_class_weight
from sklearn.preprocessing import StandardScaler
from sklearn.linear_model import LogisticRegression
from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.model_selection import train_test_split, GridSearchCV, cr
from sklearn.metrics import accuracy_score, recall_score, precision_sc
from sklearn.metrics import ConfusionMatrixDisplay
from sklearn.metrics import classification_report
from sklearn.pipeline import Pipeline
from imblearn.pipeline import Pipeline as ImbPipeline
from sklearn.decomposition import PCA
from imblearn.over_sampling import SMOTE, BorderlineSMOTE
from google.colab import files
uploaded = files.upload()
```

Choose Files No file chosen

Upload widget is only available when the cell has been executed in the current browser session. Please rerun this cell to enable.

```
Saving pivoted_df.csv to pivoted_df.csv
```

Load the dataframe in, inspect the data.

In [5]:

```
pivoted_df = pd.read_csv('~/Documents/Flatiron/Project_5_/data/pivoted_
```

In [6]:

```
pivoted_df.head()
```

Out[6]:

	season	Age	Throws	Surgery	AB_release_speed_weighted_avg	CH_release_speed_weigh
0	2008	37.0	1	0.0	0.0	8
1	2009	38.0	1	0.0	0.0	8
2	2010	39.0	1	0.0	0.0	8
3	2011	40.0	1	0.0	0.0	8
4	2012	41.0	1	0.0	0.0	8

5 rows × 130 columns

In [7]:

```
pivoted_df.shape
```

Out[7]:

```
(3688, 130)
```

In [8]:

```
pivoted_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 3688 entries, 0 to 3687
Columns: 130 entries, season to SV_vz0_weighted_avg
dtypes: float64(128), int64(2)
memory usage: 3.7 MB
```

In [9]:

```
pivoted_df['Surgery'].value_counts()
```

Out[9]:

```
0.0    2772
1.0     916
Name: Surgery, dtype: int64
```

Time to start modeling! Split target and features and make a baseline model.

In [10]:

```
y = pivoted_df['Surgery']
X = pivoted_df.drop('Surgery', axis=1)
```

In [11]:

```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.
```

In [12]:

```python
#Make a pipeline to simplify process
logreg_pipeline = Pipeline([
    ('scale', StandardScaler()),
    ('logreg', LogisticRegression(solver='liblinear'))
])

# Define parameter grid to search
param_grid = {
    'logreg__C': [0.001, 0.01, 0.1, 1, 10, 100],  # Regularization str
    'logreg__penalty': ['l1', 'l2']  # Norm used in the penalization
}

# Initialize GridSearchCV with pipeline, parameter grid, and scoring me
grid_search = GridSearchCV(logreg_pipeline, param_grid, cv=5, scoring=

# Assuming X_train and y_train are already defined
grid_search.fit(X_train, y_train)

# Best parameters found
print("Best parameters: ", grid_search.best_params_)

# Best cross-validation score
print("Best cross-validation score: {:.2f}".format(grid_search.best_sc

# Test set score using the best parameters
print("Test set score: {:.2f}".format(grid_search.score(X_test, y_test
```

```
/usr/local/lib/python3.10/dist-packages/sklearn/svm/_base.py:1244: Conver
genceWarning: Liblinear failed to converge, increase the number of iterat
ions.
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/svm/_base.py:1244: Conver
genceWarning: Liblinear failed to converge, increase the number of iterat
ions.
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/svm/_base.py:1244: Conver
genceWarning: Liblinear failed to converge, increase the number of iterat
ions.
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/svm/_base.py:1244: Conver
genceWarning: Liblinear failed to converge, increase the number of iterat
ions.
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/svm/_base.py:1244: Conver
genceWarning: Liblinear failed to converge, increase the number of iterat
ions.
  warnings.warn(

Best parameters:  {'logreg__C': 10, 'logreg__penalty': 'l1'}
Best cross-validation score: 0.76
Test set score: 0.77
```

In [13]:

```
logreg_pipeline = Pipeline([
    ('scale', StandardScaler()),
    ('logreg', LogisticRegression(penalty='l1', C=10.0, solver='liblin
])
```

In [14]:

```
logreg_pipeline.fit(X_train, y_train)
```

Out[14]:

```
Pipeline(steps=[('scale', StandardScaler()),
                ('logreg',
                 LogisticRegression(C=10.0, penalty='l1', solver='libline
ar'))])
```

In a Jupyter environment, please rerun this cell to show the HTML representation or trust the notebook.
On GitHub, the HTML representation is unable to render, please try loading this page with nbviewer.org.

In [15]:

```
logreg_pipeline.score(X_test, y_test)
```

Out[15]:

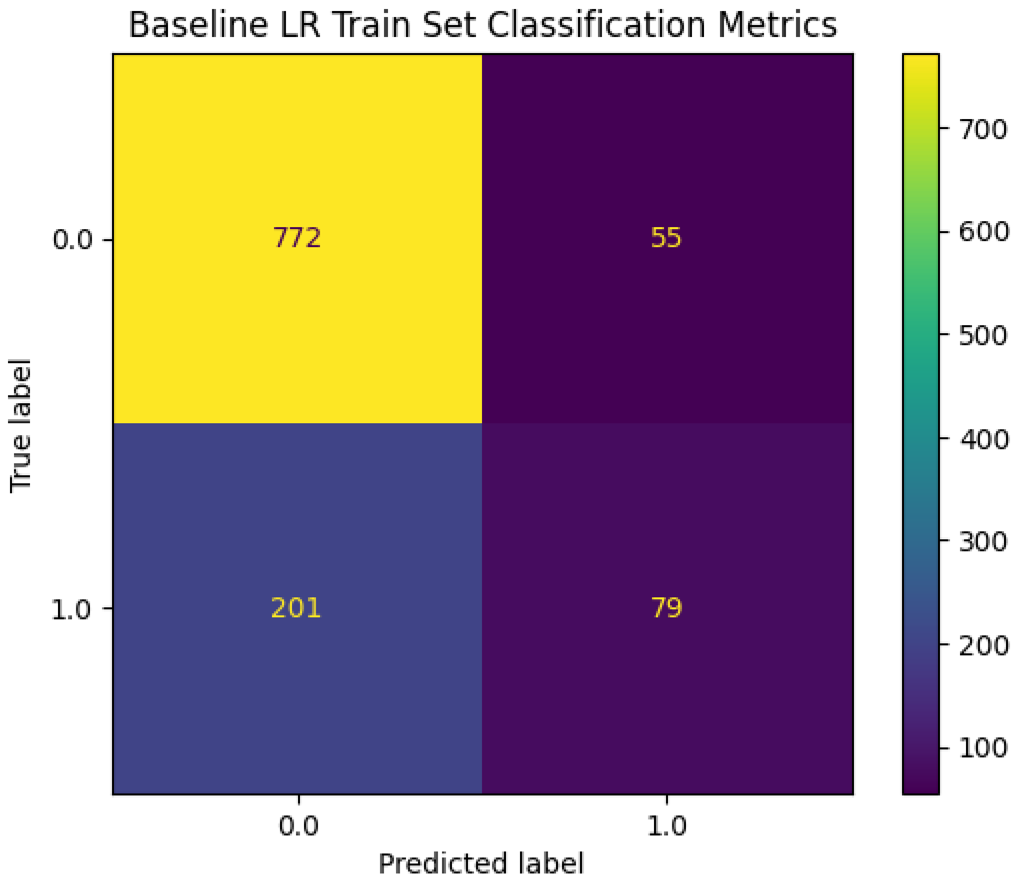
```
0.7687443541102078
```

In [16]:

```
y_pred = logreg_pipeline.predict(X_test)
```

In [17]:

```python
ConfusionMatrixDisplay.from_predictions(y_test, y_pred)
plt.title('Baseline LR Train Set Classification Metrics')
plt.show()
print(classification_report(y_test, y_pred))
```



```
              precision    recall  f1-score   support

         0.0       0.79      0.93      0.86       827
         1.0       0.59      0.28      0.38       280

    accuracy                           0.77      1107
   macro avg       0.69      0.61      0.62      1107
weighted avg       0.74      0.77      0.74      1107
```

Dataset is imbalanced, need to adjust. Should also focus on Recall score since this is a medical issue (better to have False Positive than True Negative!)

In [18]:

```python
y = pivoted_df['Surgery']
X = pivoted_df.drop('Surgery', axis=1)
```

In [19]:

```python
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.
```

In [24]:

```python
# Set up pipeline
weight_logreg_pipeline = Pipeline([
    ('scale', StandardScaler()),
    ('logreg', LogisticRegression(solver='liblinear'))
])

# Define the parameter grid to search over, including class weights
param_grid = {
    'logreg__C': [0.01, 0.1, 1, 10],
    'logreg__penalty': ['l1', 'l2'],
    'logreg__class_weight': [None, 'balanced', {0: 1, 1: 2}, {0: 1, 1:
    'logreg__max_iter': [5000],
    'logreg__tol': [0.01]
}

# Create a scoring function that focuses on recall for the positive cl
recall_scorer = make_scorer(recall_score, pos_label=1)

# Initialize GridSearch with pipeline, param grid, and recall
grid_search = GridSearchCV(weight_logreg_pipeline, param_grid, cv=5, s

# Fit the grid search to the data
grid_search.fit(X_train, y_train)

# Print the best parameters found and the best recall score
print("Best parameters: ", grid_search.best_params_)
print("Best cross-validation recall score: {:.2f}".format(grid_search.

# Evaluate the best model on the test set
best_model = grid_search.best_estimator_
y_pred = best_model.predict(X_test)
print("Test set recall score: {:.2f}".format(recall_score(y_test, y_pr
```

```
Best parameters:  {'logreg__C': 0.01, 'logreg__class_weight': {0: 1, 1:
5}, 'logreg__max_iter': 5000, 'logreg__penalty': 'l1', 'logreg__tol': 0.0
1}
Best cross-validation recall score: 0.87
Test set recall score: 0.86
```

In [25]:

```python
best_model.fit(X_train, y_train)
```

Out[25]:

```
Pipeline(steps=[('scale', StandardScaler()),
                ('logreg',
                 LogisticRegression(C=0.01, class_weight={0: 1, 1: 5},
                                    max_iter=5000, penalty='l1',
                                    solver='liblinear', tol=0.01))])
```

In a Jupyter environment, please rerun this cell to show the HTML representation or trust the notebook.
On GitHub, the HTML representation is unable to render, please try loading this page with nbviewer.org.

In [26]:

```
best_model.score(X_test, y_test)
```

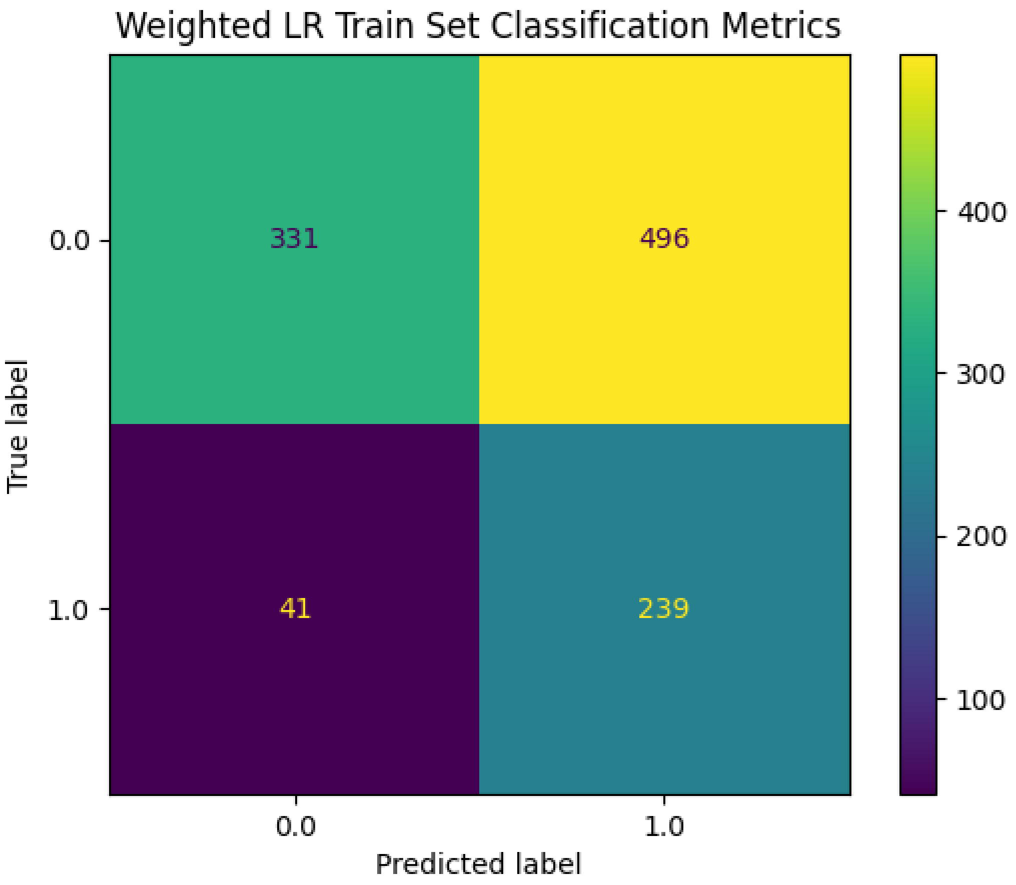
Out[26]: `0.5149051490514905`

In [28]:

```
y_pred = best_model.predict(X_test)
```

In [29]:

```
ConfusionMatrixDisplay.from_predictions(y_test, y_pred)
plt.title('Weighted LR Train Set Classification Metrics')
plt.show()
print(classification_report(y_test, y_pred))
```



```
              precision    recall  f1-score   support

         0.0       0.89      0.40      0.55       827
         1.0       0.33      0.85      0.47       280

    accuracy                           0.51      1107
   macro avg       0.61      0.63      0.51      1107
weighted avg       0.75      0.51      0.53      1107
```

Much better model. False Negatives is low, other classes much higher.

Decision Tree Classifier, baseline model.

In [30]:

```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.
```

In [31]:

```
tree_clf = DecisionTreeClassifier(criterion='gini', max_depth=5)
tree_clf.fit(X_train, y_train)
```

Out[31]:

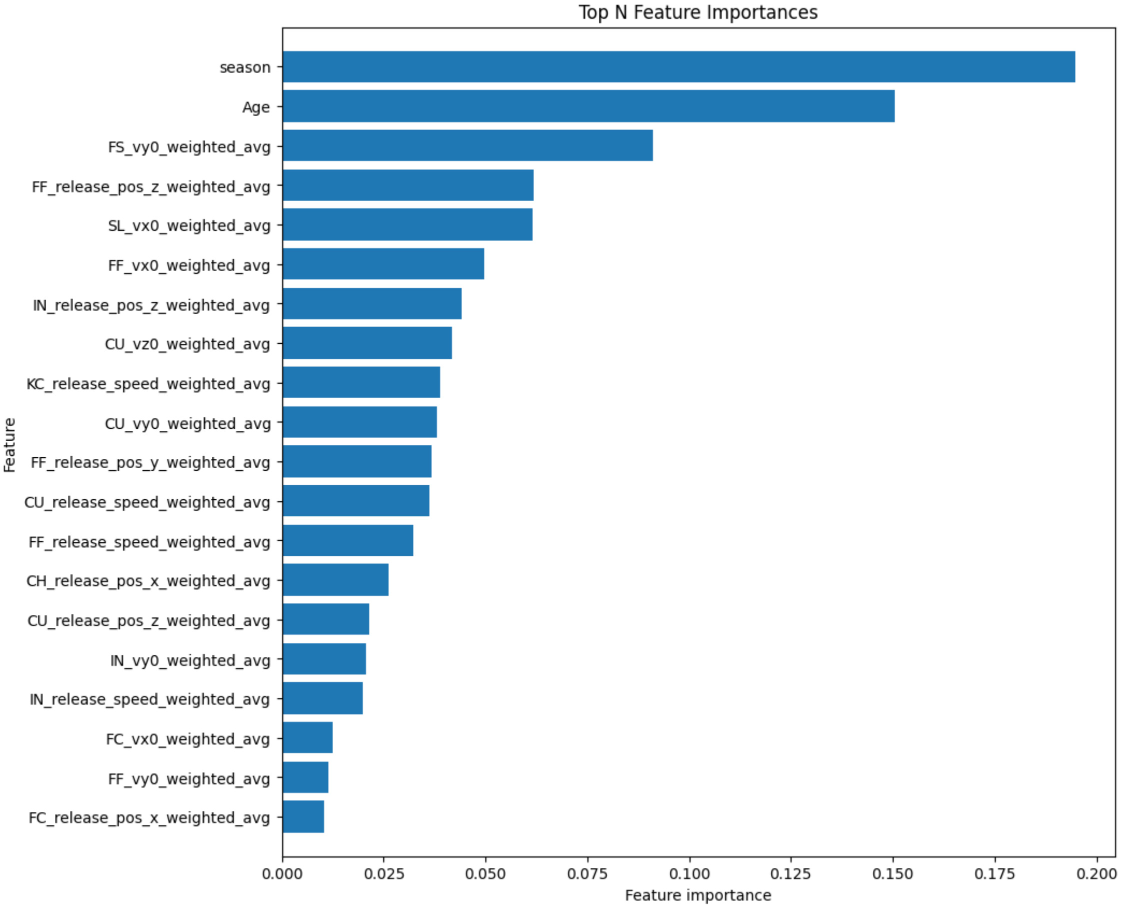
```
DecisionTreeClassifier(max_depth=5)
```

In a Jupyter environment, please rerun this cell to show the HTML representation or trust the notebook.
On GitHub, the HTML representation is unable to render, please try loading this page with nbviewer.org.

In [32]:

```
def plot_feature_importances(model, n_top_features=20):
    importances = model.feature_importances_
    indices = np.argsort(importances)[-n_top_features:]
    plt.figure(figsize=(10,10))
    plt.title('Top N Feature Importances')
    plt.barh(range(n_top_features), importances[indices], align='cente
    plt.yticks(range(n_top_features), [X_train.columns[i] for i in ind
    plt.xlabel('Feature importance')
    plt.ylabel('Feature')
    plt.ylim(-1, n_top_features)

plot_feature_importances(tree_clf, n_top_features=20)
plt.show()
```



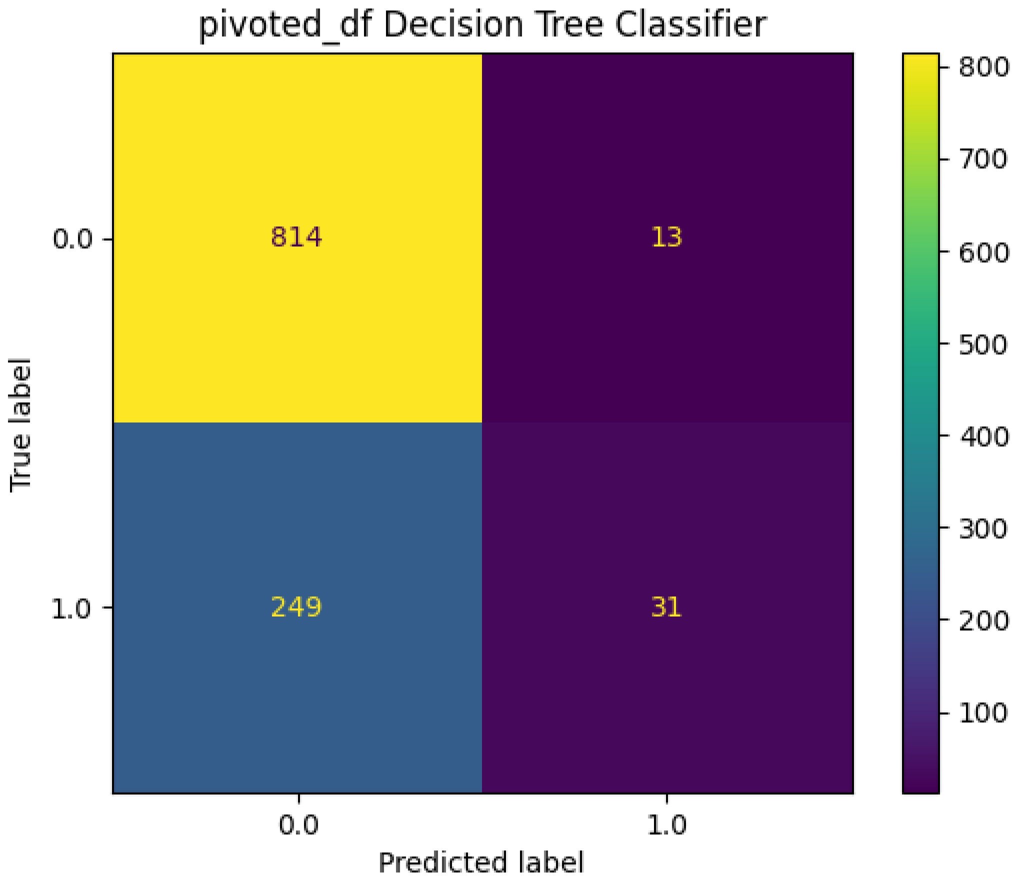
In [33]:

```
pred = tree_clf.predict(X_test)
```

In [34]:

```
pred = tree_clf.predict(X_test)

ConfusionMatrixDisplay.from_predictions(y_test, pred)
plt.title('pivoted_df Decision Tree Classifier')
plt.show()
print(classification_report(y_test, pred))
```



```
              precision    recall  f1-score   support

         0.0       0.77      0.98      0.86       827
         1.0       0.70      0.11      0.19       280

    accuracy                           0.76      1107
   macro avg       0.74      0.55      0.53      1107
weighted avg       0.75      0.76      0.69      1107
```

Terrible for TP and FP. Need to adjust. Features are interesting. Mostly fastball, curveball, some slider and split-finger.

In [35]:

```
y = pivoted_df['Surgery']
X = pivoted_df.drop('Surgery', axis=1)
```

In [36]:

```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.
```

In [37]:

```
param_grid = {
    'criterion': ['gini', 'entropy'],
    'max_depth': [5, 10, 15, 20],
    'min_samples_split': [2, 5, 10],
    'min_samples_leaf': [1, 2, 4],
    'class_weight': ['balanced', {0:1, 1:2}, {0:1, 1:3}]
}

tree_clf = DecisionTreeClassifier()
scorer = make_scorer(recall_score)
grid_search = GridSearchCV(estimator=tree_clf, param_grid=param_grid,
grid_search.fit(X_train, y_train)

print("Best parameters:", grid_search.best_params_)
print("Best score:", grid_search.best_score_)

best_tree = grid_search.best_estimator_
y_pred = best_tree.predict(X_test)
print("Test recall score:", recall_score(y_test, y_pred))
```

```
Best parameters: {'class_weight': 'balanced', 'criterion': 'gini', 'max_d
epth': 5, 'min_samples_leaf': 2, 'min_samples_split': 10}
Best score: 0.6524852362204725
Test recall score: 0.7607142857142857
```

In [38]:

```
best_tree.fit(X_train, y_train)
```

Out[38]:

```
DecisionTreeClassifier(class_weight='balanced', max_depth=5, min_samples_
leaf=2,
                       min_samples_split=10)
```

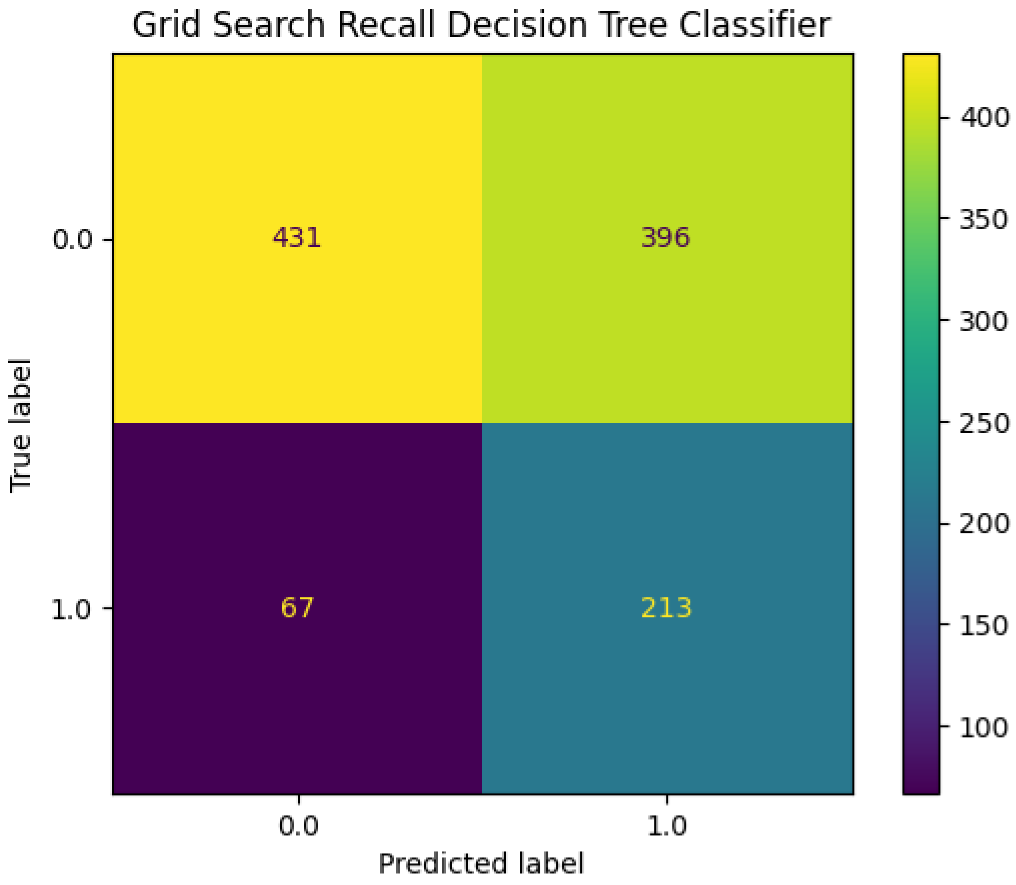
In a Jupyter environment, please rerun this cell to show the HTML representation or trust the notebook.
On GitHub, the HTML representation is unable to render, please try loading this page with nbviewer.org.

In [39]:

```
pred = best_tree.predict(X_test)
```

In [40]:

```
ConfusionMatrixDisplay.from_predictions(y_test, pred)
plt.title('Grid Search Recall Decision Tree Classifier')
plt.show()
print(classification_report(y_test, pred))
```



```
              precision    recall  f1-score   support

         0.0       0.87      0.52      0.65       827
         1.0       0.35      0.76      0.48       280

    accuracy                           0.58      1107
   macro avg       0.61      0.64      0.56      1107
weighted avg       0.74      0.58      0.61      1107
```

The Logistic Regression model with adjusted class weights performed the best.

In [ ]:

```

```