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AI in Automated Cephalometric Analysis for Orthodontic Assessment

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ADMINISTRATIVE INFORMATION

Support - King Khalid University.

Review Stage at time of this submission - Completed but not published.

Conflicts of interest - None declared.

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Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 2 October 2025 and was last updated on 2 October 2025.

INTRODUCTION

Review question / Objective To evaluate the successful detection rate (SDR), mean radial error, and time utilization of AI-assisted cephalometric landmark detection compared with conventional/manual methods.

Rationale Traditional cephalometric analysis has limitations like errors and inconsistencies, while AI improves accuracy, efficiency, and reproducibility in orthodontics.

Condition being studied Process of cephalometric landmark identification for lateral skull radiographs and analysis for orthodontic diagnosis and treatment planning.

METHODS

Search strategy Comprehensive searches in PubMed, Cochrane Library, Scopus, Web of Science, and Elsevier up to August 2025.

Participant or population Patients of any age needing cephalometric landmark identification for orthodontic evaluation, from diverse retrospective and multicenter datasets.

Intervention AI-assisted automated systems, including deep learning or machine learning algorithms, designed to detect cephalometric landmarks.

Comparator Conventional manual cephalometric analysis by trained orthodontists or standard software.

Study designs to be included Randomized controlled trials, retrospective and prospective diagnostic/validation studies, cross-sectional observational and comparative experimental studies.

Eligibility criteria English-language original studies from 2000 using human radiographs with quantitative data on accuracy or time, excluding reviews, case reports, and animal studies.

Information sources Electronic databases searched included PubMed, Scopus, ScienceDirect, Cochrane Library, and Web of Science.

Main outcome(s) Successful Detection Rate (SDR) of landmarks, the Mean Radial Error (MRE) in millimeters, and the time efficiency for analysis.

Additional outcome(s) Treatment planning accuracy, diagnostic concordance, intraclass correlation coefficients (ICC), and patient satisfaction.

Data management Independent screening in EndNote, full-text review, extraction to Excel, and third-author resolution of disagreements.

Quality assessment / Risk of bias analysis Used RoB2 for RCTs and ROBINS-I for observational studies, visualized with Robvis plots.

Strategy of data synthesis Meta-analyses were conducted using both fixed-effect and random-effects models to pool continuous and dichotomous outcomes, with heterogeneity assessed using I^2 statistics. Publication bias was examined with Begg/Egger.

Subgroup analysis Examined AI model type and anatomical regions like sella, maxilla, and mandible.

Sensitivity analysis Conducted by sequentially excluding individual studies to assess the robustness of the meta-analysis findings.

Language restriction Included only English-language publications.

Country(ies) involved United States of America, Saudi Arabia, India.

Other relevant information The analysis adhered to PRISMA guidelines.

Keywords Artificial Intelligence, AI, Cephalometric Analysis, Cephalometry, Orthodontics, Automated Landmark Detection, Deep Learning,Meta-Analysis.

Dissemination plans Standard academic dissemination through publication in a peer-reviewed journal is implied.

Contributions of each author

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