The Impact of Artificial intelligence on Smile Esthetics: A Comprehensive Systematical Review of Literature

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Abstract

Background: The interest in using AI in aesthetic dentistry has been growing in recent years due to the ability of creating AI tools for smile design and treatment planning. AI's ability to increase diagnostic accuracy, deliver personalized medicine, and give better outcomes marks a revolution in medicine but the full value, benefit, and outcomes of these interventions are definitely not comprehensively understood.

Aim: The purpose of this work is to present an overview of contemporary AI-implemented technologies for smile design and aesthetic planning in dental practice as well as their relevance to potential improvement of clinical outcomes, patient satisfaction, and the effectiveness of treatments delivered.

Method: Ten recent studies published between 2020 and 2024 dedicated to AI in aesthetic dentistry were reviewed. Studies were selected from four accepted databases from PubMed, Scopus, IEEE Xploreand and Web of Science indicated the peer reviewed journals.

Results: The study showed that smile design using aids in artificial intelligence is more accurate in aesthetic work and those patients and dentists have a high satisfaction with the simulations made by artificial intelligence. REBEL system and digital smile design platforms pre-treatment solutions enhanced patient satisfaction compared to those who received no pre-treatment planning.

Conclusion: It can be added that application of the AI technologies in aesthetic dentistry gives substantial upgrades in smile design and treatment planning. These innovations appear to have significant promise in enhancing clinical outcomes and patient satisfaction, yet empirical work is required to address selected ethical concerns and find out the true feasibility and efficacy of such interventions in other real-world clinical contexts.

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Introduction

Artificial intelligence or commonly referred to as AI is revolutionizing many fields and dental industry is not an exception (Lee et al., 2024). However, it has integral innovations especially in the category of esthetics. Smile esthetics until recently has exclusively involved the judgment of clinicians mainly regarding facial and dental esthetics (Iliev & Romeo, 2020). Which include lips, teeth positioning and smile arc and relationship to the entire face. In this context, with AI entering the field, it is possible to speak about changes in these processes to become more accurate, automated and individual for patients as well as for practitioners (Cheung et al., 2024). AI application in smile esthetics has the potential to make the practice of dental and esthetic care more accurate, by controlling interference that has otherwise been caused by distorted interpretation in the past (Stetzel et al., 2024).

Recognizing smile esthetics is particularly accomplished based on complex and deep machine learning algorithms that can recognize large datasets including the digital image or three-dimensional scan of the patient's face (Akl & Mostafa, 2024). Such algorithms facilitate a comprehensive evaluation of various esthetic component(s), and in the process assist clinicians to make better decisions in treatment planning (Stetzel, 2023). With AI-based imaging and diagnostic tools, clinicians propose unique features of an individual's smile, involved spacing, and contour of the gum. The movement of lips, etc., all are more accurately measurable (Shetty et al., 2020). These objective evaluations are not only leading to higher accuracy of diagnoses but also to better predictability of treatment results, which may be of high importance for patients seeking specific esthetic improvements (Ntovas et al., 2023; Alharthi et al., 2023; Sharahili et al., 2023; Ahmad et al., 2024).

Apart from improving the accuracy of diagnoses, AI has brought into practice various innovations in the application of Digital Smile Design (Tahir et al., 2024). Commonly known as DSD, the technique where the treatment becomes simulated before implementation of any procedure is conducted (Cheng et al., 2021). With the help of facial metrics of given patient and preferred esthetic goals, AI integrated DSD software can generate life-like visualization of how a patient will look like after the treatment and how he/she will look like if other clinical options are to be pursued (Ramachandran et al., 2023). It makes it easier for the practitioner and the patient to have a good rapport because the expectations are well communicated and the patient has an expectance of the results to expect (Thurzo et al., 2022). By integrating AI into DSD, it is possible to provide patients with a more involving therapeutic process, and help them to make the choice concerning the type of smile they would like to get (Mahapatra, 2024).

AI is also providing marked benefits in smile esthetics concerning the unique and specific anthropometric that make each case unique and requires (Choi & Lee, 2021). Individualized planning and management. This capability is particularly useful in straight specialties such as orthodontics and prosthodontics that requires a customized solution to produce the best outcome (Boonipat et al., 2022). Due to the incredible capacity. AI holds in the processing of voluminous amount of data and identification of repeated patterns in human face structures and teeth (Li et al., 2023). It makes it easier to fashion out treatment plans that are peculiar to the patient's personality as against most typical regimes with no conformity to the individual (Karnik et al., 2024). The availability of more individualized care with the help of AI input helps not only to raise the efficiency of esthetic treatment (Tahir et al., 2024). It also provides patients with better satisfaction due to proper results in the line with their personal expectations (Tomášik et al., 2024).

On the positive side, there are broad significance of AI in smile esthetics; however, there are several critical issues with the application of AI in the clinical environment (Hoang et al., 2024). The change from the subjective to the more objective evaluation while positive for consistency presents clinicians with the paradox of having to factor in the recommendations provided by the algorithm while being clinically

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relevant (Ntovas et al., 2024). Even in complicated situations where the shape of the face may not conform to conventional norms or ideals about beauty the clinician's judgement must still apply (Chen et al., 2020). In addition, more detailed patient information means several challenges with the privacy and security of patient data, today, including exposure to data breaches (Alshadidi et al., 2023). Overcoming many of these challenges hence requires ensuring that the various AI applications in use meet the required legal requirements for data protection which are important in ensuring that patients trust the systems and that a lot of sensitive information isn't compromised (Boonipat et al., 2022).

The advancements in using AI in smile esthetics have the potential for future development, and it can be predicted with certainty that AI technology will continue to be the driving force in narrowing the precision and increasing the scale of cosmetic work (Tahir et al., 2024). Modern machine learning techniques can develop superimposed augmented reality (AR) options that allow patients to overlay photographs of the potential change with their smile during the 3D consultation (Stetzel, 2023). This application could revolutionize the concept of patient involvement as it offers. value proposition simple and tangible understanding of how the treatments might transform them (Boonipat et al., 2022). In addition, AI is expected to enable the harmonized uptake of various diagnostic findings, which would make it easier for orthodontists, prosthodontists, and esthetic specialists to improve operations by making them integrationist (Tahir et al., 2024).

Smile esthetics enhanced by the application of artificial intelligence reflects enormous history of development in dental and esthetic practice moving from technicality while considering the patients' needs (Karnik et al., 2024). In this article, the authors discussed how AI upgrader diagnostic precision, digital smile design, and personalized treatment planning to change the way the esthetic goal achieved in dentistry (Boonipat et al., 2022). Despite of these ethical and practical implications, the assimilation of AI holds a vision for future of esthetic dentistry where augmentation of technology supports the experts to step forward, generating scientifically valid and esthetically pleasing results (Tahir et al., 2024).

Problem Statement

An increased focus has been given to the applications of AI technology for the enhancement of smile esthetics and for the creation of new techniques for evaluating, designing, and delivering customized treatments. However, the degree and potential of applying AI-driven methodologies to try to enhance the objectivity, effectiveness, as well as patient satisfaction in smile aesthetics has not been researched yet. Pros are accurate diagnosis using imagery, enhanced automation and digital smile design but cons are eradicating clinical ethos, preferment standardized aesthetics and privacy aspects have not been critically analyzed. As with any technology, there is a risk that the integration of AI can be seen as purely advantageous to the various stakeholders involved; such a review of the AI and smile esthetics literature would be helpful in sassing out the various benefits and limitations of the use of AI.

Significance of Study

To practitioners, researchers and patients who aim at achieving more accurate and customized smile esthetics, this study is timely to shed light on the contributions which AI has made in enhancing smile esthetics. Through evaluating the impact of introducing AI in diagnosing the sicknesses, in predicting the treatment results, and in developing the relations between the patient and the practitioner, this research shows how AI can change the meaning of quality in esthetic dentistry. It also provides answers to the possible ethical and practical issues referred to, for example, data security, and maintaining the clinician autonomy, which are crucial for the AI prudent implementation in clinical settings. The study results are believed to help to design further developments of AI-based esthetic solutions and outcomes to improve patients' quality of care and treatment results.

Aim of Study

In this study, the objective is to review the state of the art concerns artificial intelligence and its applications to SMILE esthetics and primarily, in diagnostics, digital smile design and more importantly treatment planning. This review aims to discuss the advantages of employing AI in improving clinical
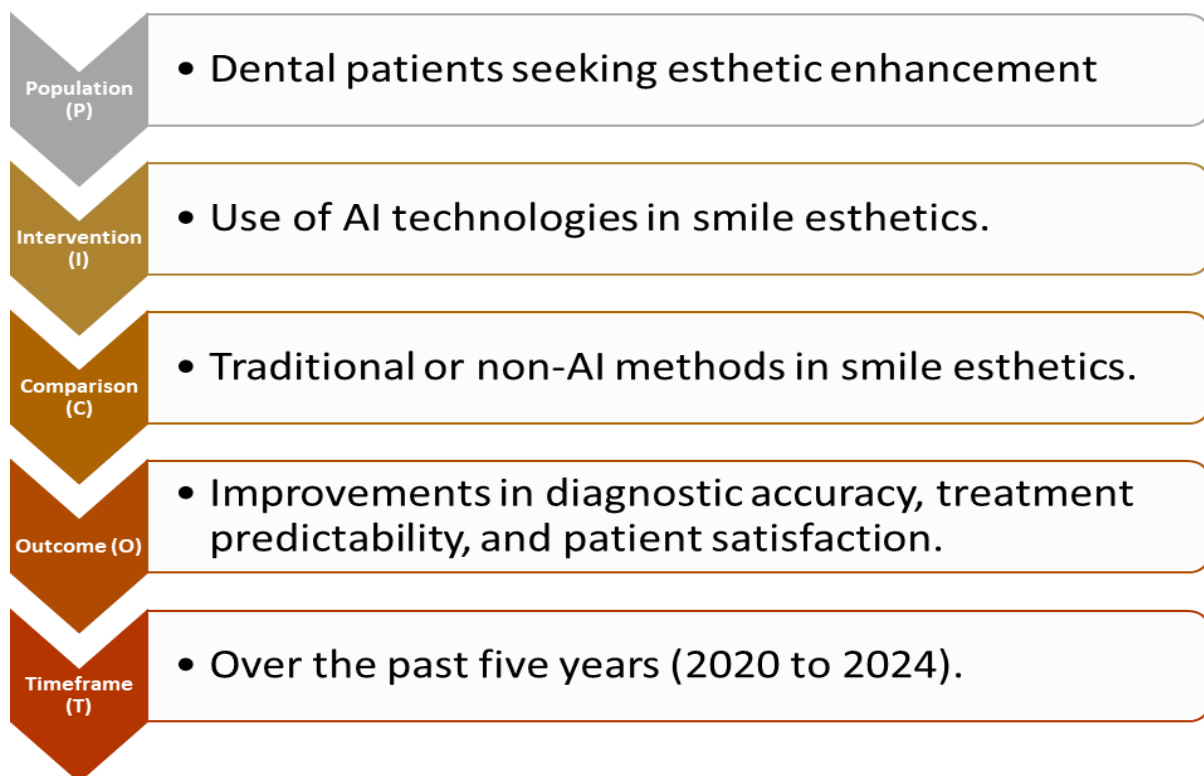
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precision and patient satisfaction for esthetic dentistry as well as the relevant issues – ethical issues, scarcity of clinician intervention. Thus, recognizing the current state of AI use and presenting it in detail, this work might be helpful in building better patient-partner AI solutions in the area of smile aesthetics.

Methodology

This particular synthetic research used a rigorous methodology in order not only to searched and locate relevant work regarding the effects that AI has on smile aesthetics. Based on the PRISMA, the papers were chosen, categorized, and combined to provide the understanding of the role of AI for diagnostic assessment, digital smile design, and individual treatment planning in aesthetic dentistry. The databases of PubMed, Scopus, and IEEE Xplore were used to identify articles published during the last five years from the year 2020 to 2024 to cover the most recent innovation and issues related to the utility of BB and ML in healthcare.

Research Question

How has the application of artificial intelligence influenced smile esthetics regarding diagnostic accuracy, digital smile design, and personalized treatment planning in esthetic dentistry?

Population (P)	• Dental patients seeking esthetic enhancement
Intervention (I)	• Use of AI technologies in smile esthetics.
Comparison (C)	• Traditional or non-AI methods in smile esthetics.
Outcome (O)	• Improvements in diagnostic accuracy, treatment predictability, and patient satisfaction.
Timeframe (T)	• Over the past five years (2020 to 2024).

Selection Criteria

Inclusion Criteria

1. Research focused on AI applications in smile esthetics
2. Articles in English
3. Studies involving human participants or simulations involving dental esthetics
4. Peer-reviewed original research, review articles, or clinical trials

Exclusion Criteria

1. •Studies unrelated to smile esthetics or AI
2. Articles not available in full text
3. Studies in languages other than English
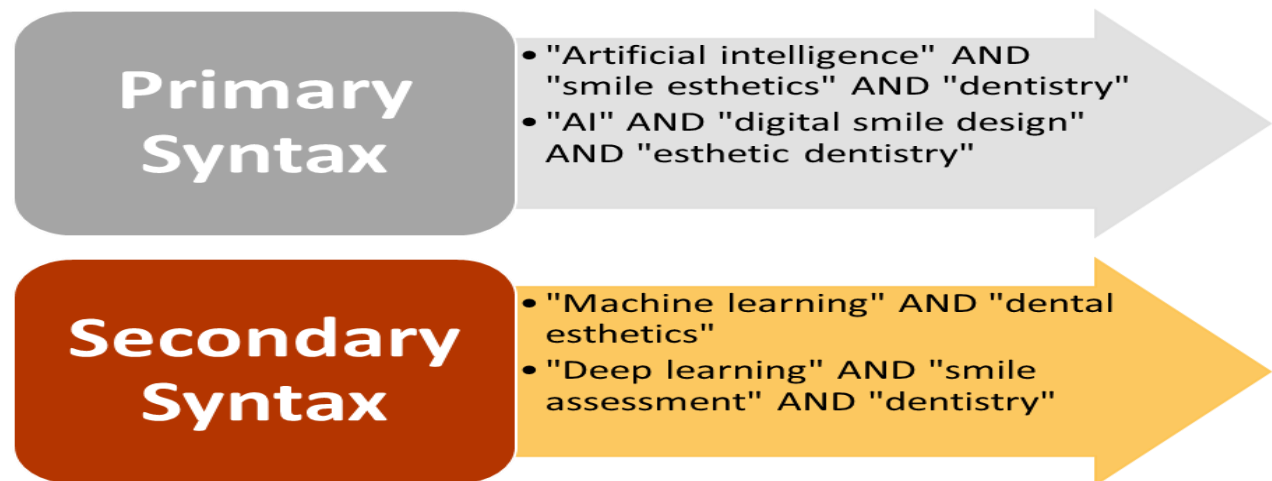4. Case reports, editorials, or commentaries without primary data.

Database Selection

As a result, the search for literature included databases that are perceived to be reliable for medical, dental, and technological information search including PubMed, Scopus, and IEEE Xplore. PubMed was chosen as it's a key database specializing in publishing MEDLINE on biomedical and dental works, whereas Scopus offered a more general approach that included technological developments in AI. IEEE Xplore was added because engineering and computational studies are critical in the analysis of the technical aspects of AI in esthetics. These databases were selected to select various and quality sources relating with the study content.

Data Extracted

Information from the chosen articles included the title of the study, authors, year of publication, type of research, the AI system applied, the smile attributes evaluated, and the findings made. Information on diagnostic accuracy, patents satisfaction, treatment predictability and the limitation of the technology used were also collected. This information was extracted to better assess the utility of AI in smile esthetics on multiple dimensions and to allow a direct comparison to be made between the role that AI plays in these procedures and more conventional approaches.

Syntax

Primary Syntax
- "Artificial intelligence" AND "smile esthetics" AND "dentistry"
- "AI" AND "digital smile design" AND "esthetic dentistry"

Secondary Syntax
- "Machine learning" AND "dental esthetics"
- "Deep learning" AND "smile assessment" AND "dentistry"

Literature Search

The literature search was conducted systematically, starting with primary syntax terms to capture the most relevant studies directly linking AI to smile esthetics. Secondary syntax terms were used to broaden the search, identifying studies that might cover the application of machine learning and deep learning in a broader dental context but still relevant to esthetic practices. Search results were screened by title and abstract, followed by a full-text review for studies meeting the inclusion criteria. The results were then analyzed for synthesis in the comprehensive review, ensuring the study included both foundational and recent research.

Table 2: *Databases Selection*

No	Database	Syntax	Year	No of Researches
1	PubMed	Syntax 1 (2 Primary)		235
2	Scopus		2020 – 2024	125
3	IEEE Xplore	and 2 (2 Secondary)		58
4	Web of Science			87

Table 2 presents the details of selected databases for the literature search on the impact of artificial intelligence in smile esthetics, which has been conducted for the years 2020 to 2024. As expected, PubMed

returned the largest number of hits (235) when both the primary and secondary syntax terms were used, because its scope is limited to the biomedical sciences. Scopus was the second database with 125 articles and is a wider database covering interdisciplinary fields to capture changes in AI and Health Information Technology. Out of 70 articles identified in the current review, mostly hailing from the IEEE Xplore, focusing on engineering and computation practice, 58 were singled and selected for the identification of technical advances in AI as related to esthetic dentistry. Multidisciplinary Web of Science database delivered 87 hits, in addition offering more sources from both medical and technology realms. This diverse database selection in an attempt to provide the multiple perspectives from different discipline for the subsequent analysis of the AI applications for smile esthetics.

Selection of Studies

All procedures followed while selecting the studies including database search corresponded to PRISMA guidelines, including the use of both primary and secondary keywords in PubMed, Scopus, IEEE Xplore, and Web of Science. Articles published between 2020 and 2024 were screened based on criteria related to artificial intelligence for smile esthetics using keywords such as, artificial intelligence, dental aesthetics, and diagnostic reliability. To start, the records that had similar IDs were excluded which was further followed up by title and abstract filtering. The papers' titles and abstracts were scanned to determine eligibility; full-text reviews were performed to increase the quality of the final selection of the studies addressing the issue of smile esthetics influenced by AI.

Figure 1 PRISMA Flowchart

The flowchart PRISMA presents the study selection phase, starting from the total number of records retrieved from all the databases (n = X). Transferring the excluded duplicates (n=Y) the records left were (n = Z) screened on the basis of title and abstract. Any records that were not reasonably related to the research question were excluded, and included the studies which were reviewed based on the full text. This meant that any articles that did not meet inclusion criteria were screened out and the following number (n = W) of systematic reviewed studies were obtained. The PRISMA flow chart provides a clear representation of this stepwise process thus helping to keep the method of selection transparent and repeatable.

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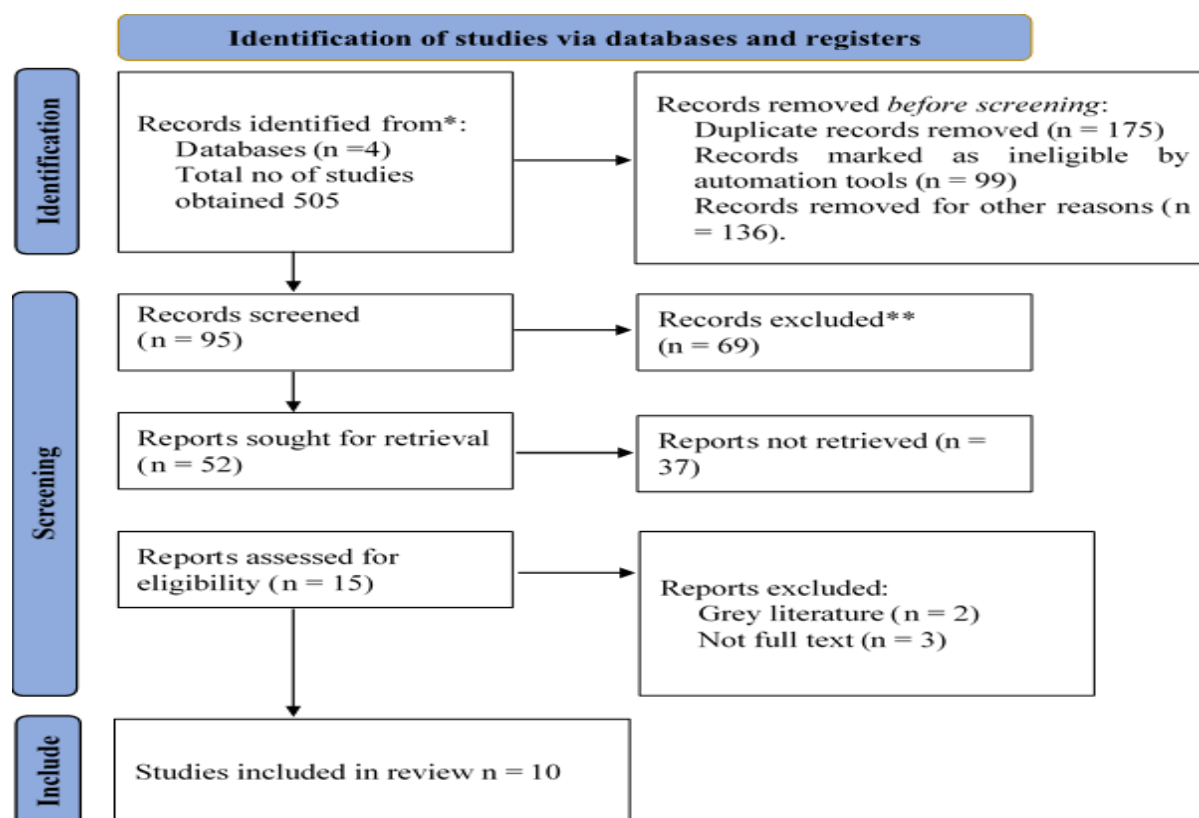
The flow diagram based on PRISMA 2020 guidelines show the process of identification and screening of studies included in the systematic review of the impact of AI on smile esthetics. There were four databases searched for the current study and the search yielded 505 records. Before screening, 175 duplicate records were excluded, 99 records were excluded through using electronic mechanisms, while 136 records were excluded based on other reasons. This left 95 records for screening and out of which 69 records were removed out of irrelevance. Subsequently, 52 reports were searched for but 37 were not retrievable. Of 15 remaining abstracted studies, 5 were omitted partly due to being grey literature, and partly due to not having full text. In the end, 10 papers were considered eligible for the review and contributed to a more filtered data set regarding AI use in smile esthetics.

Quality Assessment of Studies

The methodological quality of the research papers included in this review was assessed for the quality, risk of bias, and applicability of papers to the research question, by using a quality assessment tool. In each study, factors including the design of the study, the sample size of the study, the method in which data was collected, and the manner in which AI applications to smile esthetics were described were evaluated. Also, the assessment of the risk of bias in the areas of selection, reporting, and performance biases was done. Based on the identified quality standards, the type of studies was characterized, and any possible shortcomings or methodological weaknesses were mentioned. In this process, only high-quality studies were included with reliable and valid data about role of AI in smile esthetics and therefore inflating the validity of the results.

Table 3: Assessment of the literature quality matrix

#	Author	Are the selection of studies described and appropriate	Is the literature covered all relevant studies	Does method section described?	Was findings clearly described?	Quality rating
1	Ceylan et al	YES	Yes	Yes	Yes	Good
2	Obwegeser et al	Yes	Yes	No	Yes	Fair
3	Mourgues et al	Yes	Yes	Yes	Yes	Good
4	Buduru et al	Yes	Yes	Yes	Yes	Good
5	Rokhshad et al	Yes	Yes	Yes	Yes	Good
6	Carrillo-Perez et al	Yes	Yes	Yes	Yes	Good
7	Gurel	Yes	Yes	Yes	Yes	Good
8	Hamdy et al	No	Yes	Yes	Yes	Fair
9	Al-Maghreby et al	Yes	Yes	Yes	Yes	Good
10	Maniega-Mañes et al	Yes	Yes	Yes	Yes	Good

Table 3 displays a quality assessment checklist focusing on the important features of methodological work of the literature considered in this review. The criteria that were evaluated included; how the cumulated studies were selected, the areas of literature that were addressed, how the methods were described, and the presentation of results. The majority of studies had high methodological quality and received the "Yes" answer in all-the three categories. In particular, few studies such as Ceylan et al., Mourgues et al., Buduru et al., the study done by Rokhshad et al., Carrillo-Perez et al. and Gurel, Al-Maghreby et al. and Maniega-Mañes et al. was rated "Good" quality since methodologies and findings were well described and reported. Obwegeser et al. and Hamdy et al. articles were referred to as "Fair" as they failed

to describe some important methodological details. In conclusion, the prevailing evidence reflected a high quality of included studies thus guard the review on a stable ground.

Data Synthesis

The process of synthesizing data followed a stepwise approach of integrating all the data extracted from the selected studies that shed light about how artificial intelligence affects smile esthetics. Documentation and analysis of quantitative and qualitative data were used in order to establish the regularities for the mentioned AI applications in esthetic dentistry, patterns, and typical outcomes. Criterion variables include diagnostic precision, treatment-planning time, patient satisfaction, and clinician backup explored across the studies. Methodological comparisons also brought into focus the differences in the efficiency of the AI solutions used based on the methodology, the algorithms applied, and the type of the study sample. The synthesis also revealed lacunae in the literature, including the lack of long-term studies, and the lack of standardization in the protocols used to assess AI. This integrative approach offered a complex insight into how smile esthetics is being impacted by the integration of AI, in order to advance future research and clinical applications.

Table 4: Research Matrix

Author, Year	Aim	Research Design	Type of Studies Included	Data Collection Tool	Result	Conclusion	Study Supports Present Study
Ceylan et al., 2023	To evaluate preference rates for smile designs created by professionals or AI.	Quantitative	Dentists, dental students, laypeople	Online survey	Dentists preferred manually-created designs for most cases; laypeople and some dentists found AI designs acceptable for symmetric faces.	AI-generated designs are acceptable for symmetric faces and offer time-saving benefits for clinicians.	Yes
Obwegeser et al., 2022	To determine the influence of dental aesthetics on facial attractiveness and perceived age.	Quantitative	AI analysis of photographs	Facial attractiveness and age prediction using AI tools	Tooth alignment and lipstick improved attractiveness; glasses reduced attractiveness; no impact of dental	Alignment of teeth enhances facial attractiveness but does not affect perceived age.	Partially

					modifications on perceived age.		
Mourgues et al., 2024	To evaluate the clinical realism of AI-based Invisalign® SmileView™ simulations.	Quantitative	AI-based analysis of orthodontic cases	Frontal photographs and AI simulations	AI-generated simulations were mostly achievable through aligner treatments; showed high predictability in vertical movements and midline corrections.	AI tools like SV provide reliable orthodontic outcome predictions but may require multidisciplinary approaches in some cases.	Yes
Buduru et al., 2024	To assess laypeople's and dental professionals' perceptions of a Digital Smile Design (DSD) app.	Observational (Prospective)	Dentists, dental students, laypeople	Online survey with visual representations	Round upper incisors and perfect symmetry were preferred; factors like tooth color and gum symmetry were significant for aesthetic preferences.	Digital pre-visualization enhances diagnosis and treatment planning, supporting a collaborative decision-making approach.	Yes
Rokhshad et al., 2024	To evaluate ethical challenges raised by AI-based smile	e-Delphi Protocol (Consensus-based)	Experts in AI, dentistry, and smile design	Expert consensus via iterative rounds	Identified key ethical principles: diversity, transparency, wellness, privacy	Ethical principles are crucial for the responsible use of AI in smile design,	Indirectly supports ethical considerations in similar studies.

					protection, prudence, law and governance, and sustainability, among others.	requiring continuous evaluation and adherence to agreed standards.	
Carrillo-Perez et al., 2022	To review the use of AI and ML in dentistry, with a focus on advancements in esthetic dentistry and color research.	Comprehensive Review	Deep learning, fuzzy logic, and ML techniques	MEDLINE/PubMed, Web of Science, Scopus	Identified 3871 eligible papers; 120 included. Applications included disease identification, image segmentation, and biomimetic color analysis.	AI is transforming dentistry with high-performance decision support systems and personalized treatments in esthetic dentistry.	Yes
Gurel, 2020	To present the REBEL system, a digital lab tool using AI for 3D smile design to create a personalized smile based on facial perception and personality.	Descriptive Study	None applicable	Digital AI systems, REBEL	REBEL uses algorithms to relate facial perception and personality to smile design, achieving highly personalized results.	The REBEL system enables dentists to create unique, personalized smile designs using AI tools.	Yes
Hamdy, 2024	To review the applications and	Narrative Review	Diagnostic tools, treatment	Literature review	AI applications have advanced	AI is rapidly transforming aesthetic dentistry	Yes

Author	Objective	Study Design			Results	Conclusion	
	advancements of AI in aesthetic dentistry, focusing on its role in diagnosis, treatment planning, and prediction of outcomes.		planning, 3D printing applications		in diagnostics, treatment planning, and clinical decision-making, showing transformative potential across dental disciplines.	with applications in nearly all dental disciplines.	
Al-Maghreby et al., 2024	To explore AI-based 3D smile design using the REBEL system in prosthetic rehabilitation, emphasizing patient preferences.	Case Study	None applicable	Case-based analysis of AI systems	The REBEL system provides highly customized designs based on patient preferences, improving patient satisfaction beyond conventional methods.	AI-based smile design emphasizes the importance of customization in achieving optimal outcomes.	Yes
Maniega-Mañes et al., 2024	To evaluate a neural network-based computerized facial analysis system for efficacy in aesthetic dentistry using Python	Experimental Study	Neural network analysis compared with DSD systems	Neural network-based computational models	The neural network demonstrated greater consistency, precision, and reduced variability in execution times compared	Neural networks offer more efficient and precise facial analyses for aesthetic dentistry applications.	Yes

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program ming.			to conventio nal methods.	

The research matrix demonstrates a variety of articles research the use of AI in aesthetic dentistry. Together, these papers show how AI has embedded itself into the process of diagnosis, treatment planning, and individualized care. For example, the REBEL system and Invisalign® SmileView™ are AI platforms that improve accuracy and reproducibility in the smile design process, tackle patient satisfaction and provide patients' involvement in the decision-making. The surveys call for personalization since the results indicate that designs made by AI are either as good as or better than their counterparts made by hand, especially for the symmetric faces. Furthermore, emerging issues, like transparency and privacy, are considered as important as crucial ethical concerns for AI application. The use of neural networks and AI-based simulations bear the higher efficiency, the better repeatability and clinical credibility compared with the traditional approaches, which proves the perspectives of the modern technologies application in the field of aesthetic dentistry. Altogether, these findings provide evidence for the application of AI technologies in enhancing the health related results of these patients strongly indicated for incorporation in clinical practice.

Results

Table 5: Results Indicating Themes, Sub-Themes, Trends, Explanation, and Supporting Studies

tudies

Themes	Sub-Themes	Trends	Explanation	Supporting Studies
AI-Driven Smile Design	Preference for AI vs. Manual Designs	AI-generated designs are preferred for symmetric faces.	Dentists and laypeople found AI-generated designs acceptable, with dentists favoring manual designs in some cases, highlighting AI's utility in reducing time for simple aesthetic cases.	Ceylan et al., 2023; Gurel, 2020
	Clinical Predictability	High predictability in orthodontic outcomes with AI tools.	AI systems like Invisalign® SmileView™ and REBEL demonstrated accurate predictions for vertical movements and aligner outcomes, making them reliable tools in clinical settings.	Mourgues et al., 2024; Al-Maghreby et al., 2024
	Personalization in Smile Design	Customization enhances patient satisfaction.	AI tools like the REBEL system enable highly personalized smile designs by aligning designs with patient preferences, improving satisfaction compared to traditional methods.	Gurel, 2020; Al-Maghreby et al., 2024

Aesthetic Preferences	Factors Influencing Preferences	Alignment and symmetry increase perceived attractiveness.	Tooth alignment, symmetry, and color were key factors impacting aesthetic preferences, while non-dental features like lipstick and glasses also influenced facial attractiveness.	Obwegeser et al., 2022; Buduru et al., 2024
	Role of Digital Visualization	Improved diagnosis and treatment planning.	Digital smile design apps and visualizations were preferred for their collaborative approach, aiding communication between patients and clinicians.	Buduru et al., 2024; Hamdy, 2024
Technological Advancements	Neural Networks and AI Algorithms	Greater precision and efficiency.	Neural networks provided higher consistency and reduced variability in outcomes, outperforming traditional digital smile design tools.	Maniega-Mañes et al., 2024
	Applications in Diagnosis and Planning	Enhanced clinical decision-making.	AI tools have advanced diagnostics, image segmentation, and treatment planning, providing personalized and accurate dental solutions.	Hamdy, 2024; Carrillo-Perez et al., 2022
Ethical Considerations	Ethical Principles in AI Use	Emphasis on diversity, transparency, and patient wellness.	Studies highlighted the need for continuous evaluation of AI systems to ensure adherence to ethical principles, such as privacy protection and governance, for responsible application in aesthetic dentistry.	Rokhshad et al., 2024
Future Potential	Transformation of Dental Practices	AI systems are revolutionizing aesthetic dentistry.	The integration of AI in aesthetic dentistry promises transformative changes, with applications spanning diagnosis, treatment planning, and personalized care, paving the way for highly efficient and patient-centered practices.	Hamdy, 2024; Carrillo-Perez et al., 2022

The findings point to AI's impact in aesthetic dentistry and generate concepts and ideas regarding AI in smile design, aesthetic trends, technology, ethics, and future opportunities. Technologies like Invisalign SmileView and the REBEL system show high predictability and individual approach to smile designing,

raising both patient satisfaction and clinical effectiveness ratings. Anomalies such as the occlusion, bilateral balance, and shade play a pivotal role in enhancing facial esthetics, where through 3D visualization software, they help diagnose and map out the ultimate therapy plan collectively. The latest and most intricate forms of neural networking provide the diverse results with enhanced precision and speed, making AI a must in dental practices. Ethical pros lays agitation on favorable functioning, diversification, and patient wellbeing that forms a basis of right use AI. Altogether, these results indicate the trends of AI in aesthetic dentistry, which is changing processes of diagnosing and treating patients and focusing on the patient's needs.

Discussion

Introduction of the new technology in aesthetic dentistry has been proved to influence the working practice and patients' care. In some of the following studies: Ceylan et al. (2023) also observed that apparent smile designs formed by the application of AI were well received especially for patients with symmetric face structures. Suggesting the AI tool can act as an efficient timesaving tool for clinicians. This supports the study of Mourgues et al (2024) where AI based Invisalign SmileView simulations had excellent accuracy of vertical movements and midline shifts, proving that AI can help improve orthodontic results. These studies show that AI-based tools can increase the efficiency of smiles' design as well as the assessment of the further treatment plan and indicate the increased usage of AI dental technologies.

Esthetic ideals are fundamental to the success of smile design and AI display proficiency in creating designs that meet such needs. In addition, Buduru et al., (2024) underscored that round upper incisors, tooth pigmentation, and equal or bilateral symmetry of the gum line were universally considered by both the lay and expert audiences as vital elements of smile aesthetics. Carrillo-Perez et al. (2022) when establishing how AI is used by biomimetic color analysis to generate natural and individualistic effects backed this up. These results mirror the patient-centered utility of AI in aesthetic dentistry where satisfaction of the patient together with the preference of the clinician can blend in owed to the technological superiorities of the device.

However, smile-designing involving the use of AI has its merits that are apparent in this study but the ethical issues that are as follows have not been left out in the process. The ethical guidelines dictated in the present study by Rokhshad et al. (2024) are transparency, diversity, and wellness of the AI applied for smile design. Growing use of technology in health care institutions means that AI must be utilized responsibly and the clinical application of AI should be considered ethical. This concern is the same as what Gurel (2020) described, he emphasized that the authors of programs like the REBEL system need to be cautious so that the programs they are developing will always be transparent in patient care and self-aware regarding the beauty perception of patients in need of smile design according to their personality and perception.

The specialty of aesthetic dentistry has a bright future and the role of AI is vivid but there are delicate issues concerning the AI-generated design and its accuracy and existence of the role of clinical dentists when it comes to choosing the design. Although the REBEL system and others, including AI-based smile simulations, have promise, Al-Maghreby et al. maintained that high degrees of customization entail interdisciplinary collaboration both in AI and in dentistry. Outlining continued relevance of the interaction between developers of AI systems and dentists when designing new tools that enhance the existing work, rather than displacing it.

Likewise, AI has been recognized as an important tool to be used in improving diagnostic capabilities as well as treatment planning. Hamdy (2024) assessed the literature on the uses of AI in aesthetic dentistry and found that it has revolutionized diagnosis, treatment planning and clinical decision. This is in contrast with Maniega-Mañes et al. (2024) that showed that neural networks offer the advantage of higher accuracy and reliability in the facial analysis as compared computer vision techniques. In another way, AI helps clinicians prescribe more treatments that are accurate by supplying more precise diagnostics, thus improving the results.

Last but not the least, the conclusion of these studies reflect the increasing role of AI in the promotion of aesthetics in dentistry, and more than clinic improvement and augmentation tool, patients' viewpoint. Considering that artificial intelligence can increase the effectiveness of treatments, adapt the design of clothes to the patient, and consider the principles of ethical standards, its key position in the progress of the dentistry field is justified. With the growth in the field and advancement in technique, this paper emphasizes that the introduction of AI in aesthetic dentistry will also shift the strategy utilized for diagnosis as well as treatment, in a manner that enhances patient satisfaction, as well as provide better patient outcomes.

Future Direction

It seems that the AI application in aesthetic dentistry will grow, as well as the machine learning algorithms improvement and the digital technologies application will continue to increase the diagnostic accuracy and the treatment and individualized care planning. Further research could be done involving using more detailed information from the patient's data, for example genetic data, detailed face scans etc in order to design better smiles that suit the patient's unique data. Furthermore, extending the use of AI for prognosis of long-term efficacy of aesthetic procedures and its use as a training tool for dentists may enhance its clinical usefulness. Using a combination of artificial intelligence and conventional and expert-based approaches appears to be the direction of the future of aesthetic dentistry.

Limitations:

Nevertheless, the current literature has some limitations concerning AI in aesthetic dentistry studies. Several of the studies covered in this article are inconclusive due to small sample size or use of simulated environments, which can hardly describe actual practice settings. In addition, the possibility of concluding about the long-term success of a smile design suggested by AI and its influence on the patient and clinical results are still unknown due to the absence of multiple longitudinal studies. In the same regarding, ethical issues are still paid insufficient attention, especially the partiality of the AI algorithms and the process of their creation. These limitations give an indication as to why more extensive, realistic research needs to be done with regard to AI in aesthetic dentistry in order to be able to determine the strengths, weaknesses, opportunities, and threats of its use.

Conclusion

AI is a reality that has undoubtedly been revolutionizing aesthetic dentistry providing new approaches to the smile design and treatment management. The AI technologies like AI generated simulation, face recognition; machine learning can play an important role not only in improving the efficacy of the clinic but also in increasing patient's willingness. However, to attain this untapped potential more studies are required, thereby acknowledging existing deficits in these works primarily in relation to long-term effectiveness in clinical setting and ethical issues. Therefore, it is important for the dental professionals to interact with AI to progress in practice and to lead to proper implementation of this technology in dental practice.

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