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Generative AI for Automated Orthodontic Treatment Simulation in Adolescents

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INTRODUCTION & AIM

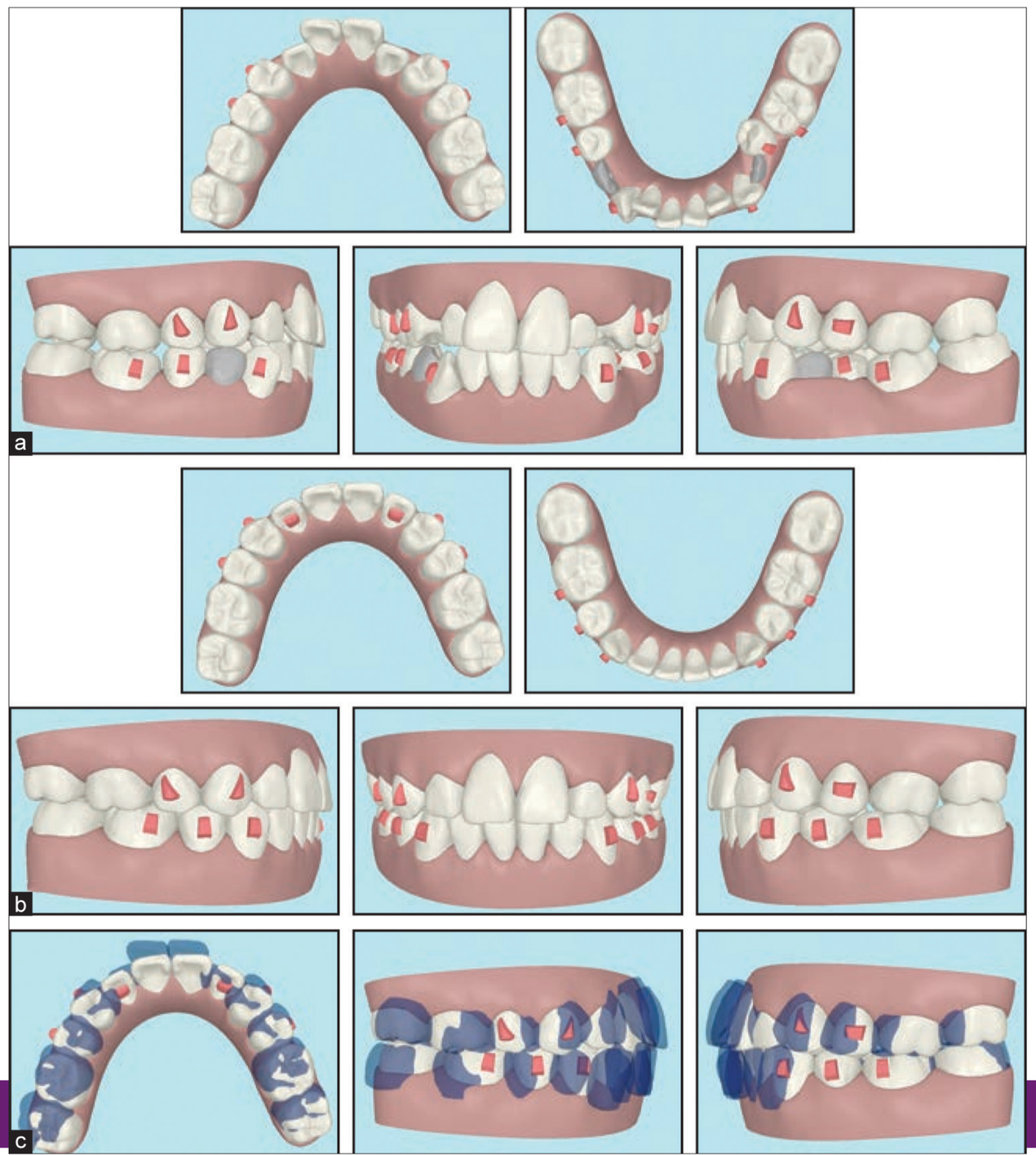
Accurate prediction of orthodontic treatment outcomes is essential for effective treatment planning and patient communication. Traditional orthodontic planning relies on clinician experience, cephalometric analyses, and manual evaluation of radiographs and facial photographs. However, these methods may be time-consuming and sometimes limited in predicting individual variations in tooth movement and facial profile changes.

Recent advances in generative artificial intelligence (AI), including Generative Adversarial Networks (GANs) and diffusion models, enable the generation of realistic medical images and predictive simulations. In orthodontics, such technologies may allow clinicians to visualize potential treatment outcomes and simulate gradual changes in dental alignment and facial profile over time.

The aim of this study was to evaluate the potential of generative AI models to simulate orthodontic treatment outcomes in adolescent patients and assess their usefulness in treatment planning, workflow efficiency, and patient communication.

METHOD

A generative diffusion model was trained on a dataset of 8,000 orthodontic cases, including panoramic radiographs, lateral cephalograms, and baseline facial photographs. The model generated predicted orthodontic outcomes at 6-, 12-, and 18-month intervals, simulating progressive tooth movement and facial profile changes during treatment.
Orthodontists evaluated AI-generated simulations by comparing them with actual post-treatment results using the Structural Similarity Index (SSIM), mean cephalometric landmark deviation, and qualitative assessment of dental alignment and facial profile changes. Additionally, clinicians assessed the potential impact of AI-based simulations on treatment planning efficiency and patient communication.



RESULTS & DISCUSSION

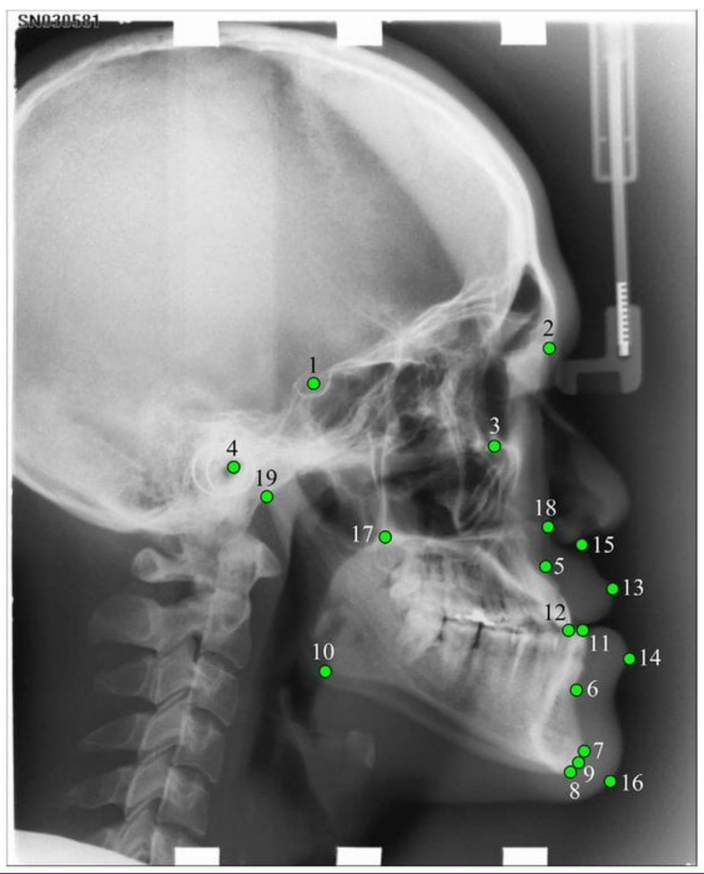
The generative diffusion model demonstrated high accuracy in predicting orthodontic treatment outcomes.

- Structural Similarity Index (SSIM): 0.93, indicating strong similarity between AI-generated simulations and real post-treatment images.
- Mean cephalometric deviation: < 1.5 mm across key dental landmarks.
- AI-generated simulations enabled visualization of treatment progress at 6-, 12-, and 18-month intervals.
- Orthodontists reported improved communication with patients and parents, as visual projections helped align expectations regarding treatment outcomes.
- Workflow analysis showed a 34% reduction in treatment planning time compared with conventional digital planning methods.

These findings suggest that generative AI models can provide realistic and clinically useful orthodontic treatment simulations while improving efficiency in orthodontic workflows.

The results suggest that generative AI models can produce realistic simulations of orthodontic treatment outcomes with high structural similarity to real post-treatment results. Visualized predictions of dental and facial changes may support clinicians in treatment planning and improve communication with patients and their families.

However, the reliability of AI-based simulations depends on dataset quality, model training, and variability in biological responses to orthodontic forces. Therefore, further validation in larger and more diverse patient populations is necessary.



CONCLUSION

Generative AI models offer a promising approach for automated orthodontic treatment simulation in adolescents. These technologies may enhance treatment planning, improve patient communication, and increase clinical workflow efficiency. Further validation and integration into digital orthodontic systems will be essential for their broader implementation in clinical practice.

FUTURE WORK / REFERENCES

Future studies should focus on validating generative AI models in larger and more diverse clinical datasets. The integration of such systems with digital orthodontic workflows and treatment planning software may further enhance their clinical usefulness.