

Predicting SRS-22 MCID Attainment After Adult Spinal Deformity Surgery: Do Clinical or Radiographic Clusters Perform Better?

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Introduction

Adult spinal deformity (ASD) spans multiple phenotypes, so predicting meaningful postoperative patient-reported improvement is challenging. Unsupervised clustering may create more homogeneous phenotypes and support more individualized expectation-setting. However, it is unknown whether clustering driven mainly by patient-reported outcomes (PROMs) versus radiographic parameters changes the accuracy of MCID prediction.

Materials and Methods

Retrospective analysis of prospectively collected data. 498 ASD patients with complete preoperative data and ≥2-year follow-up were analyzed. Three clustering strategies with different variable selection were compared: C12-3 and C12-7 (radiographic-dominant, division in three and seven clusters), and C16-3 (clinical-dominant, division in three clusters). SRS-22 MCID thresholds were calculated globally and within clusters using published methods. Predictors included demographic, clinical, surgical, and radiographic variables. Supervised models (logistic regression, ElasticNet, random forest, LDA, QDA, KNN, SVM) were trained using an 80/20 train-test split with 5-fold cross-validation; discrimination was assessed by AUC.

Results

The best global model achieved AUC=0.70. Cluster-based models improved discrimination in selected phenotypes, but the benefit depended on both clustering strategy and prediction method. With C12-3, ElasticNet achieved AUC≈0.78 in cluster 3. With C12-7, performance was highest in the younger idiopathic and severe sagittal-imbalance clusters (AUC 0.72–0.82) and moderate in other clusters (AUC 0.63–0.68). With C16-3, cluster 1 showed the highest AUC overall (AUC≈0.80). Across all comparisons, ElasticNet consistently outperformed the other prediction models.

Table caption: Predictive performance for the best prediction model, for each clustering method.

Conclusion

No clustering strategy consistently outperformed the others for predicting SRS-22 MCID attainment. Nonetheless, clustering highlighted ASD phenotypes in which MCID prediction is substantially more (or less) reliable, supporting phenotype-specific counseling and shared decision-making.

Type of Clustering	Cluster	Split Method	Best Method	Accuracy	AUC	Sensitivity	Specificity
Complete dataset	-	80/20	ElasticNet	0,648	0,7	0,758	0,52
C12_3	1	ElasticNet	5-fold CV	0,613	0,631	0,729	0,519
	2	ElasticNet	80/20	0,697	0,624	0,724	0,507
	3	ElasticNet	80/20	0,786	0,624	0,724	0,507
C16_3	1	ElasticNet	5-fold CV	0,805	0,575	0,572	0,589
	2	ElasticNet	80/20	0,61	0,574	0,582	0,579
	3	QDA	80/20	0,594	0,559	0,528	0,59
C12_7	1	SVM	5-fold CV	0,82	0,427	0,305	0,585
	2	ElasticNet	80/20	0,721	0,628	0,795	0,411
	3	Logistic Regression	80/20	0,653	0,618	0,725	0,479
	4	ElasticNet	80/20	0,801	0,628	0,795	0,411
	5	SVM	5-fold CV	0,818	0,427	0,305	0,585
	6	LDA	80/20	0,637	0,622	0,73	0,48
	7	ElasticNet	5-fold CV	0,675	0,627	0,8	0,406