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### **Machine Learning vs. Deep Learning for Tooth Wear Analysis**

P. BINVIGNAT<sup>1</sup>, S. Valette<sup>2</sup>, A. Hara<sup>3</sup>, P. Lahoud<sup>4</sup>, R. Jacobs<sup>4</sup>, R. Sarig<sup>5</sup>, A. Chaurasia<sup>6</sup>, M. Ducret<sup>1</sup>, R. Richert<sup>1</sup>

<sup>1</sup>Hospices Civils de Lyon, Lyon, France, <sup>2</sup>Centre de recherche en acquisition et traitement de l'image pour la santé, Lyon, France, <sup>3</sup>Oral Health Research Institute, Department of Cariology and Operative Dentistry, Indiana University School of Dentistry,, Indianapolis, Indiana, United States, <sup>4</sup>University Hospitals Leuven,, Leuven, Belgium, <sup>5</sup>Goldschleger School of Dental Medicine, Faculty of Medicine., Tel Aviv, Israel, <sup>6</sup>King George's Medical University., Lucknow, India

**Objectives** This study aims to compare the efficacy and explainability of machine learning (ML) and deep learning (DL) techniques in reconstructing the anatomy of upper central incisors, particularly in cases of tooth wear, to enhance digital smile design.

**Methods** A dataset of permanent maxillary incisor teeth was collected from three universities and categorized based on the degree of alteration of the incisal surface. ML and DL approaches were employed to learn and simulate tooth shapes. ML approaches were based on a combined approach of isotopological remeshing with principal component analysis, while DL approaches were based on the learning of Deep Signed Distance Functions. The performances of both approaches were evaluated using five anatomical features: tooth volume and length, external surface, tooth inclination and root/crown angle. Distances between initial and reconstructed shapes were also compared. Explainability was assessed through feature contribution analysis for ML approaches.

**Results** Among the 345 STL files collected, 285 were included in the dataset. The shapes were learned for ML and DL approaches with a maximal Euclidian distance inferior to 0.3 mm. For the ML approach, the first five modes of shape variations represented 70.9% of the overall shape variability in the population. The surface and volume of the tooth could mostly be explained by the variations in the mode 1. Regarding the simulation of intact teeth, DL presented significantly more precise and accurate reconstructions compared to ML, with differences observed in surface, volume, and maximal distance ( $p < 0.05$ ).

**Conclusions** Overall, our comparative analysis underscores the potential of DL as a robust and accurate tool for digital smile design, particularly in addressing challenges associated with tooth wear. However, further research should focus on refining DL models and integrating explainable AI methodologies to ensure transparency and foster trust among clinicians and patients.