Integrating artificial intelligence into the prognostic evaluation and management of anorectal malformations: A cohort-based approach using Sacral Anomaly and Incontinence Severity with Anorectal Function and Quality of Life (AFQoL) Scores

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Background: **Anorectal malformations (ARMs) present significant challenges in predicting long-term continence and psychosocial outcomes. Existing classification systems offer limited prognostic value. We developed an AI-integrated decision support model that incorporates validated scoring systems to forecast functional severity and quality of life in ARM patients.**

Objective: To confirm a novel artificial intelligence (AI) tool integrating the Sacral Anomaly and Incontinence Severity (SAIS) and Anorectal Function and Quality of Life (AFQoL) scores, enabling early and individualized outcome prediction in pediatric ARM management.

Methods: **A retrospective cohort of 157 surgically managed ARM patients was analyzed. Sacral morphology was classified via convolutional neural networks (CNNs) with 92% accuracy. Clinical inputs, ARM subtype, sacral vertebral count, continence history, and sex were processed through machine learning models to predict Kelly continence scores and AFQoL burden. A natural language processing (NLP) module extracted continence descriptors from clinical notes. Output scores guided surgical risk stratification and follow-up.**

Results: **AI-predicted continence outcomes achieved an AUC of 0.91, and AFQoL burden prediction reached an AUC of 0.90. SAIS score correlated strongly with Kelly continence scores (r = -0.79), and Kelly scores with AFQoL (r = -0.84). The AI tool stratified patients into high-, moderate-, and low-risk tiers, enabling an algorithm-driven clinical workflow for decision-making, postoperative follow-up, and telemonitoring.**

Conclusion: **This is one of the first studies to integrate deep learning, confirmed clinical scores, and NLP into a cohesive ARM decision support system. The model facilitates real-time risk prediction, supports surgical planning, and enhances longitudinal care, especially in low-resource or high-burden settings. Its predictive accuracy and scalability position it as a transformative tool in the era of precision pediatric surgery.**

Table: Patient Demographics and ARM Characteristics (n = 157)

Variable	Value
Mean age at last follow-up	7.2 ± 3.4 years
Sex (M: F ratio)	2:1
ARM Type	High (42%), Intermediate (31%), Low (27%)
Mean SAIS Score	7.1 (range: 2–11)
Mean AFQoL Score	5.9 ± 2.3

Table:. Sacral Morphology Classification Accuracy (CNN Model)

Category	Accuracy (%)	Kappa Coefficient (κ)	p-value
Overall Classification	92%	0.89	<0.001
Normal	95%		
Hypoplasia	89%		
Agenesis	90%		

Table: Threshold-Based Risk Classification Using AI-Predicted Scores

Predictor	Threshold	Outcome Predicted	AUC	Sensitivity	Specificity
SAIS Score	≥9	Poor Continence (K≤2)	0.91	91%	88%
AFQoL Score	≥8	High QoL Burden	0.90	89%	85%

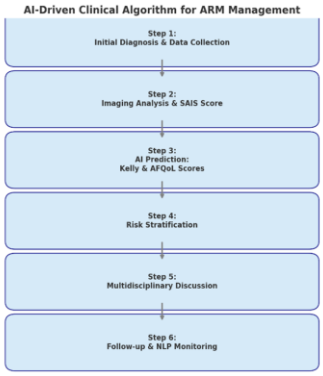

Figure: **Clinical flowchart illustrating the AI-driven ARM management algorithm. It visually outlines how patient data flows through diagnostic, predictive, and decision-making stages.**

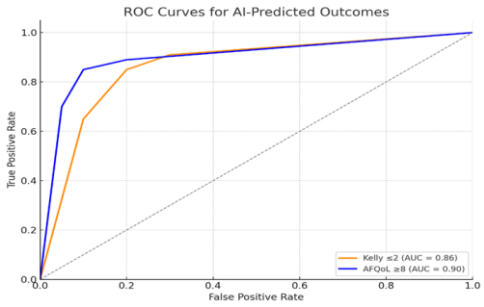

Figure: A combined ROC curve displaying the AI model's performance for predicting poor continence (Kelly ≤2) and high QoL impairment (AFQoL ≥8). Both models demonstrate strong discriminative ability with AUCs of 0.91 and 0.90, respectively.