BEYOND SCALPEL: ARTIFICIAL INTELLIGENCE IN RISK PREDICTION AND MANAGING ORO- FACIAL TRAUMA

RICHA WADHAWAN[1], SACHIN DEV SINGH[2], ANUJ SHANKAR TIWARI [3], SUSHMIT PRIYAM BORA[4], DEEPAK KUMAR KHARELIYA[5], VINAY PRASAD TAMTA[6]

[1] PROFESSOR, DEPARTMENT OF ORAL MEDICINE, DIAGNOSIS & RADIOLOGY, PDM DENTAL COLLEGE & RESEARCH INSTITUTE, BAHADURGARGH, HARYANA, INDIA
wadhawanricha1@gmail.com
[2]READER, DEPARTMENT OF ORAL & MAXILLOFACIAL SURGERY, TEERTHANKER MAHAVEER DENTAL COLLEGE AND RESEARCH CENTRE, MORADABAD, UTTAR PRADESH, INDIA
sdev0076@gmail.com
[3]CONSULTANT ORAL AND MAXILLOFACIAL SURGEON, DENTAL DEPARTMENT, FORTIS HOSPITAL, NOIDA, UTTAR PRADESH, INDIA
astindia20087@gmail.com
[4]REGISTRAR, DEPARTMENT OF DENTISTRY, ASSAM MEDICAL COLLEGE AND HOSPITAL, DIBRUGARH, ASSAM, INDIA
sushmit.bora@gmail.com
[5]POST GRADUATE, DEPARTMENT OFORAL AND MAXILLOFACIAL SURGERY, GOVERNMENT COLLEGE OF DENTISTRY, INDORE, MADHYA PRADESH, INDIA
drkhareliya@gmail.com
[6]ASSISTANT PROFESSOR, DEPARTMENT OF INFORMATION TECHNOLOGY, HNB GARHWAL UNIVERSITY, SRINAGAR, UTTARAKHAND, INDIA
vinayprasadtamta@gmail.com
Corresponding author: wadhawanricha1@gmail.com

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Abstract:

The incorporation of artificial intelligence (AI) into medical diagnostics and risk management has significantly transformed healthcare, particularly in complex fields such as oro-facial trauma. AI-driven tools, like machine learning algorithms, have demonstrated substantial promise in detecting high-risk patients, predicting injury outcomes, and supporting decision-making in treatment planning. These advanced technologies leverage vast datasets, including imaging, patient history, and clinical records, to provide insights that enhance diagnostic accuracy for fractures, soft tissue injuries, and potential complications. The use of AI in oro-facial trauma care not only improves patient management but also streamlines surgical procedures and optimizes healthcare resource allocation. This review highlights current applications and future opportunities of AI in enhancing the precision and effectiveness of risk assessment, ultimately improving care in oro-facial trauma management. It examines AI's transformative role in predicting, evaluating, and managing oro-facial injuries, emphasizing its potential to elevate diagnostic accuracy and optimize patient outcomes.

Introduction: AI is revolutionizing the field of oral and maxillofacial surgery, transforming diagnostic accuracy, surgical precision, and patient care in profound ways. This technological leap is not just enhancing the current standard of care but is redefining the future of the specialty, particularly in the management of complex conditions like maxillofacial tumors, cysts, oro-facial trauma, and dental implant procedures (1). By harnessing machine learning algorithms and deep neural networks, AI can process massive datasets, detect subtle patterns, and provide critical insights that empower surgeons to make more informed, precise decisions (2). One of the most transformative aspects of AI in oral and maxillofacial surgery is its ability to analyze complex medical imaging—such as computed tomography (CT) scans, magnetic resonance imaging (MRIs), and 3 dimensional (3D) models—with remarkable speed and accuracy (3). By assisting in preoperative assessments, virtual simulations, and personalized treatment planning, AI optimizes patient care from the moment of diagnosis, reducing complications and ensuring tailored interventions (4). For example, in surgical planning, AI-powered tools enhance the understanding of 3D spatial relationships between critical anatomical structures like the facial nerve, major vessels, and maxillofacial bone. This ensures more accurate interventions and reduces the likelihood of revision surgeries, ultimately improving patient outcomes and satisfaction (5). AI is not limited to diagnostic support; it plays a pivotal role in real-time surgical execution. During procedures, AI systems assist by improving precision, minimizing risks, and adapting to dynamic surgical environments. In disciplines like orthognathic surgery and tumor resection, AI enables advanced planning and prediction, such as determining osseointegration success in dental implants or anticipating potential complications during complex resections. This empowers surgeons to anticipate challenges, ultimately enhancing the success rates of procedures (6). Furthermore, AI's capabilities extend beyond diagnosis and surgery. The integration of digital imaging, 3D photography, intraoral scans, and predictive models has made significant strides in post-operative care, enabling more accurate assessments of recovery and potential issues. In this way, AI offers a comprehensive approach, not only diagnosing conditions but also continuously guiding treatment throughout the patient’s journey. Its ability to analyze complex datasets leads to personalized, precision-driven care that adapts to the unique needs of each patient (7). The evolution of AI is especially transformative in the area of oro-facial trauma, where it enhances risk prediction, diagnosis, and surgical intervention. By evaluating massive volumes of imaging data and historical patient outcomes, AI models can predict complications, identify optimal treatment strategies, and ensure the best possible results. This ability to predict and plan with unprecedented accuracy is particularly vital in high-stakes, intricate surgeries, where even small errors can lead to significant consequences (8). However, as AI becomes an integral part of clinical practice, ethical concerns related to data privacy, inclusivity, and transparency must be addressed. Ensuring that AI technologies are equitable and beneficial to all patients is paramount, so that its implementation not only improves the accuracy and efficiency of care but also aligns with the broader goal of providing patient-centered, ethical healthcare (9). AI is rapidly reshaping the landscape of oral and maxillofacial surgery, ushering in an era of personalized, efficient, and precise care. With its transformative power to enhance diagnostics, refine surgical precision, and optimize patient outcomes, AI is poised to redefine the future of oral and maxillofacial surgery.

This technology not only improves existing practices but also opens new frontiers for the field, ensuring that the care delivered is of the highest standard, both for today's patients and for generations to come. This review highlights how AI is revolutionizing oro-facial trauma management by enhancing risk prediction, enabling precise diagnosis, improving surgical planning, and optimizing recovery processes (10).

Research Design:

The research design serves as the ground plan that directs the whole research process. It outlines the procedures that will be followed in order to collect, analyze, and interpret the data. In addition to assisting in the selection of the most suitable techniques for data collection and analysis, it is responsible for determining the general structure of the investigation. The three primary types of research designs are as follows: descriptive research, which seeks to describe characteristics of a phenomenon; experimental research, in which variables are manipulated in order to observe their effects on others; and correlational research, which examines the relationships between variables without the use of manipulation. In order to guarantee the reliability of the findings of the study, it is essential to select the appropriate design.

Sampling:

The process of selecting a subset of individuals from a larger population in order to provide a representative sample of that group for the purposes of study is referred to as sampling. Researchers are able to collect data from a more manageable group through the use of sampling, which is necessary because it is sometimes impractical to examine an entire population. Probability sampling, in which every individual in the population has a predetermined probability of being chosen (for example, random sampling), and non-probability sampling, in which selections are made based on judgment or convenience (for example, purposive sampling) are the two basic types of sampling. There is a correlation between the type of sampling that was used and the generalisability and dependability of the findings of the research.

Data Collection Methods:

The process of acquiring the information that is required to answer research questions or test hypotheses is referred to as data collection and it is an essential component of research methodology. For example, surveys and questionnaires, which enable the collection of standardized data from large groups; interviews, which offer in-depth qualitative insights; observations, in which researchers record behaviors or phenomena in real-world settings; and experiments, in which variables are manipulated in controlled environments to observe causal relationships. These are all examples of common methods. Both the aim of the research and the kind of data that is required will determine which approach is used.

Data Analysis:

After the data has been collected, the researchers will need to analyze it in order to get significant insights. The process of assessing non-numerical data, such as texts or photographs, in order to recognize patterns, themes, or trends is referred to as qualitative data analysis. Content analysis and theme analysis are two examples of techniques that are frequently utilized. In contrast, quantitative data analysis is concerned with numerical data and often incorporates statistical approaches to detect patterns or test hypotheses. This type of analysis is used to analyze data. Statistical analysis may be performed by researchers with the use of software tools such as SPSS or R. It is important to verify that the technique of analysis is in line with the study strategy and the kind of data in order to obtain correct results.

Inclusion Criteria:

- Individuals who fall within a particular age range (for example, those between the ages of 18 and 65).
- Participants who have specific health problems or disease statuses that are pertinent to the study should be considered.
- Participation based on gender, such as male-only or female-only participants, provided this is pertinent to the study being conducted.
- In the event that it is relevant, only individuals hailing from a certain geographical place or region are included.
- Participants who have been subjected to particular circumstances within a predetermined time frame (for example, that of six months).
- In cases when comprehension is of the utmost importance, individuals who are fluent in the language that is necessary for the research are involved.
- Individuals who have been diagnosed with a certain medical condition or disease, such as diabetes or hypertension, are eligible to participate.
- To be included in the study are only those individuals who have given their informed agreement to take part.

Exclusion Criteria:

- People who fall outside of the age range that has been given (for example, those who are under the age of 18 or those who are above the age of 65).
- Those individuals who have serious co morbidities that have the potential to influence the results of the study.
- Women who are pregnant are not allowed to participate in the study if it might potentially endanger the health of either the mother or the unborn child.
- Individuals who are using immunosuppressants or other drugs that have the potential to influence the findings of the research.
- People who have serious mental health disorders that might potentially impair their participation or the quality of the data.
- Those individuals who have a history of substance misuse, which may have an impact on the findings of the research.
- Those individuals who are unable to or unwilling to adhere to the research procedure or offer informed consent.
- Individuals who have previously taken part in a research that is comparable in order to ensure that there is no bias or repetition of data.
- Individuals who are not fluent in the language that is necessary for the study, in the event that understanding is a vital component.

PRISMA flowchart of study is shown in **[Figure 1]:**

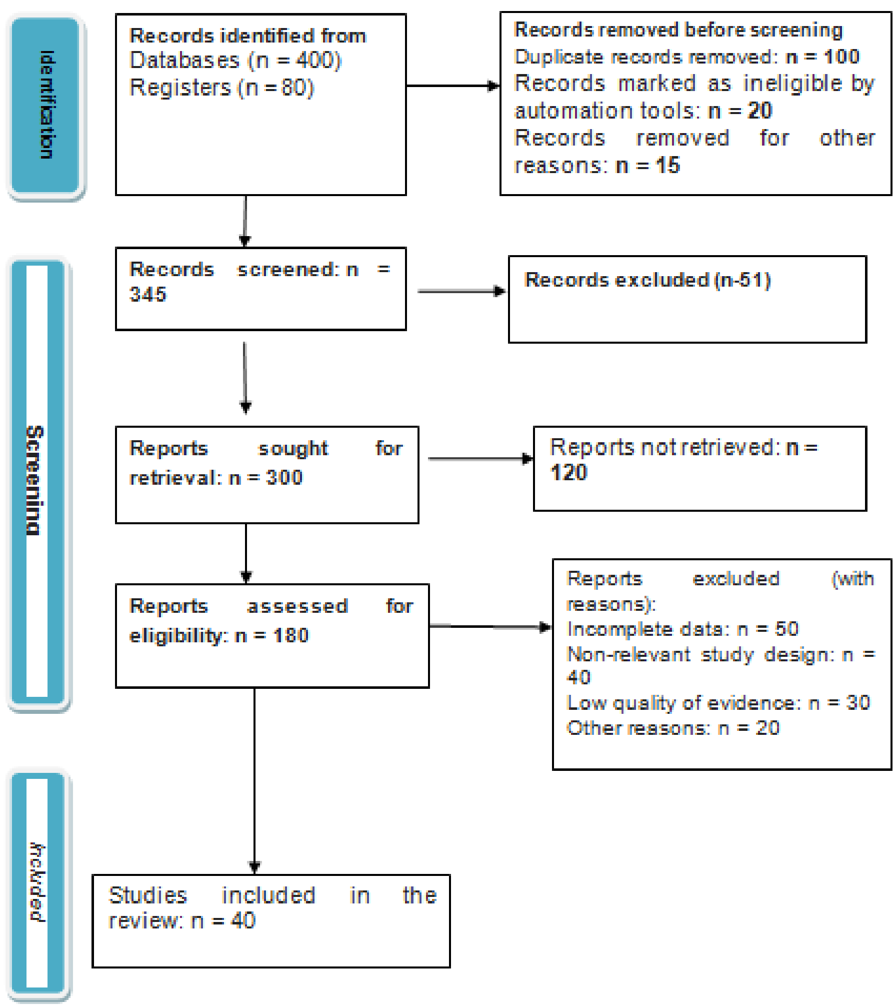

Figure 1: Prisma flowchart

Discussion:

AI is revolutionizing oral and maxillofacial surgery, particularly in robotic-assisted procedures, by enhancing precision, safety, and patient outcomes across various complex surgeries. This transformative technology is especially impactful in cranial interventions, including dental implants, tumor resections, biopsies, and temporomandibular joint surgeries (11). Research consistently demonstrates that AI-assisted surgeries significantly outperform traditional freehand methods, delivering notable advancements in surgical accuracy and patient safety (12). One of the most promising applications of AI is in the diagnosis and management of maxillofacial cysts, tumors, and oral cancer. Early detection of pre-cancerous lesions is crucial and AI-powered tools—such as auto fluorescence measurement and advanced imaging techniques—are paving the way for earlier and more accurate diagnoses (13). Convolutional neural networks (CNNs) have demonstrated diagnostic capabilities comparable to expert clinicians, greatly enhancing the detection of oral cancers (14). Additionally, AI's ability to analyze radiomic data is improving the identification of metastatic lymph nodes, offering valuable insights into tumor characteristics and the surrounding microenvironment. By analyzing clinical and biological data, AI can predict cancer progression, survival rates, recurrence risks, and postoperative complications, marking a significant step forward in personalized treatment strategies (15). Machine learning algorithms also play a critical role in the early screening, diagnosis, and prognosis of oral cancer. Systems such as dentalXr and Dentomo are automating the diagnosis of maxillofacial conditions through 2 dimensional/ 3 dimensional (2D/3D) image classification and asymmetry analysis (16). This integration of AI not only streamlines the diagnostic process but also significantly improves accuracy, reducing human error and ensuring faster intervention. Furthermore, AI is essential in predicting treatment-related complications like xerostomia and extra-nodal extension in head and neck cancer patients, further advancing the potential for personalized care (17). In the field of orthognathic surgery, AI is transforming the management of dentofacial deformities. From diagnosis to postoperative care, AI-driven tools are automating labor-intensive tasks such as tele-radiograph annotations and cephalometric diagnoses, reducing inter-operator variability and improving consistency. By leveraging machine learning, 3D imaging analysis tools now offer a more accurate representation of complex dentofacial deformities, improving surgical planning and patient outcomes (18). AI algorithms, trained on extensive datasets of cephalometric data and unannotated images, can predict the need for surgery, enhancing decision-making and minimizing undesirable aesthetic and functional outcomes.

Moreover, AI-driven planning software now provides realistic preoperative simulations, improving patient communication and setting expectations for postoperative appearance. Looking ahead, the future of orthognathic surgery envisions a fully AI-driven digital workflow where algorithms automatically diagnose dentofacial deformities, propose highly personalized treatment plans, perform surgical simulations, and assess outcomes. This level of sophistication could revolutionize care delivery, requiring a robust database of patient data for continuous training and validation (19). AI's role in oral and maxillofacial surgery is not only about improving clinical outcomes but also reshaping the entire landscape of diagnosis, treatment planning, and patient care. With its precision, predictive capabilities, and ability to personalize treatment, AI is poised to be the cornerstone of a new era in surgical excellence (20).

AI and cone beam computed tomography (CBCT) analysis:

AI is transforming dentistry, particularly in the analysis of CBCT scans, by revolutionizing diagnostic accuracy and treatment planning. CBCT, a state-of-the-art 3D imaging technology, provides dental professionals with unparalleled insights into a patient's oral and maxillofacial anatomy (21). However, interpreting these intricate images has historically been complex and time-consuming. AI addresses this challenge by streamlining and optimizing the process. It enhances the workflow through crucial preprocessing tasks such as noise reduction, Region of Interest cropping, and image alignment, ensuring that CBCT data is ready for detailed analysis (22). Once optimized, AI algorithms excel in segmentation, detection, and classification with remarkable precision, addressing a wide range of clinical applications, including tooth classification, alveolar bone detection, lesion identification, mandible segmentation, malocclusion classification, and buccal bone thickness measurement (23). These capabilities elevate diagnostic accuracy, enabling dental professionals to deliver more timely and effective treatments. Despite its transformative potential, AI's integration into CBCT analysis faces challenges, such as the lack of high-quality annotated datasets and variations in data acquisition protocols (24). Overcoming these obstacles is crucial to unlocking AI's full potential in dentistry. As AI technology continues to evolve, it promises to redefine dental practices by delivering unprecedented precision, efficiency, and improved patient care and outcomes. One of AI's most transformative contributions is its ability to reduce motion and metal artifacts—distortions caused by patient movement or high-attenuation materials like dental crowns and implants. Historically, these artifacts compromised the diagnostic quality of CBCT images. AI's advanced image reconstruction algorithms and deep learning techniques significantly minimize these disruptions, resulting in clearer, more reliable images that have profound implications for patient care. This AI-driven image clarity has revolutionized surgical planning, leading to fewer revision surgeries and implant repositioning. Tumor and cyst resections can now be performed with greater precision, eliminating the need for follow-up procedures, resulting in more predictable and reliable outcomes, improving both patient satisfaction and healthcare efficiency (25).

Fracture detection: AI is making significant strides in the detection of fractures, a critical component of oral and maxillofacial trauma management [**Figure 2**]. A CNN-based system developed by Vinayahalingam et al. demonstrated exceptional sensitivity (95%) and precision (98%) in identifying fractures on panoramic radiographs, outperforming or matching experienced clinicians (26). Similarly, Wang et al.'s deep learning model for classifying mandibular fractures on CT scans achieved over 90% accuracy, enhancing preoperative planning and surgical decisions in complex cases (27). AI is also improving cephalometric analysis, traditionally a labor-intensive task. Machine learning enhances landmark detection accuracy, reducing analysis time while matching expert clinicians. Arık et al. developed a fully automated cephalometric system using deep CNNs, which performs landmark identification, measurements, and classifications, marking a new clinical era (28). AI's role extends to pathology identification, such as odontogenic cysts, tumors, and oral cancers, where deep learning aids in distinguishing conditions like dentigerous cysts and keratocysts, improving diagnostic accuracy and enabling personalized treatments. Early detection of malignant oral disorders is also possible, leading to better intervention and patient outcomes. By automating landmark detection and pathology diagnosis, AI increases precision, minimizes errors, streamlines workflows, and supports surgical planning, revolutionizing oral and maxillofacial surgery (29).

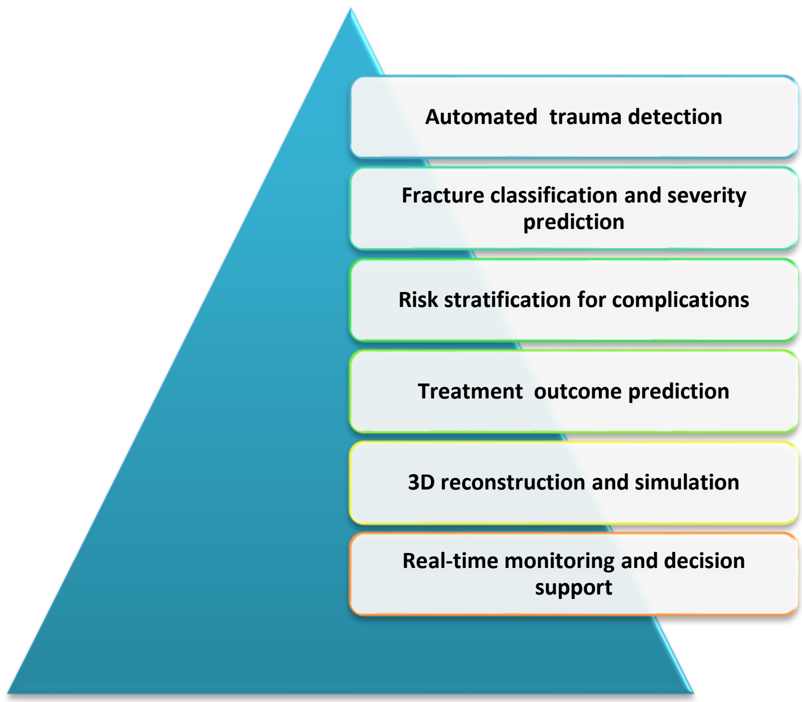

Figure 2: AI Applications in oro-facial trauma

Tumor resection and reconstruction

AI is transforming the planning and simulation of maxillofacial tumor cases by accurately outlining tumor boundaries to ensure complete removal while preserving surrounding structures. AI-driven software can model reconstruction strategies, forecasting outcomes and complications, allowing surgeons to explore different approaches before surgery, ultimately improving surgical accuracy and shortening procedure times. A study by Santer et al. found that AI detected suspicious lymph nodes in advanced head and neck cancers with 86% accuracy, enhancing preoperative staging and planning. AI models also predict the effectiveness of reconstructive options, improving patient recovery by ensuring better outcomes (30).

Oral cancer diagnosis and prognosis

Oral cancer is the most common malignancy in the oral and maxillofacial region, and early detection is crucial for survival. AI, particularly machine learning, is playing a pivotal role in improving early diagnosis, prognosis, and treatment prediction (31). Aubreville et al.'s AI-driven approach detected oral squamous cell carcinoma in confocal laser images with 88.3% accuracy, outperforming traditional methods (32). DenseNet121 and faster Region- based convolution neural network (R-CNN) have also been applied to identify oral cancer in photographic images with high precision. AI models can predict cancer outcomes such as survival rates and lymph node metastasis, offering more reliable predictions than conventional methods. Deep learning models are also outperforming radiologists in diagnosing cancer-related issues, improving treatment planning (33).

Treatment complications and prognosis

AI is revolutionizing the prediction and management of complications in cancer treatments, improving patient outcomes. Chu et al. and Men et al. used AI to predict xerostomia in head and neck cancer patients with high accuracy, providing proactive care strategies (34, 35). In nasopharyngeal carcinoma, AI refines radiotherapy by identifying early warning signs and minimizing side effects, leading to better patient well-being. Li et al. developed an endoscopic image-based model that surpassed expert detection in nasopharyngeal cancer diagnosis, enabling quicker and more accurate results (36). Du et al. applied machine learning to post-treatment images to detect recurrence, ensuring timely intervention (37). Lin et al.'s deep learning model enhanced tumor delineation on MRI scans, improving treatment planning accuracy. AI is also detecting early radiation-induced damage, empowering clinicians to prevent complications before they escalate, transforming cancer care (38).

Maxillofacial bone defect reconstruction

Maxillofacial bone defects, resulting from congenital deformities, trauma, or surgery, can significantly impact a patient’s quality of life. Reconstructive surgery aims to restore function and appearance, and machine learning is aiding in planning and performing these surgeries (39). Jie et al. developed a model that predicts missing bone data and assesses symmetry post-surgery, yielding results comparable to navigation-guided surgery (40). Dalvit Carvalho da Silva et al. used machine learning to identify the facial skeleton midline, assisting surgeons in reconstruction. These innovations are enhancing the success of bone defect reconstructions (41).

Orthognathic surgery

Orthognathic surgery addresses dental issues, facial deformities, and conditions like sleep apnea, improving both appearance and function. Traditionally, clinical exams and manual methods were used, but advancements in 3D printing, digital software, and machine learning have significantly improved outcomes (42). Deep learning assesses surgery needs and evaluates facial symmetry pre- and post-surgery, aiding in better decision-making. AI also predicts aesthetic outcomes, assisting patients and surgeons in planning. Machine learning helps optimize preoperative planning by analyzing soft tissue changes based on bone movements, improving communication and ensuring precise surgical results. By analyzing data from 3D scans, CBCT, and dental models, AI optimizes aesthetic, bite alignment, and airway changes, leading to more effective surgeries (43).

Dental implants

Dental implants are an effective solution for replacing missing teeth, but their success relies on bone quality and meticulous planning. Machine learning enhances implant planning and success rates (44). Deep learning, using 3D scans, produces results comparable to manual methods for implant placement. AI also predicts complications such as implant failure or peri-implantitis, aiding in better care. By analyzing CBCT scans, AI determines optimal implant placement, taking into account bone density and proximity to vital structures, improving the success and longevity of implants. This technology enhances precision in implant procedures, making them more effective and efficient (45).

Intraoperative guidance and robotics

The integration of AI with robotic surgical systems enhances precision and safety in oral and maxillofacial surgeries. AI-powered robotic systems have shown superior accuracy in dental implant surgeries compared to freehand techniques (46). These systems dynamically adjust to intraoperative conditions, optimizing drill trajectories and depth to ensure accurate implant placement while avoiding critical structures. In tumor resections and reconstructive surgeries, AI-driven robots provide real-time guidance, processing intraoperative imaging data to ensure procedures follow preoperative plans and alerting surgeons to deviations. This approach is particularly beneficial for complex cases with intricate anatomy (47)**.**

Intraoperative decision support

AI algorithms are being developed to provide real-time decision support during surgeries. Machine learning models can detect and highlight critical structures like nerves and blood vessels, alerting surgeons to potential risks, especially in complex cases or for less experienced practitioners. AI can also predict complications by analyzing real-time physiological data and surgical parameters, offering warnings about risks such as excessive bleeding or nerve damage, enabling timely preventive measures (48).

Augmented reality (AR) integration

Combining AI with AR has promising applications in enhancing intraoperative guidance in oral and maxillofacial surgery. AI algorithms process real-time imaging data and overlay critical information onto the surgeon's field of view through AR displays, such as anatomical structures, osteotomy lines, or implant positions. This technology provides real-time feedback, improving surgical precision and planning (49).

Clinical decision support

AI systems are being developed to assist clinical decision-making in oral and maxillofacial surgery by analyzing large datasets of patient information, treatment approaches, and outcomes. These models help in treatment planning, risk assessment, and predicting outcomes, such as in orthognathic surgery, where AI predicts aesthetic and functional results based on preoperative data. In oncologic cases, AI aids in selecting surgical options by forecasting margin status, functional preservation, and long-term survival (50).

Risk assessment and complication prevention

AI-driven risk assessment tools identify patients at increased risk of complications. By analyzing preoperative data, these systems highlight high-risk cases, enabling more thorough optimization or adjustments to surgical plans. In the postoperative phase, AI monitors patient data to anticipate complications, such as infection or wound separation, allowing for early intervention (51).

Challenges and future directions

While AI shows tremendous potential, several challenges must be addressed before widespread clinical implementation. These challenges involve data quality, clinical integration, validation, regulatory approval, and ethical considerations. The success of AI systems depends on high-quality, diverse datasets, which can be difficult to obtain in the rarefied field of oral and maxillofacial surgery (52). Standardizing data collection and fostering collaborative data-sharing initiatives can aid in addressing this. Furthermore, AI systems must undergo rigorous clinical validation and regulatory approval, with agencies like the Food and Drug Administration (FDA) developing frameworks for evaluating AI-based medical devices.AI must also be seamlessly integrated into existing clinical workflows. This requires technical integration with hospital information systems and adaptation of clinical processes. Education and training programs will help clinicians effectively use AI systems and interpret results. Developing more interpretable AI models will build trust and improve adoption in clinical settings (53).

Ethical and legal considerations:

AI in healthcare raises ethical and legal concerns, such as data privacy, informed consent, and algorithmic bias. Clear guidelines and legal frameworks are necessary to ensure patient safety, define responsibilities, and address issues of medical liability in AI-driven decision-making. Addressing these considerations is essential for AI's ethical integration into clinical practice (54). [**Table 1]** provides an overview of several studies that predict the use and effectiveness of AI in different aspects of oral and maxillofacial surgery. The predictions made in these studies involve the following key areas (55-62).

Table 1: Predicted use and effectiveness of AI in oral and maxillofacial surgery

Authors	**Published Year**	**Study Title**	**Objective**	**AI application**	**Findings/ Results**
Zhou et al.	2020	Predicting surgical outcomes	To use AI for predicting success rates of	Predictive modeling with deep learning	AI accurately predicted the success rates of

		using AI models	reconstructive surgery for oro-facial trauma patients	algorithms	reconstructive surgeries, improving treatment plans
Miller et al.	2020	AI-assisted reconstruction in facial trauma	Investigating AI-driven robotic systems in reconstructive surgery for oro-facial trauma	Robotic systems powered by AI and real-time data analysis	AI systems aided in surgical precision, reducing revision surgeries and enhancing recovery times
Hung et.al	2021	AI in cephalometric analysis of facial injuries	To investigate AI's use in cephalometric analysis for diagnosing oro-facial injuries.	CNNs for cephalometric analysis	AI achieved high accuracy in analyzing cephalometric data to diagnose and classify facial injuries
Kim et al.	2021	Role of AI in post-operative monitoring	To assess AI's ability in monitoring recovery post-surgery for oro-facial trauma patients	AI-based monitoring systems (wearables, sensors)	AI identified early signs of infection and healing issues, reducing hospital readmission rates
Lee et al.	2021	Machine learning models for predicting trauma risk	To evaluate machine learning for risk prediction in oro-facial trauma	Supervised machine learning, random forest, Supervised machine learning	AI accurately identified high-risk trauma patients, improving triage decisions
Wu et al.	2022	GANs in facial imaging	To evaluate GANs in enhancing	GANs	GANs enhanced CT scan and MRI

			radiographic images for diagnosing oro-facial trauma		image quality, improving diagnosis of fractures and tissue damage
Xu et al	2023	AI in predicting complications in facial trauma	To determine AI's predictive power in anticipating complications in facial trauma surgeries	Deep learning algorithms and predictive analytics	AI models identified patients at high risk of complications post-surgery with a high degree of accuracy
Patel et al.	2023	AI in maxillofacial surgery for surgical outcomes	Assess AI's ability to predict surgical outcomes for maxillofacial reconstructions	CNNs and predictive models	AI accurately predicted post-surgical complications such as infection and misalignment

Future Prospects:

As AI rapidly evolves, its impact on oro-facial trauma management is set to revolutionize patient care and healthcare systems globally. The future of AI in this field presents transformative possibilities, enhancing outcomes, optimizing treatment strategies, and empowering healthcare providers with advanced tools [**Figure 3**] (63).

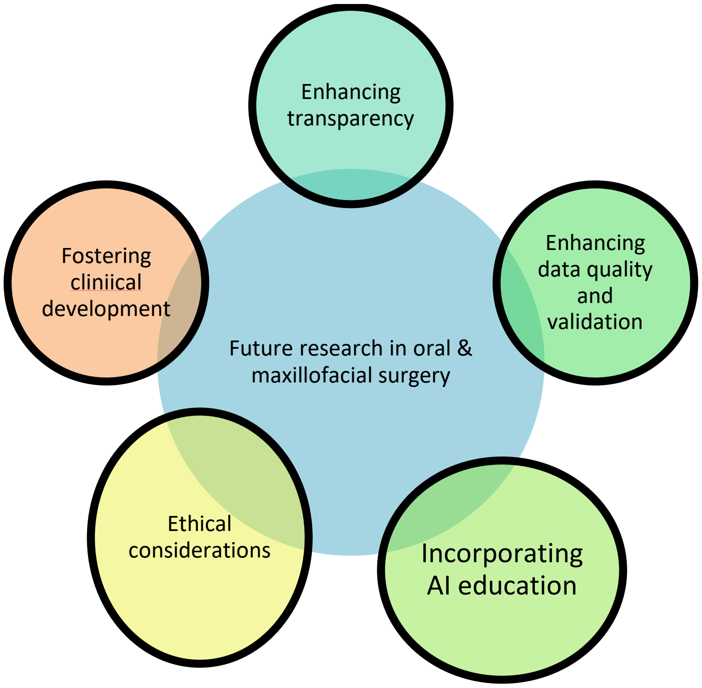

Figure 3: Future prospect of artificial intelligence in oral and maxillofacial surgery

Key prospects include:

1. **Personalized treatment plans:** AI will enable highly individualized treatment strategies, tailoring care based on a patient's unique genetic, clinical, and demographic data. Integrating AI with genomics and personal health metrics will allow clinicians to develop bespoke treatment and rehabilitation plans, accelerating healing and minimizing complications.
2. **Real-time decision support:** Advanced AI-driven diagnostic tools will transform real-time decision-making in trauma care. By continuously analyzing data from wearable sensors, imaging devices and electronic health records, AI will provide clinicians with timely alerts on patient condition changes, offering actionable insights for immediate adjustments to treatment plans (64).
3. **Predictive analytics for long-term outcomes:** AI's ability to process vast datasets will revolutionize the prediction of long-term recovery outcomes, complications, and re-injury risks. By leveraging historical data, AI will inform not only immediate care but also long-term monitoring, ensuring better post-operative care and reducing the risk of chronic conditions or secondary injuries (65).
4. **Enhanced surgical precision through robotics:** AI-powered robotic systems will play a pivotal role in enhancing surgical precision. By assisting in complex surgeries with precise movements and real-time adjustments, AI will reduce errors, improve patient outcomes, and lead to minimally invasive procedures, shorter recovery times, and superior aesthetic results (66).

5. **AI-powered imaging and diagnostics:** AI-driven imaging technologies, including deep learning algorithms for CT scans and MRIs, will significantly improve diagnostic accuracy and speed. These advancements will enable earlier detection of oro-facial fractures and soft tissue injuries, leading to more accurate treatment planning and optimal management (67).
6. **AI in preventative medicine:** AI will transform preventive care by analyzing patient risk factors—such as genetics, lifestyle choices, and trauma history—to identify those at higher risk for oro-facial injuries. Early interventions and education based on these insights will help mitigate trauma before it occurs, reducing injury rates globally (68).
7. **Collaborative AI systems for multidisciplinary care:** AI will facilitate seamless collaboration among multidisciplinary healthcare teams, including trauma surgeons, dentists, oral and maxillofacial specialists, and rehabilitation experts. By enabling real-time data sharing, AI will ensure that all specialists have access to the most current information, enhancing coordinated care.
8. **Global accessibility through telemedicine:** AI's scalability will expand access to oro-facial trauma care, particularly in underserved regions. Through AI-powered telemedicine platforms, remote diagnosis and consultation will become routine, allowing patients in rural or low-resource areas to receive expert care without the need to travel long distances (69).

Conclusion:

The integration of AI into oro-facial trauma management marks a monumental leap in healthcare innovation. With its unparalleled ability to predict risks, enhance diagnostic precision, and streamline treatment planning, AI is reshaping both immediate care and long-term patient outcomes. By automating complex tasks—such as radiographic analysis, surgical predictions, and implantology management—AI is elevating the precision, efficiency, and safety of oral and maxillofacial surgery. While challenges remain in refining AI’s diagnostic capabilities and achieving complete surgical autonomy, the potential for transformative breakthroughs is clear. As collaboration between AI developers, healthcare professionals, and researchers continues, AI will fully integrate into clinical practice, enhancing the quality of care. With ongoing advancements, AI will empower healthcare providers to deliver personalized, data-driven solutions, transforming the landscape of oro-facial trauma management and ultimately improving patient experiences worldwide.

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