Chettinad Health City Medical Journal
Volume 14, Issue 4 - 2025, Pg. No. 49-54
Peer Reviewed & Open Access Journal

Review Article

Next-Gen Surgery: AI's Transformative Impact on Oral and Maxillofacial Surgery

A Saneem Ahamed[1], Mubeena[2], N Deva Kumar[3]

[1]Professor and Head Department of Oral and Maxillofacial Surgery, Priyadarshini Dental College and Hospital, Thiruvallur, India
[2]Student, Priyadarshini Dental College and Hospital, Thiruvallur, India
[3]Student, Department of Oral and Maxillofacial Surgery, Priyadarshini Dental College and Hospital, Thiruvallur, India
DOI: https://doi.org/10.24321/2278.2044.202549

I N F O

Corresponding Author:
A Saneem Ahamed, Department of Oral and Maxillofacial Surgery, Priyadarshini Dental College and Hospital, Thiruvallur, India
E-mail Id:
Saneem.omfs@gmail.com
Orcid Id:
https://orcid.org/0009-0007-9233-5332
How to cite this article:
Ahamed A S, Mubeena, Kumar N D. Next-Gen Surgery: AI's Transformative Impact on Oral and Maxillofacial Surgery. Chettinad Health City Med J. 2025;14(4):49-54.

Date of Submission: 2024-09-25
Date of Acceptance: 2025-03-10

A B S T R A C T

The advent of Artificial Intelligence (AI) is revolutionising the landscape of oral and maxillofacial surgery (OMFS), enhancing diagnostic capabilities, surgical planning, and postoperative care. AI technologies, including machine learning and deep learning, offer valuable insights that support surgeons in making informed decisions and improving patient outcomes. By analysing complex medical data, AI assists in assessing images before and after surgical procedures, which helps to reduce patient dissatisfaction, particularly in aesthetic surgeries. This review article aims to explore AI's transformative potential in OMFS, evaluating recent technological advancements, identifying current challenges, and discussing future prospects. The successful integration of AI within OMFS relies on a synergistic relationship between advanced technology and the nuanced expertise of skilled surgeons, who are essential for high-quality patient care. Continued research is crucial to refine AI algorithms, ensuring they complement rather than replace the critical role of human practitioners in optimising therapeutic outcomes.

Keywords: Oral And Maxillofacial Surgery, Artificial Intelligence, Diagnosis, Cysts And Tumours, Implantology, Orthognathic Surgery

Introduction

Oral and maxillofacial surgery is a specialised domain of dentistry focused on the diagnosis, surgical intervention, and adjunctive management of pathological conditions, traumatic injuries, and structural anomalies affecting the functional and aesthetic properties of the hard and soft tissues within the oral and maxillofacial region. This speciality serves as the surgical aspect of dental practice.[1]

Oral surgery became a medical speciality in the 18th century, and throughout the past 100+ years, the field of Oral and Maxillofacial Surgery (OMFS) has changed its nomenclature multiple times and changed the scope of its operations and the way anaesthesia is administered.[2] Oral and Maxillofacial Surgery (OMFS) is an essential speciality dedicated to enhancing patient quality of life by addressing intricate conditions of the face, mouth, and jaws. By integrating cutting-edge surgical methodologies with state-of-the-art technologies, OMFS proficiently manages a diverse array of challenges, including facial traumas, oral malignancies, and craniofacial anomalies. Its evolution underscores the speciality's distinctive position at the nexus of dentistry and medicine, ensuring comprehensive care that prioritises both functional and aesthetic outcomes. AI encompasses the replication of human cognitive functions by a system or machine. Its primary aim is to design machines that can simulate human thought processes and behaviours, including perception, reasoning, learning, planning, and prediction.[3] The key subfields of AI include machine learning (ML), deep learning (DL), artificial neural networks (ANNs), and robotics.[4]

By emulating human intelligence, AI systems provide numerous advantages for individuals in their everyday lives. From filtering out spam emails to advanced smartwatches that distinguish between daily and aerobic activities using accelerometer sensors and personalised product suggestions from online retailers, AI has become an integral part of societies globally.[3] Moreover, artificial intelligence (AI) has significantly expanded its presence and relevance across various fields, including dentistry. In dentistry, machine learning (ML) and its subset, deep learning (DL), play a significant role in diagnosis, decision-making, predicting treatment outcomes, and treatment planning.[4] Figure 1 illustrates how ML and DL work in oral and maxillofacial surgery (OMFS).

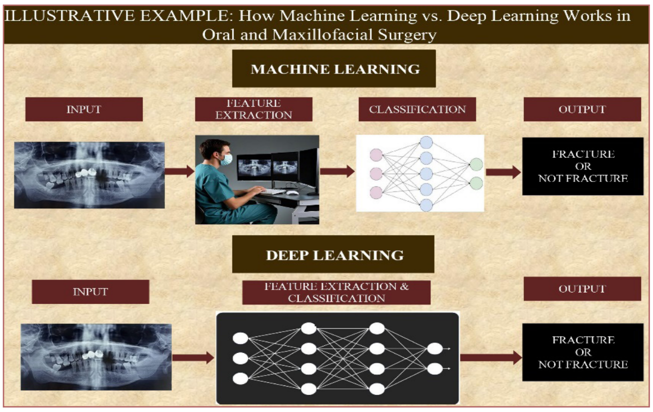

Figure 1.Example of how Machine Learning (ML) and Deep Learning (DL) work in Oral and Maxillofacial Surgery (OMFS).

The use of intelligent medical technologies has made the 4P model of medicine—Predictive, Preventive, Personalised, and Participatory—more achievable. Applications with AI capabilities are crucial for encouraging treatment plan adherence and enhancing patient outcomes. In recent decades, the use of artificial intelligence (AI) in oral and maxillofacial surgery (OMFS) has grown significantly, improving the field in a number of ways. AI holds great promise for enhancing surgical precision, planning, and patient outcomes. It is used in procedures including preoperative planning, intraoperative measurements, diagnosis, cephalometric analysis, outcome evaluation, and postoperative follow-up.[5] AI revolutionises medicine by swiftly analysing complex data to uncover patterns, enhancing predictive accuracy and personalising treatment. It identifies early signs of disease, optimises treatment plans, and improves risk assessment through genetic and lifestyle factors, enabling proactive and individualised patient care.[6]

This review article explores the transformative potential of AI in oral and maxillofacial surgery (OMFS), focusing on how these technologies are reshaping surgical procedures and patient care. The aim is to evaluate the influence of AI on OMFS, with objectives that include assessing recent technological advancements, pinpointing current challenges, and discussing future prospects, ultimately offering a comprehensive understanding of AI's role in advancing this specialised field of healthcare.

Materials And Methods

Literature Search

A thorough search was carried out across key academic databases, focusing on studies and articles exploring the integration of Artificial Intelligence (AI) in Oral and Maxillofacial Surgery (OMFS), including AI and OMFS history, specifically in areas such as AI in Orthognathic Surgery, AI in Implant Dentistry, and AI in the Diagnosis of Maxillofacial Cysts and Tumours.

Search Strategy

The search was limited to English-language articles. The following keywords were used: "AI," "Artificial Intelligence", "Artificial Intelligence in Dentistry", "Artificial Intelligence in OMFS", "OMFS", "Oral and Maxillofacial Surgery", "History of OMFS", and "Evolution of OMFS".

Keywords were adapted to the syntax of each database. Additionally, searches were conducted for "AI in Implantology", "AI in Orthognathic Surgery", "AI in Diagnosis of Maxillofacial Cysts and Tumours", and "AI in Diagnosis of Maxillofacial Tumors".

Data Sources

- Journal of Oral and Maxillofacial Surgery (JOMS)
- PubMed/MEDLINE
- ResearchGate
- Annals of Oral and Maxillofacial Surgery
- Google Scholar

Study Selection

The selection process began with an initial review of titles and abstracts to identify studies relevant to the application of AI in oral and maxillofacial surgery (OMFS), its historical perspectives, and the evolution of OMFS. Studies were included if they focused on the use of AI in areas such as implantology, orthognathic surgery, and the diagnosis of maxillofacial cysts and tumours. Full-text articles were reviewed to ensure relevance and quality. Additionally, reference lists of selected articles were examined to identify further studies pertinent to the topic.

AI in Implant Dentistry

AI's incorporation into implant operations ushers in a new era of accuracy and productivity. To assist doctors in making well-informed, evidence-based decisions on implant placement, artificial intelligence (AI) algorithms analyze vast amounts of patient data, including radiographic pictures, three-dimensional scans, and clinical records.[7] Cone beam CT (CBCT) scans are crucial for dental implant planning, but many practitioners may lack the expertise to analyse

ISSN: 2278-2044
DOI: https://doi.org/10.24321/2278.2044.202549

them effectively. AI has the potential to bridge this gap. While its success in measuring bone dimensions has been limited, highlighting the need for further research, AI has demonstrated promise in identifying anatomical landmarks such as the mandibular canal and maxillary sinus, thus aiding in surgical planning.[4]

Mangano et al. combined AI and augmented reality for guided implant surgery in a partially edentulous patient, finding it efficient and time-saving for simple cases.[8] Sakai et al. used preoperative CBCT scans to predict implant drilling protocols, analysing conventional with and without tapping drills and undersized drilling. Their study achieved a 93.7% accuracy, showing AI's potential to predict implant stability based on drilling methods, which is valuable for novice implantologists.[9] Prosthetically driven implantology requires precise 3D spatial placement, with AI significantly augmenting clinical decision-making. Further investigation is crucial to advance AI's role in autonomous implant planning.[4]

Currently, two systems are used in clinical practice for implant detection. The first, a website called "What Implant Is That?" What Implant Is That? allows dentists to compare their radiographs with a database of implant images.[4] The second system, developed by Michelinakis et al., uses a questionnaire about implant characteristics to match responses with a database for identification.[10] However, both methods rely on the clinician to manually match images, increasing the risk of human error. AI offers an advantage by automating the identification process. Convolutional Neural Networks (CNNs) within the deep learning family can create algorithms to detect implants by analysing spatial hierarchies of features like edges, textures, and shapes, reducing the likelihood of mistakes.[4]

Rajan et al. found that AI-assisted dental implants had a 92% success rate and an 87% prediction accuracy, outperforming the traditional methods with a 78% success rate and 71% accuracy. The AI group also experienced fewer complications and needed less postoperative intervention.[11]

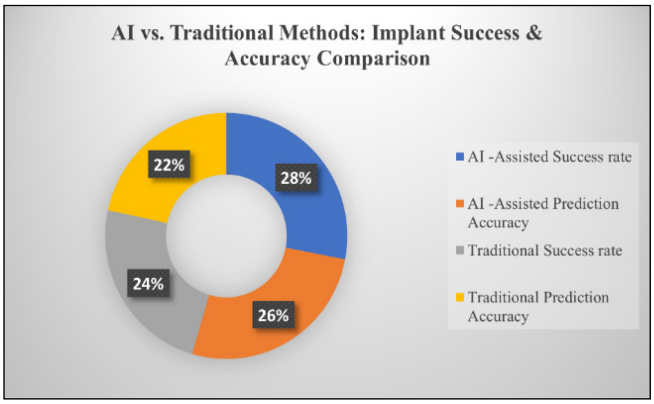

Figure 2.Pie chart comparing the success rate and prediction accuracy of AI-assisted and traditional dental implant methods

AI in Diagnosis of Maxillofacial Cysts and Tumors

Jawbone cysts and tumors often remain asymptomatic until they reach an advanced stage, leading to delayed detection and suboptimal treatment outcomes. While panoramic radiography (orthopantomograms) is a critical tool for early diagnosis, the inherent complexity of image interpretation, due to overlapping craniofacial structures, presents challenges.[12] Accurate lesion and tumour segmentation is crucial in computer-aided diagnosis systems. While this is typically done manually by radiologists, it can be time-consuming due to the large data volume and challenging when dealing with small lesions.[13] Clinical practice has a lot of potential when AI is incorporated into the automated diagnosis of these illnesses. Dental fillings, root canal therapy, cavities, and maxillofacial cysts can already be diagnosed with a number of commercial programmes, including DentalXR and Dentomo. For example, Abdolali et al. developed a technique that uses asymmetry analysis to automatically segment radicular cysts, dentigerous cysts, and keratocysts. Additionally, Rana et al. separated keratocysts and measured their volume using a surgical navigation algorithm.[5] Recent advancements in deep convolutional neural networks (DCNNs), particularly the YOLO algorithm, offer an innovative solution by enabling rapid, simultaneous detection and classification of lesions. With adequate training, YOLO shows promise as a computer-aided diagnostic system, enhancing the accuracy and efficiency of identifying odontogenic cysts and tumors.[12]

It is crucial to recognise that human input is still needed for the initial stage of lesion diagnosis, and it is still challenging to create a fully automated model for tumour and cyst detection. Santer et al.'s thorough review of 13 research studies showed the promising potential of AI in detecting suspicious lymph nodes in patients with locally advanced head and neck squamous cell carcinoma, with a mean accuracy of 86% for lymph node detection.[5] This augments clinicians' diagnostic rigour and advances more nuanced clinical decision algorithms.[12]

Application of AI in Orthognathic Surgery

OGS is aimed at achieving both functional and aesthetic corrections through therapeutic intervention. Evaluation of facial asymmetry is crucial in planning and executing OGS.[14]

Lin et al. conducted a study using a Deep Convolutional Neural Network (DCNN) model to evaluate facial asymmetry in patients before and after orthognathic surgery (OGS). The model achieved an accuracy of 78.85% and was able to assess facial symmetry within 1 degree with 98.63% accuracy. The study found a significant improvement in facial symmetry post-surgery ($p < 0.02$). However, the study's limitation was the small sample size and the fact that the validation was restricted to data from a single centre.[15] A study reported on a Convolutional Neural Network (CNN)-based AI model that assessed facial symmetry before and after orthognathic surgery (OGS) using CBCT images. The model showed impressive accuracy, achieving 90% in evaluating facial symmetry. Despite its strong performance, the authors emphasised the need for larger datasets to further improve the model's accuracy.[16]

Three-dimensional (3-D) stereophotogrammetry has gained prominence in dentistry and orthopaedics for capturing detailed facial topography with high precision and clinical reliability. This technique integrates photographs from multiple vantage points using synchronised digital cameras to generate comprehensive 3-D imagery, potentially valuable for predicting post-treatment facial morphology. However, despite the availability of commercial software such as the Dolphin system for post-orthognathic surgical simulations, the opacity of its underlying computational algorithms raises concerns regarding their empirical validation.[17]

AI applications hold significant potential for early diagnosis and prediction of the need for orthognathic surgery (OGS), aiding clinicians in planning treatment timing and duration. However, many studies emphasise that improving the performance of these AI models requires further training on larger datasets from multiple centres and diverse populations.[18]

Diverse Applications of AI in OMFS

AI has been integrated into oral and maxillofacial surgery (OMFS), assisting in tasks such as diagnosis, cephalometric analysis, preoperative planning, intraoperative measurements, outcome assessment, and postoperative follow-up. Notably, in the management of oral cancer, a prevalent head and neck cancer, AI leverages complex neural networks, machine learning (ML), and advanced deep learning (DL) algorithms to diagnose, predict, and calculate survival rates. By analysing histopathology samples and examining the epithelium of both healthy and diseased tissues, AI provides critical insights that enhance patient care.[18] Figure 3 illustrates the diverse applications of AI in OMFS.

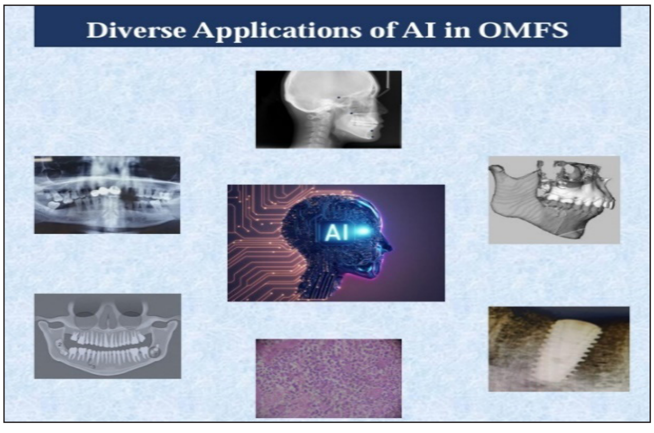

Figure 3.Diverse applications of AI in Oral and Maxillofacial Surgery (OMFS)

Discussion

AI has become an invaluable asset in maxillofacial surgery today. One of its key functions involves assessing images prior to and following surgical procedures, which helps in reducing patient dissatisfaction with outcomes, particularly in aesthetic surgeries such as rhinoplasty and orthognathic surgery.[18] Moreover, AI can assist surgeons in making intraoperative decisions by offering real-time insights and feedback, thereby enhancing surgical precision and minimising the likelihood of complications.[5] The future of robotics and AI in maxillofacial surgery promises to modernise the field while reducing human errors and improving treatment techniques.[18]

AI significantly improves surgical education by providing virtual training environments that simulate real surgical scenarios. Technologies like virtual reality (VR) and augmented reality (AR) enable trainees to practise surgeries in a risk-free setting, offering hands-on experience without the dangers of actual procedures.[19]

Although current AI tools are not equipped to perform complex surgical procedures, they may evolve to handle more intricate tasks in the future.[20] Future directions focus on further advancing AI technology to enhance efficiency and accuracy in oral and maxillofacial surgery (OMFS).[5] However, as surgeons increasingly rely on AI, they face an ethical dilemma regarding the extent to which they can trust machines in surgery without increasing their malpractice risk if a robot makes an error. This concern becomes more pressing if a patient is harmed or if surgical results are suboptimal, especially when the surgeon relies on AI for treatment decisions that may exceed the robot's capabilities. Therefore, if AI and machine learning are integrated into standard patient care, the ethical principles of beneficence and respect for patient autonomy must also apply to these technologies.[20]

Conclusion

In conclusion, while AI can significantly support oral and maxillofacial surgeons by enhancing decision-making and clinical proficiency, it should not replace the indispensable role of the surgeon. Further research is necessary to improve AI models, but the expertise and judgement of OMFS surgeons remain essential for delivering high-quality patient care. As technology evolves, it is vital for surgeons to integrate AI effectively into their practice, ensuring that it complements rather than undermines their fundamental role in patient outcomes. The successful application of AI in OMFS relies on the collaboration between advanced technology and skilled surgeons, who are the cornerstone of effective treatment and care.

Authors' Contributions:

A S A contributed to the conception and design of the study, defined the intellectual content, and provided overall supervision. He critically reviewed and edited the manuscript, guided the methodological framework of the review, and served as the guarantor of the work.

M S: conducted the literature search, developed the search strategy and selection criteria, identified relevant keywords, and collected data from multiple databases. She performed data analysis and interpretation, and was primarily responsible for manuscript preparation and drafting of the review article. N D K: assisted in the literature search, contributed to data acquisition and interpretation, supported the formulation of the methodology and refinement of the search strategy, and participated in manuscript preparation, critical editing, and review.

All authors read and approved the final manuscript and agree to be accountable for all aspects of the work.

Conflict of Interest: None

Source of Funding: None

Declaration of Generative AI and AI-Assisted Technologies in the Writing Process: None

Reference

1. Kolokythas A. What is the scope of practice of oral and maxillofacial surgeons?. Journal of Oral and Maxillofacial Surgery. 2021 Jan 1;79(1):267. [PubMed] [Google Scholar]
2. Alpert B. The Evolution of Oral and Maxillofacial Surgery Over the Past 100+ Years—With Special Emphasis on the Role of Fluoride and the High-Speed Handpiece. Journal of Oral and Maxillofacial Surgery. 2018 Aug 1;76(8):1611-5. [PubMed] [Google Scholar]
3. Xu Y, Liu X, Cao X, Huang C, Liu E, Qian S, Liu X, Wu Y, Dong F, Qiu CW, Qiu J. Artificial intelligence: A powerful paradigm for scientific research. The Innovation. 2021 Nov 28;2(4). [PubMed] [Google Scholar]
4. Altalhi AM, Alharbi FS, Alhodaithy MA, Almarshedy BS, Al-Saaib MY, Aljohani AS, Alshareef AH, Muhayya M, AL-harbi NH, ALHARBI FS, Alhodaithy M. The impact of artificial intelligence on dental implantology: a narrative review. Cureus. 2023 Oct 30;15(10). [PubMed] [Google Scholar]
5. Miragall MF, Knoedler S, Kauke-Navarro M, Saadoun R, Grabenhorst A, Grill FD, Ritschl LM, Fichter AM, Safi AF, Knoedler L. Face the future—artificial intelligence in oral and maxillofacial surgery. Journal of clinical medicine. 2023 Oct 30;12(21):6843. [PubMed] [Google Scholar]
6. Khalifa M, Albadawy M. Artificial intelligence for clinical prediction: exploring key domains and essential functions. Computer Methods and Programs in Biomedicine Update. 2024 Jan 1;5:100148. [Google Scholar]
7. Macrì M, D'Albis V, D'Albis G, Forte M, Capodiferro S, Favia G, Alrashadah AO, García VD, Festa F. The role and applications of Artificial Intelligence in Dental Implant Planning: a systematic review. Bioengineering. 2024 Jul 31;11(8):778. [PubMed] [Google Scholar]
8. Mangano FG, Admakin O, Lerner H, Mangano C. Artificial intelligence and augmented reality for guided implant surgery planning: a proof of concept. Journal of Dentistry. 2023 Jun 1;133:104485. [PubMed] [Google Scholar]
9. Sakai T, Li H, Shimada T, Kita S, Iida M, Lee C, Nakano T, Yamaguchi S, Imazato S. Development of artificial intelligence model for supporting implant drilling protocol decision making. Journal of prosthodontic research. 2023;67(3):360-5. [PubMed] [Google Scholar]
10. Michelinakis G, Sharrock A, Barclay CW. Identification of dental implants through the use of Implant Recognition Software (IRS). International dental journal. 2006 Aug 1;56(4):203-8. [PubMed] [Google Scholar]
11. Rajan RS, Kumar HK, Sekhar A, Nadakkavukaran D, Feroz SM, Gangadharappa P. Evaluating the role of AI in predicting the success of dental implants based on preoperative CBCT images: A randomized controlled trial. Journal of Pharmacy and Bioallied Sciences. 2024 Feb 1;16(Suppl 1):S886-8. [PubMed] [Google Scholar]
12. Yang H, Jo E, Kim HJ, Cha IH, Jung YS, Nam W, Kim JY, Kim JK, Kim YH, Oh TG, Han SS. Deep learning for automated detection of cyst and tumors of the jaw in panoramic radiographs. Journal of clinical medicine. 2020 Jun 12;9(6):1839. [PubMed] [Google Scholar]
13. Xu L, Qiu K, Li K, Ying G, Huang X, Zhu X. Automatic segmentation of ameloblastoma on ct images using deep learning with limited data. BMC Oral Health. 2024 Jan 9;24(1):55. [PubMed] [Google Scholar]
14. Khanagar SB, Alfouzan K, Awawdeh M, Alkadi L, Albalawi F, Alghilan MA. Performance of artificial intelligence models designed for diagnosis, treatment planning and predicting prognosis of orthognathic surgery (OGS)—a scoping review. Applied Sciences. 2022 May 31;12(11):5581. [Google Scholar]
15. Lin HH, Lo LJ, Chiang WC, Chen CF. An automatic assessment of facial symmetry before and after orthognathic surgery based on three-dimensional contour features using deep learning system. In151st The IIER International Conference 2018 (pp. 126-129). [Google Scholor]
16. Lin HH, Chiang WC, Yang CT, Cheng CT, Zhang T, Lo LJ. On construction of transfer learning for facial symmetry assessment before and after orthognathic surgery. Computer Methods and Programs in Biomedicine. 2021 Mar 1;200:105928. [PubMed] [Google Scholar]
17. Tanikawa C, Yamashiro T. Development of novel artificial intelligence systems to predict facial morphology after orthognathic surgery and orthodontic treatment in Japanese patients. Scientific reports. 2021 Aug 4;11(1):15853. [Google Scholar] [Pubmed]
18. Yeganeh A. Application of artificial intelligence in different fields of oromaxillofacial surgery. Digital

ISSN: 2278-2044
DOI: https://doi.org/10.24321/2278.2044.202549

Medicine and Healthcare Technology. 2023 Oct 18(16). [Google Scholar]
19. Satapathy P, Hermis AH, Rustagi S, Pradhan KB, Padhi BK, Sah R. Artificial intelligence in surgical education and training: opportunities, challenges, and ethical considerations–correspondence. International Journal of Surgery. 2023 May 1;109(5):1543-4. [PubMed] [Google Scholar]
20. Rokhshad R, Keyhan SO, Yousefi P. Artificial intelligence applications and ethical challenges in oral and maxillo-facial cosmetic surgery: a narrative review. Maxillofacial Plastic and Reconstructive Surgery. 2023 Mar 13;45(1):14. [PubMed] [Google Scholar]

ISSN: 2278-2044
DOI: https://doi.org/10.24321/2278.2044.202549