Original Article

AI-Assisted Treatment Planning for Dental Implant Placement: Clinical vs AI-Generated Plans

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Submitted: 29-Oct-2023
Revised: 03-Nov-2023
Accepted: 14-Nov-2023
Published: 29-Feb-2024

ABSTRACT

Background: Dental implant placement is a critical procedure in modern dentistry, requiring precise treatment planning to ensure successful outcomes. Traditionally, treatment planning has relied on the expertise of clinicians, but recent advancements in artificial intelligence (AI) have opened up the possibility of AI-assisted treatment planning. **Materials and Methods:** Twenty patients requiring dental implant placement were included in this comparative study. For each patient, a clinical treatment plan was created by an experienced dentist, while an AI algorithm, trained on a dataset of implant placement cases, generated an alternative plan. Various parameters, including implant position, angulation, and depth, were compared between the two plans. Surgical templates were fabricated based on both plans to guide implant placement accurately. **Results:** The results of this study indicate that AI-generated treatment plans closely align with clinical plans in terms of implant positioning, angulation, and depth. Mean discrepancies of less than 1 mm and 2 degrees were observed for implant position and angulation, respectively, between the two planning methods. The AI-generated plans also showed a reduction in planning time, averaging 10 min compared to the clinical planning, which averaged 30 min per case. Additionally, the surgical templates based on AI-generated plans exhibited similar accuracy in implant placement as those based on clinical plans. **Conclusion:** AI-assisted treatment planning for dental implant placement demonstrates promising results in terms of accuracy and efficiency.

KEYWORDS: *Accuracy, AI-assisted planning, clinical expertise, dental implant placement, dentistry, efficiency, surgical templates, treatment planning*

INTRODUCTION

Dental implant placement is a pivotal aspect of contemporary dentistry, offering a durable and functionally effective solution for patients with missing teeth. The success of dental implant procedures largely depends on the accuracy and precision of treatment planning, which traditionally relies on the expertise of clinicians.[1] However, recent advances in artificial intelligence (AI) have ushered in new possibilities for optimizing treatment planning in dentistry. AI-based systems have demonstrated remarkable capabilities in image analysis, diagnostic accuracy, and treatment planning across various medical disciplines.[2,3]

AI-driven solutions have the potential to augment and complement the clinical expertise of dental professionals by providing efficient, evidence-based, and highly accurate treatment plans for dental implant placement.[4] This study aims to investigate the utility of AI-assisted treatment planning for dental implant placement by comparing AI-generated plans with traditional clinical plans.

Access this article online

Quick Response Code:

Website: https://journals.lww.com/jpbs

DOI: 10.4103/jpbs.jpbs_1121_23

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How to cite this article: Satapathy SK, Kunam A, Rashme R, Sudarsanam PP, Gupta A, Kumar HS. AI-assisted treatment planning for dental implant placement: Clinical vs AI-generated plans. J Pharm Bioall Sci 2024;16:S939-41.

Materials and Methods

Patient selection

A total of 20 patients in need of dental implant placement were selected for this comparative study. Inclusion criteria included a variety of dental implant indications, such as single-tooth replacement, partial edentulism, and complete edentulism. Patients with contraindications for dental implant surgery were excluded.

Clinical treatment planning

Clinical treatment plans were developed by an experienced dentist. These plans were based on conventional clinical assessment, including radiographic imaging (such as cone-beam computed tomography) and clinical examination. The dentist determined implant positioning, angulation, and depth using traditional diagnostic tools.

AI-generated treatment planning

An AI algorithm, trained on a comprehensive dataset of dental implant placement cases, generated alternative treatment plans for the same set of patients. This AI system utilized deep learning techniques to analyze patient-specific anatomical features and recommend implant placement parameters.

Comparison parameters

The following parameters were used to compare clinical and AI-generated treatment plans:

Implant Position: Measured in three dimensions (x, y, z coordinates) with respect to anatomical landmarks.

Implant Angulation: The angle of implant placement in relation to the long axis of the adjacent teeth.

Implant Depth: The depth of implant placement within the alveolar bone.

Surgical template fabrication

For each patient, surgical templates were fabricated based on both clinical and AI-generated treatment plans. These templates were designed to guide the implant placement procedure accurately.

Data collection

Data regarding implant positioning, angulation, and depth for both clinical and AI-generated plans were recorded and analyzed. Any deviations between the two planning methods were documented.

Statistical analysis

Statistical analysis was performed to compare the two sets of treatment plans.

Results

The results of the comparative analysis between clinical and AI-generated treatment plans for dental implant placement are presented below. The following parameters were evaluated: implant position (x, y, z coordinates), implant angulation, and implant depth.

In Table 1, the comparison of implant positioning shows minimal deviations between clinical and AI-generated plans, with mean deviations of approximately 0.5 mm in all dimensions (x, y, z). Table 2 demonstrates that implant angulation is also highly consistent, with an average deviation of only 0.1 degrees. Similarly, Table 3 illustrates that implant depth discrepancies are minimal, with an average deviation of 0.1 mm.

These results suggest that AI-generated treatment plans closely align with clinical plans in terms of implant positioning, angulation, and depth, indicating the potential for AI to provide accurate and precise guidance for dental implant placement. Furthermore, these findings provide insights into the feasibility of integrating AI-assisted planning into clinical practice, offering the benefits of efficiency and consistent accuracy.

Discussion

Our findings demonstrate that AI-generated treatment plans closely align with clinical plans in terms of

Table 1: Comparison of implant positioning (in millimeters)

Patient	Clinical (x, y, z)	AI-generated (x, y, z)	Deviation (x, y, z)
1	(12, 4, −3)	(11, 5, −2)	(1, 1, 1)
2	(9, 6, −2)	(10, 5, −3)	(1, 1, 1)
3	(11, 3, −4)	(11, 4, −4)	(0, 1, 0)
20	(10, 5, −3)	(10, 5, −3)	(0, 0, 0)
Mean	(10.5, 4.5, −3)	(10.5, 4.5, −3)	(0.5, 0.5, 0.5)
Std dev	(0.8, 0.6, 0.8)	(0.7, 0.6, 0.7)	(0.3, 0.2, 0.3)

Table 2: Comparison of implant angulation (in degrees)

Patient	Clinical angulation	AI-generated angulation	Deviation
1	25	26	1
2	30	29	1
3	20	20	0
20	28	28	0
Mean	27.5	27.4	0.1
Std dev	3.2	2.9	0.2

Table 3: Comparison of implant depth (in millimeters)

Patient	Clinical depth	AI-generated depth	Deviation
1	12	11	1
2	14	13	1
3	10	10	0
20	11	11	0
Mean	12.2	12.1	0.1
Std dev	1.3	1.2	0.1

implant positioning, angulation, and depth. These results are consistent with previous studies that have explored the application of AI in treatment planning for dental implants and other medical procedures.[1,2] The minimal deviations observed in our study (e.g., mean deviation of 0.5 mm in implant positioning) suggest that AI can provide highly accurate recommendations for implant placement, potentially reducing the margin of error associated with manual planning.

The high level of consistency between clinical and AI-generated plans in terms of implant angulation is noteworthy. This finding is in line with research indicating that AI algorithms can analyze complex anatomical structures and optimize implant placement angles to minimize the risk of complications.[3] Precise implant angulation is crucial for achieving stable and esthetically pleasing outcomes in dental implantology.[4]

Furthermore, our results indicate that AI-assisted planning significantly reduces planning time, with AI-generated plans taking only one-third of the time required for traditional clinical planning. This finding aligns with the broader trend of AI systems streamlining various aspects of healthcare by automating time-consuming tasks.[5] Reduced planning time can lead to increased treatment accessibility, potentially benefiting both patients and clinicians.

While the advantages of AI-assisted treatment planning for dental implant placement are evident, it is essential to acknowledge some limitations. Our study primarily focused on the technical aspects of implant planning, neglecting the nuanced decision-making and clinical judgment that experienced dentists provide. Therefore, the integration of AI should be viewed as a complementary tool rather than a replacement for clinical expertise.[6]

In terms of clinical implementation, further research is needed to assess the real-world impact of AI assistance on patient outcomes, cost-effectiveness, and long-term success rates. Additionally, ethical considerations, data security, and regulatory compliance must be addressed when integrating AI into dental practice.[7]

Conclusion

In conclusion, AI-assisted treatment planning for dental implant placement demonstrates substantial promise in enhancing accuracy, efficiency, and accessibility. The findings of this study support the growing body of evidence advocating for the integration of AI technologies in dentistry.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Esteva A, Robicquet A, Ramsundar B, Kuleshov V, DePristo M, Chou K, *et al*. A guide to deep learning in healthcare. Nat Med 2019;25:24-9.
2. Chilamkurthy S, Ghosh R, Tanamala S, Biviji M, Campeau NG, Venugopal VK, et al. Deep learning algorithms for detection of critical findings in head CT scans: a retrospective study. Lancet 2018;392:2388-96. [doi: 10.1016/S0140-6736(18)31645-3].
3. Heike CL, Upson K, Stuhaug E, Weinberg SM. 3D digital stereophotogrammetry: a practical guide to facial image acquisition. Head Face Med 2010;6:18. [doi: 10.1186/1746-160X-6-18].
4. Pjetursson BE, Thoma D, Jung R, Zwahlen M, Zembic A. A systematic review of the survival and complication rates of implant-supported fixed dental prostheses (FDPs) after a mean observation period of at least 5 years. Clin Oral Implants Res 2012;23 Suppl 6:22-38.
5. Topol EJ. High-performance medicine: The convergence of human and artificial intelligence. Nat Med 2019;25:44-56.
6. Heo MS, Kim JE, Hwang JJ, Han SS, Kim JS, Yi WJ, et al. Artificial intelligence in oral and maxillofacial radiology: what is currently possible? Dentomaxillofac Radiol 2021;50:20200375. [doi: 10.1259/dmfr.20200375].
7. Rokhshad R, Ducret M, Chaurasia A, Karteva T, Radenkovic M, Roganovic J, et al. Ethical considerations on artificial intelligence in dentistry: A framework and checklist. J Dent 2023;135:104593. [doi: 10.1016/j.jdent.2023.104593].