

Content available at: <https://www.ipinnovative.com/open-access-journals>

IP Annals of Prosthodontics and Restorative Dentistry

Journal homepage: <https://www.aprd.in/>**Review Article****Artificial intelligence applications in dental implantology: A narrative review**Veena Benakatti^{1*}, Ramesh P Nayakar¹, Suvidha Patil¹¹Dept. of Prosthodontics, KAHER'S KLE VK Institute of Dental Sciences, Belagavi, Karnataka, India**ARTICLE INFO***Article history:*

Received 22-12-2023

Accepted 10-04-2024

Available online 15-05-2024

Keywords:

Artificial intelligence

Dental Implants

Machine learning

Deep learning

Peri-implantitis

ABSTRACT

Artificial intelligence (AI) has a substantial impact on various domains of society, including its significant role in revolutionizing dental care. These technological innovations have transformed dental treatment, expediting efficiency and innovation in the field. This review focuses on the substantial advancements in AI-based research in dental implantology, exploring the various applications of AI to enhance dental implant care. Comprehensive data from databases, including PubMed, Scopus, Web of Science, Cochrane, and Google Scholar, was thoroughly scrutinized and presented. AI has significantly impacted healthcare and dental implantology by enhancing efficiency, diagnosis, and clinical decision-making. In dental implantology, AI plays a crucial role in several aspects, such as implant identification, implant planning, prediction, and peri-implantitis management. AI models, including machine learning and deep learning, have been applied to identify implant brands accurately, outperforming dental professionals in some cases. Implant planning has been streamlined using AI to evaluate bone dimensions and locate critical anatomical landmarks. Using patient data and radiographic features, AI-driven prediction models proved as powerful tools for predicting implant success and peri-implantitis risk. Additionally, AI helps in the early recognition of complications like fractured implants and bio-tribocorrosion.

This is an Open Access (OA) journal, and articles are distributed under the terms of the [Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License](https://creativecommons.org/licenses/by-nc-sa/4.0/), which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: reprint@ipinnovative.com**1. Introduction**

Artificial intelligence (AI) is the widely discussed concept of the current times. The pervasive impact of AI extends across various domains of society, encompassing education, agriculture, healthcare, military, and governance alike. Its far-reaching influence has revolutionized these sectors, driving innovation, efficiency, and improved decision-making processes. AI and robotics have made significant inroads into the dental specialty, revolutionizing various aspects of dental care. For instance, we can observe their influence in invisible aligners, caries diagnosis, image-guided surgery, virtual surgical planning, and robotic implant placement.^{1,2} These innovations have undoubtedly transformed the way dental treatments are performed and

have brought groundbreaking advancements in the field. This review emphasizes the substantial advancements in AI-based research applied to dental implantology and the focus is on exploring the diverse applications of AI in dental implantology.

2. Methodology

For this review, comprehensive data from databases, including PubMed, Scopus, Web of Science, Cochrane, and Google Scholar, was thoroughly examined. Only English-language journal articles published until 2023 were included, ensuring the most up-to-date and relevant information regarding AI applications in dental implantology. The keywords used for the search strategy were AI, dental implants, and dental implantology.

* Corresponding author.

E-mail address: kenganalveena@gmail.com (V. Benakatti).

This review delves into various applications where AI is actively researched to address specific issues, such as dental implant identification, implant planning, peri-implantitis, and predictions in dental implantology.

3. Discussion

3.1. AI in dental implant identification

Dental implant identification, an essential process during the maintenance and repair of implants, is one of the challenges faced by clinicians in practice.³ In the history of implantology, several methods were proposed for implant identification however none of them are quick or easy and require a significant amount of human effort, experience, and time. In a thrust for implant identification, AI techniques were implemented by researchers and proved to be beneficial. This is one of the several AI applications in dental implantology that is highly researched in the current times.

In the AI technique of implant identification, the data-to-train AI model is a digital intraoral radiograph of the implant. The data is split into a training and testing set where the training dataset trains the algorithm and the test dataset analyses the performance of the trained AI model. Different AI models are tested by researchers on different implant systems with varied sample sizes and the performance of these AI systems was found to be promising as outlined in Table 1. In some of the comparative studies, AI models have demonstrated superior performance over dental professionals in implant identification.

Researchers have conducted diverse studies utilizing various AI algorithms and implant systems, with considerable variation in sample sizes. Reported accuracies in implant identification ranged from 71% to 98%.^{4–15} Few studies compared the performance of AI models with dental professionals, revealing that AI exhibited superior performance. Based on these studies researchers suggested testing additional algorithms with a broader range of implant systems and increased sample sizes to facilitate the clinical implementation of AI in dental implant identification. The integration of AI for implant identification will increase efficiency and reduce the effort and time spent using conventional methods.

3.2. AI in implant planning

Pre-surgical planning is an essential task in dental implantology to assure long-term success and minimize risks related to surgery. CBCT (cone-beam computed tomography) is an effective tool in implant planning, by offering vital information on roots, bone, nerves, and other crucial anatomic structures. This aids in choosing the location, and correct implant size, and predicting the need for supplementary surgical procedures. However, the process requires the clinician to manually demarcate

structures and arrive at a treatment plan making the process complex and time-consuming. DL, a subset of AI is successfully implemented in medical image interpretation and can be a helpful tool in implant planning.¹⁶ Implant planning for a mandibular area needs accurate detection of the mandibular canal and the width and height of the alveolar bone.¹⁷ Tooth segmentation is a crucial step in implant planning for reconstructing 3D tooth models and is typically done manually by the operator. These manual delineations can be automated with deep learning a subset of AI.¹⁸ Table 2 outlines AI applications in dental implant planning.

Researchers have achieved considerable success in utilizing AI models for segmenting and locating critical anatomic landmarks as well as measuring bone dimensions that are valuable in implant planning. However, the implementation of AI in implant planning may still require validation through clinical trials and continuous improvements to optimize its performance.

3.3. AI in peri-implantitis management

Peri-implantitis influences over 25% of dental implants leading to progressive bone loss and loss of implants. Consequently, routine implant maintenance and long-term management of peri-implantitis are essential components of preventive care. This calls for risk estimation, detection, and grading of peri-implantitis.²⁸ Several studies^{29–32} have implemented AI to predict and detect peri-implantitis, as outlined in Table 3. R-CNN (Region-based Convolutional Neural Networks), random forest classifiers, logistic regression, and support vector machine (SVM) algorithms were implemented for peri-implantitis detection and some of these models demonstrated the risk factors associated with the development of peri-implantitis. AI systems achieved considerable accuracy in peri-implantitis detection and prediction, integration of AI can be a valuable adjunct to improve diagnostic capabilities and effective treatment strategies to prevent and manage peri-implantitis.

3.4. AI-driven prediction in dental implantology

Despite advancements in implant technologies and newer diagnostic and planning protocols, complications remain a significant concern. Consequently, there is a need for new methods that assess a patient's condition and predict the success of dental implants. With the rapid progress in AI and the abundant data available, the development of AI-based systems for auxiliary diagnostics has become relevant. In dental implantology, AI systems can offer a valuable supplementary diagnosis based on mathematical decision-making and forecasting.³³

Lyakhov PA et al proposed an AI system that analyzes patient statistics to predict the single implant survival. The system's novelty lies in its design to effectively recognize

Table 1: AI in dental implant identification

Author	Radiograph used	Number of images used	Algorithm architecture	Accuracy of the model	Comparison with the dental professional
Lee JH et al ⁴	Panoramic and Periapical radiographs	3000	VGG-19 (visual geometry group), GoogLeNet Inception-v3, ResNet-50	89.1% 92.2% 90.7%	Not reported
Said M H et al ⁵	Periapical and panoramic radiographs	1206	Pretrained GoogLeNet Inception	93.8 %	Not reported
Sukegawa s et al ⁶	Panoramic Radiographs	8859	Basic CNN (convolutional neural networks), VGG16 transfer, VGG16 fine-tuning, VGG19 transfer, VGG19 fine-tuning	86% 89.9% 93.5% 88% 92.7%	Not reported
Takahashi T et al ⁷	Panoramic radiographs	1282	YOLOv3 (you only look once)	71%	Not reported
Lee JH et al ⁸	Periapical and panoramic radiographs	11,980	Automated deep CNN	95.4%	AUC less than 0.954
Lee JH et al ⁹	Periapical and panoramic radiographs	10770	Pre-trained and fine-tuned deep CNN architecture (Google Net Inception-v3)	97.1%	AUC of 0.925
Kim J E et al ¹⁰	Periapical radiographs	801	SqueezeNet, GoogLeNet, ResNet-18, MobileNet-v2, ResNet-50	96% 93% 98% 97% 98%	Not reported
Mata Santos R P et al ¹¹	Periapical radiographs	1800	Deep CNNs	85.29%	Not reported
Sukegaws et al ¹²	Panoramic radiographs	9767	ResNet18 ResNet 34 ResNet 50 ResNet 101 ResNet 152	97.8% 98% 98% 98.41% 98.51%	Not reported
Kim HS et al ¹³	Periapical radiographs	355	Pretrained YOLOv3	96.7%	Not reported
Kong H J et al ¹⁴	Panoramic radiographs	28,112	Ensemble technique applied to EfficientNet and Res2Next algorithms	95%	Not reported
Park W et al ¹⁵	Periapical and panoramic radiographs	156,965	Automated deep learning (DL) algorithm	88.53%	Not reported

and interpret a comprehensive database of patient factors derived from case histories. Notably, the proposed system achieves an accuracy of 94.48% in predicting the success of single implants. AI systems are becoming increasingly popular owing to their ability to process complex medical data and provide accurate predictions hence, AI can be a handy tool for supplementary diagnostics.³³ Algorithms such as SVM, weighted SVM, and radial basis function with dynamic decay adjustment (RBF-DDA) provided valuable insights for clinicians and researchers seeking to improve the prediction and success rates of dental implant procedures.³⁴ Studies have explored the combined predictive model approach with various algorithms in predicting dental implant success and the approach holds promise in evaluating the success of dental implants.³⁵ Studies have found success in accurately predicting dental implant success even when dealing with imbalanced data.³⁶

AI could identify the crucial factors affecting the prognosis of implants with the mesiodistal position of the implant identified as the most crucial factor influencing prognosis.³⁷ ML algorithms were implemented to predict the necessity of dental implants by leveraging patients' historical data and current symptoms.³⁸ AI can serve as a valuable addition to existing evaluation methods for assessing and predicting osseointegration.³⁹ DL models can be effective tools for predicting the fate of dental implants after surgery helping clinicians make more informed decisions for their patients.⁴⁰ Several other studies^{41–45} have adopted AI to predict bio-tribocorrosion, and postoperative discomfort in dental implant surgery, recognize and classify fractured dental implants, classify dental implant size, study the correlation between the initial stability of implants and peri-implant bone mineral density and these AI applications are presented in Table 4.

Table 2: AI in implant planning

Author	Objective	AI model	Results/Accuracy
Widisari M et al ¹⁷	Automatic and simultaneous detection of alveolar bone and mandibular canal	Dental-YOLO	99.46%
Moufti et al ¹⁹	To detect and trace edentulous alveolar bone on CBCT images	“U-Net” CNN	78%
Bayrakdar et al ²⁰	Measuring bone height and thickness, segmentations of teeth, maxillary sinus, jaws, mandibular canals, and missing teeth	Diagnocat AI system	72.2%, 66.4%, and 95.3%
Mangan FG et al ²¹	3D planning for implants using AI and augmented reality	Using AI and augmented reality	-
Kung PC et al ²²	Improving the design of dental implants by considering patients’ conditions	U-net, ANN, and random forest models	86%
Alsomali, M. et al ²³	To develop an AI model that can automatically localize the position of radiographic stent GP markers in CBCT images to recognize proposed implant positions,	DL model	83%
Chen Z et al ²⁴	AI-assisted implant planning software program for guided implant surgery	-	-
Sakai T et al ²⁵	AI model to identify the appropriate implant drilling protocol utilizing CBCT images	LeNet-5	93.8%.
Lerner H et al ²⁶	AI-driven optimization of the design and manufacturing of custom abutments	-	-
Tilebon et al ²⁷	Enhancing the etching process for dental implant surface treatment	Combination of MLP-ANN-based modeling and NSGA-II-based multi-objective optimization	-

Table 3: AI in Peri-implantitis Management

Author	Objective	AI model	Accuracy of the model
Liu et al ²⁹	To Detect the peri-implant marginal bone loss on periapical radiographs	R-CNN	73%
Rekwak et al ³⁰	To predict dental implant failure and peri-implantitis	Logistic regression, random forest classifiers, SVMs, and ensemble techniques	87.2% to 84%
Mameno et al ³¹	To develop predictive models for peri-implantitis based on demographic data and other parameters	Logistic regression SVMs random forests	63%, 64%, 71%
Chen YC et al ³²	To evaluate the extent of periodontal damage around dental implants in periapical film	CNN models	90.45%.

4. Conclusion

Integrating AI into dental implantology has ushered in a new era of precision, efficiency, and predictive capabilities. AI has addressed numerous challenges faced by clinicians in implant identification, planning, and prediction of outcomes. The sheer variety of implant systems in the market has made implant identification a complex task, but AI-driven models have emerged as a reliable solution. In the domain of implant planning, AI has streamlined the process by automating tasks that not only save time but also enhance the accuracy of treatment plans. AI’s potential in predicting osseointegration, risk factors associated with implant failure, and the need for dental implants add an invaluable decision support system for clinicians. Moreover,

AI has demonstrated its prowess in recognizing peri-implantitis at an early stage, a critical concern in dental implant maintenance.

However, it’s essential to note that whilst AI holds immense promise, there are still practical limitations in its clinical application. Further research and validation through clinical trials are necessary to ensure the reliability and effectiveness of AI models in real-world dental practice. Additionally, the need for well-organized datasets and advanced AI architectures cannot be overstated, as these are fundamental to the success of AI applications in dental implantology.

Table 4: AI-driven Prediction in Dental Implantology

Author	Objective	AI model	Results/Accuracy
Lyakhov PA et al ³³	Predicting the success of single-implant survival	CNN architecture	94.48%
Oliveria et al ³⁴	Predicting the success of dental implants	SVM, weighted SVM, and RBF-DDA	-
Moayeri R S et al ³⁵	Predicting the success of dental implants	W-J48, SVM, Neural Network, K-NN, and Naïve Bayes	The combined approach with an accuracy of 90%
Sabjekar M et al ³⁶	Predict the success or failure of dental implants	ensemble of decision tree, SVM, k-nearest neighbor, and Naïve Bayes	91%
Ha S R et al ³⁷	To identify the most crucial factors predicting the prognosis of dental implants	Decision tree model SVM	64-93%, 73-95%
Alharbi MT et al ³⁸	Predicting the necessity of dental implants	Bayesian network, random forest, AdaBoost algorithm, Improved AdaBoost algorithm	72.8%, 77.8%, 86.1%, 91.7%
Oh S et al ³⁹	Prediction of osseointegration from radiographs	ResNet-18,34,50, DenseNet-121,201, MobileNet-V2, and MobileNet-V3	80.6%, 82.2%, 83.6%, 81.8%, 81.6%, 82.4%, 79.9%
Huang N et al ⁴⁰	Predicting the risk of dental implant loss using CBCT scans	Logistic regression DL model Integrated model	72%, 87%, 90%
Ramachandran R A et al ⁴¹	Early detection and prediction of bio-tribocorrosion in dental implant materials	Logistic Regression, Latent Dirichlet Allocation, k-NN, Decision Tree, Support Vector Classifier, and Random Forest models	All models achieved over 90%
Yadalam P K et al ⁴²	Predicting postoperative discomfort in dental implant surgery	An AI-based multi-linear regression model	89.6%
Lee D W et al ⁴³	Recognition and classification of fractured dental implants	VGGNet-19 GoogLeNet Inception-v3 Automated deep CNN	92%, 96%, 97%
Park J H et al ⁴⁴	Classifying dental implant size using periapical radiographs	VGG16 Cluster analysis	99%, 98%

5. Source of Funding

None.

6. Conflict of Interest

None.


References

- Shan T, Tay FR, Gu L. Application of artificial intelligence in Dentistry. *J Dent Res*. 2021;100(3):232–44.
- Yan KX, Liu L, Li H. Application of machine learning in oral and maxillofacial surgery. *Artif Intell Med Imaging*. 2021;2(6):104–14.
- Lee JH, Kim YT, Lee JB, Jeong SN. A performance comparison between automated deep learning and dental professionals in classification of dental implant systems from dental imaging: A Multi-Center Study. *Diagnostics (Basel)*. 2020;10(11):910. doi:10.3390/diagnostics10110910.
- Jae-Hong L. Identification and classification of dental implant systems using various deep learning based convolutional neural network architectures. *Clin Oral Impl Res*. 2019;30:217. doi:10.1111/clr.175_13509.
- Said MH, Roux MKL, Catherine JH, Lan R. Development of an artificial intelligence model to identify a dental implant from a radiograph. *Int J Oral Maxillofac Implants*. 2020;36(6):1077–82.
- Sukegawa S, Yoshii K, Hara T, Yamashita K, Nakano K, Yamamoto N, et al. Deep Neural Networks for Dental Implant System Classification. *Biomolecules*. 2020;10(7):984. doi:10.3390/biom10070984.
- Takahashi T, Nozaki K, Gonda T, Mameno T, Wada M, Ikebe K, et al. Identification of dental implants using deep learning -pilot study. *Int J Implant Dent*. 2020;6:53–9.
- Lee JH, Kim YT, Lee JB, Jeong SN. A Performance Comparison between Automated Deep Learning and Dental Professionals in Classification of Dental Implant Systems from Dental Imaging: A Multi-Center Study. *Diagnostics (Basel)*. 2020;10(11):910. doi:10.3390/diagnostics10110910.
- Lee JH, Jeong SN. Efficacy of deep convolutional neural network algorithm for the identification and classification of dental implant systems, using panoramic and periapical radiographs: A pilot study. *Medicine (Baltimore)*. 2020;99(26):20787. doi:10.1097/MD.0000000000020787.
- Kim JE, Nam NE, Shim JS, Jung YH, Cho BH, Hwang JJ, et al. Transfer Learning via Deep Neural Networks for Implant Fixture System Classification Using Periapical Radiographs. *J Clin Med*. 2020;9(4):1117. doi:10.3390/jcm9041117.
- Santos RDM, Prado H, Neto ISA, de Oliveira G, Silva AIV, Zenóbio EG. Automated Identification of Dental Implants Using Artificial Intelligence. *Int J Oral Maxillofac Implants*. 2021;36(5):918–23.
- Sukegawa S, Yoshii K, Hara T, Matsuyama T, Yamashita K, Nakano K, et al. Multi-Task Deep Learning Model for Classification of Dental Implant Brand and Treatment Stage Using Dental Panoramic Radiograph Images. *Biomolecules*. 2021;11(6):815. doi:10.3390/biom1106081.
- Kim HS, Ha EG, Kim YH, Jeon KJ, Lee C, Han SS, et al. Transfer learning in a deep convolutional neural network for implant fixture classification: A pilot study. *Imaging Sci Dent*. 2022;52(2):219–24.

14. Kong HJ, Eom SH, Yoo JY, Lee JH. Identification of 130 dental implant types using ensemble deep learning. *Int J Oral Maxillofac Implants*. 2023;38(1):150–6.
15. Park W, Huh JK, Lee JH. Automated deep learning for classification of dental implant radiographs using a large multi-center dataset. *Sci Rep*. 2023;13(1):4862. doi:10.1038/s41598-023-33768-x.
16. Bayrakdar SK, Orhan K, Bayrakdar IS, Bilgir E, Ezhov M, Gusarev M, et al. A deep learning approach for dental implant planning in cone-beam computed tomography images. *BMC Med Imaging*. 2021;21:86. doi:10.1186/s12880-021-00618-z.
17. Widiarsi M, Arifin A, Suciati N, Faticah C, Astuti E, Indraswari R, et al. Dental-YOLO: Alveolar bone and mandibular canal detection on cone beam computed tomography images for dental implant planning. *IEEE Access*; 2022.
18. Lee S, Woo S, Yu J, Seo J, Lee J, Lee C, et al. Automated CNN-based tooth segmentation in cone-beam CT for dental implant planning. *IEEE Access*;8:50507–18. doi:10.1109/ACCESS.2020.2975826.
19. Moufti MA, Trabulsi N, Ghousheh M, Fattal T, Ashira A, Danishvar S, et al. Developing an Artificial Intelligence Solution to Autosegment the Edentulous Mandibular Bone for Implant Planning. *Eur J Dent*. 2023;17(4):1330–7.
20. Jaskari J, Sahlsten J, Järnstedt J, Mehtonen H, Karhu K, Sundqvist O, et al. Deep learning method for mandibular canal segmentation in dental cone beam computed tomography volumes. *Sci Rep*. 2020;10:5842. doi:10.1038/s41598-020-62321-3.
21. Mangano FG, Admakin O, Lerner H, Mangano C. Artificial intelligence and augmented reality for guided implant surgery planning: A proof of concept. *J Dent*. 2023;133:104485. doi:10.1016/j.jdent.2023.104485.
22. Kung PC, Hsu CW, Yang AC, Chen NY, Tsou NT. Prediction of Bone Healing around Dental Implants in Various Boundary Conditions by Deep Learning Network. *Int J Mol Sci*. 1948;24(3):1948. doi:10.3390/ijms24031948.
23. Alsomali M, Alghamdi S, Alotaibi S, Alfadda S, Altwaijry N, Alturaiki I, et al. Development of a deep learning model for automatic localization of radiographic markers of proposed dental implant site locations. *Saudi Dent J*. 2022;34(3):220–5.
24. Chen Z, Liu Y, Xie X, Deng F. Influence of bone density on the accuracy of artificial intelligence-guided implant surgery: An in vitro study. *J Prosthet Dent*. 2024;131(2):254–61.
25. Sakai T, Li H, Shimada T, Kita S, Iida M, Lee C, et al. Development of artificial intelligence model for supporting implant drilling protocol decision making. *J Prosthodont Res*. 2023;67(3):360–5.
26. Lerner H, Mouhyi J, Admakin O, Mangano F. Artificial intelligence in fixed implant prosthodontics: a retrospective study of 106 implant-supported monolithic zirconia crowns inserted in the posterior jaws of 90 patients. *BMC Oral Health*. 2020;20(1):80. doi:10.1186/s12903-020-1062-4.
27. Tilebon SMS, Emamian SA, Ramezanpour H, Yousefi H, Özcan M, Naghib SM. Intelligent modeling and optimization of titanium surface etching for dental implant application. *Sci Rep*. 2022;12(1):7184. doi:10.1038/s41598-022-11254-0.
28. Wang CW, Hao Y, Gianfilippo RD, Sugai J, Li J, Gong W, et al. Machine learning-assisted immune profiling stratifies peri-implantitis patients with unique microbial colonization and clinical outcomes. *Theranostics*. 2021;11(14):6703–16.
29. Liu M, Wang S, Chen H, Liu Y. A pilot study of a Deep learning approach to detect marginal bone loss around implants. *BMC Oral Health*. 2022;22(1):11. doi:10.1186/s12903-021-02035-8.
30. Rekawek P, Herbst EA, Suri A, Ford BP, Rajapakse CS, Panchal N, et al. Machine learning and artificial intelligence: A web-based implant failure and peri-implantitis prediction model for clinicians. *Int J Oral Maxillofac Implants*. 2023;38(3):576–82.
31. Mameno T, Wada M, Nozaki K, Takahashi T, Tsujioka Y, Akema S, et al. Predictive modeling for peri-implantitis by using machine learning techniques. *Sci Rep*. 2021;11:11090. doi:10.1038/s41598-021-90642-4.
32. Chen YC, Chen MY, Chen TY, Chan ML, Huang YY, Liu YL, et al. Improving dental implant outcomes: CNN-Based system accurately measures degree of peri-implantitis damage on periapical film. *Bioengineering (Basel)*. 2023;10(6):640. doi:10.3390/bioengineering10060640.
33. Lyakhov PA, Dolgalev AA, Lyakhova UA, Muraev AA, Zolotayev KE, Semerikov DY, et al. Neural network system for analyzing statistical factors of patients for predicting the survival of dental implants. *Front Neuroinform*. 2022;16:1067040. doi:10.3389/fninf.2022.1067040.
34. Oliveira ALI, Baldisserotto C, Baldisserotto J. A Comparative Study on SVM and Constructive RBF Neural Network for Prediction of Success of Dental Implants. In: Sanfeliu A, Cortés ML, editors. *Progress in Pattern Recognition, Image Analysis and Applications. CIARP*. vol. 3773. Berlin, Heidelberg: Springer; 2005.
35. Moayeri RS, Khalili M, Nazari M. A hybrid method to predict success of dental implants. *Int J Adv Comput Sci Appl*. 2016;7(5):1–6.
36. Sabzekar M, Namakin M, Babaki HAS, Deldari A, Babaiyan V. Dental implants success prediction by classifier ensemble on imbalanced data. *Comput Methods Programs Biomed*. 2021;1:100021. doi:10.1016/j.cmpbup.2021.100021.
37. Ha SR, Park HS, Kim EH, Kim HK, Yang JY, Heo J, et al. A pilot study using machine learning methods about factors influencing prognosis of dental implants. *J Adv Prosthodont*. 2018;10(6):395–400.
38. Alharbi MT, Almutiq MM. Prediction of Dental Implants Using Machine Learning Algorithms. *J Healthc Eng*. 2022;2022:7307675. doi:10.1155/2022/7307675.
39. Oh S, Kim YJ, Kim J, Jung JH, Lim HJ, Kim BC, et al. Deep learning-based prediction of osseointegration for dental implant using plain radiography. *BMC Oral Health*. 2023;23(1):208. doi:10.1186/s12903-023-02921-3.
40. Huang N, Liu P, Yan Y, Xu L, Huang Y, Fu G, et al. Predicting the risk of dental implant loss using deep learning. *J Clin Periodontol*. 2022;49(9):872–83.
41. Ramachandran RA, Barão VVR, Ozevin D, Sukotjo C, Pai S, Mathew M, et al. Early predicting tribocorrosion rate of dental implant titanium materials using random forest machine learning models. *Tribol Int*. 2023;187:108735. doi:10.1016/j.triboint.2023.108735.
42. Yadalam PK, Trivedi SS, Krishnamurthi I, Anegundi RV, Mathew A, Shames MA, et al. Machine Learning Predicts Patient Tangible Outcomes After Dental Implant Surgery. *IEEE Access*. 2022;10:131481–8. doi:10.1109/ACCESS.2022.3228793.
43. Lee DW, Kim SY, Jeong SN, Lee JH. Artificial intelligence in fractured dental implant detection and classification: evaluation using dataset from two dental hospitals. *Diagnostics (Basel)*. 2021;11(2):233. doi:10.3390/diagnostics11020233.
44. Park J, Moon H, Jung H, Hwang J, Choi Y, Kim JE, et al. Deep learning and clustering approaches for dental implant size classification based on periapical radiographs. *Sci Rep*. 2023;13:16856. doi:10.1038/s41598-023-42385-7.
45. Lv L, Xiao Y, Zhou L, Guo J, Lin Y, Chen J, et al. Correlation between peri-implant bone mineral density and primary implant stability based on artificial intelligence classification. *Sci Rep*. 2024;14(1):3009. doi:10.1038/s41598-024-52930-7.

Author biography

Veena Benakatti, Reader  <https://orcid.org/0000-0002-0281-4193>

Ramesh P Nayakar, Professor  <https://orcid.org/0000-0001-6681-307X>

Suvidha Patil, Lecturer  <https://orcid.org/0000-0003-2739-7733>

Cite this article: Benakatti V, Nayakar RP, Patil S. Artificial intelligence applications in dental implantology: A narrative review. *IP Ann Prosthodont Restor Dent* 2024;10(2):118–123.