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Artificial Intelligence in Dentistry

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Abstract
Artificial intelligence has exhibited a rapid development process with the increase in digital data storage capacity and developments in processor technologies. Artificial neural networks and deep learning algorithms inspired by the working principle of the human nervous system have significantly increased the decision-making and learning abilities of artificial intelligence. Artificial intelligence applications in dentistry first started with the detection of anomalies in radiographic images and over time have spread to a wide area such as determining the boundaries of anatomical structures, lesion separation, risk analysis, patient prognosis and treatment planning. In the continuation, artificial intelligence-supported software integrated with CAD-CAM systems has both increased the efficiency of clinical processes and provided significant improvements in patient-doctor communication. In addition, advanced technologies such as the conversion of 2-dimensional images to 3-dimensional simulations have increased the accuracy of diagnosis and treatment. This study aimed to evaluate the development process of artificial intelligence and the contributions of this development to dentistry in detail through dental departments.
Keywords: Artificial Intelligence, dental automation, dental cad-cam systems.

1. Introduction

The question of "Can machines think?" in the early 20th century can be said to be replaced by the question of "Who can machines think for and who can they work for?" in the early 21st century. The answers to these questions led to the emergence of machine-machine interaction and robotic automation instead of human-machine interaction in production. The term artificial intelligence (AI) which was first used at the Dartmouth Conference in 1956 [1] also gained meaning during this process.

ELIZA [2], which we can consider the onset of language processing technology, is a program that works on the principle of reporting coded answers to questions. Therefore, the program must contain both the questions and the coded answers to report the result. Although it seems quite simple, this program was the principle that brought AI to today.

The development of AI has accelerated with fast processors, increased data storage and data variety. However, the level up of AI technology began with the idea of imitating the human neural network [3]. This imitation should be considered in terms of working principle rather than biological and/or physiological structure. Inferring from the fact that human neural networks are not linear but network-like, the principle of AI has been developed to process the multiple data on plane network rather than linear. This is called neural networks (NNs) [4]. The most widely used types of neural networks are artificial neural networks (ANN) [5]. This system is a subset of machine learning and the basis of deep learning that mimics the human way of thinking [6]. Neural network consists of 3 stages: data entry, data processing and decision. Some programs can perform the process in multiple planes rather than in a single plane. This is called a multi-layer perception neural network (MLP) [7]. There may be thousands or even millions of neural networks in such systems that paved the way for the AI to develop its own learning algorithms. This is called deep learning. In deep learning, AI also detects the most accepted answer among the correct answers thanks to feedback. This algorithm has enabled AI to move to a new stage that it can filter the unnecessary and incompatible data. Therefore the results became more clear and understandable.

The first use of AI in dentistry began in the early 21st century with the idea of detecting anomalies in radiographic images [5, 8] In this system, a data pool of dental images is first created. The normal/healty and unhealty/atypical images are coded on all the images one by one. Then the AI processes the images on a new radiograph to determine whether they are more similar to healthy or unhealthy data, and reports the results to the user. The basic method in the selection and separation of images is detecting edges and boundaries [9]. AI detects density and color transitions and can thus reveal structures along with their boundaries. Although this system initially made unacceptable errors, including identifying anatomical structures as lesions, it has achieved

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successful results with the expansion of the data pool, the increase in the number and variety of codes, and the development of data processing algorithms.

With the nano-sized microchips in the early 2000s, digital hardware technology has become more ergonomic and has been simultaneously integrated into devices used in dentistry. In addition, with the widespread use of CAD-CAM systems, and their subsequent integration with the use of AI, the dentistry profession has advanced to a period of rapid development. Dentistry requires the ability to evaluate many data in relation to each other simultaneously. Preliminary and ongoing studies showed that AI achieved to predict exact diagnosis, patient prognosis, risk analyses, tooth movements and treatment results thanks to its success in multi-data processing [5,10] Another benefit of data combination has provided converting 2-dimensional images into 3-dimensional simulations. Difficulties and deficiencies experienced in diagnosis and treatment using 2-dimentional radiographs have been limited. Realistic images obtained by combining multiple radiographic data such as tomography and MR, provided 3-dimensional analyses.

Alharbi et al stated that artificial intelligence is used in patient analysis and treatment planning in orthodontic treatments, as well as suggesting high-level treatment options, especially in implant planning, by performing three-dimensional analysis [11]. AI in dentsitry can be described as both advantageous and disadvantageous because they are complex to use and require training/expertise. Besides, the costs of additional programs that may be required for use may not be economical for small clinics. On the other hand, each company prioritizes development on its own focus. Some of them aim to expand their data network through users by using the cloud system. While this system accelerates development for some, it can also be considered a violation of privacy for others [12].

AI have also increased the visual/presentation richness of the dentistry profession. Diagnostic and treatment stages, potential post-treatment results have become possible to consider. This has made tremendous contributions to patient communication.

AI can also provide support within the scope of occupational safety by reducing the time physicians need to spend in front of the screen. Humanistic factors and the possibility of subsequent errors can be minimized. As a result, productivity is increased in many ways [13].

The purpose of this article was to examine the contributions of AI to the practice of dentistry and to evaluate its impact on the diagnosis and treatment processes of patients. For this purpose, the innovations brought by AI to dentistry are examined in detail through the relevant departments.

2. Methodology

It has been determined that the first use of artificial intelligence in dentistry practice was in radiological examinations. For this reason, when reviweing the literature, radiological imaging and artificial intelligence were first determined as keywords. Then, the search was reduced to studies in the field of dentistry. Then, off-topic articles were eliminated using intermediate keywords such as diagnosis and treatment planning. Among these, those published in 2021 and later were included in the study. Finally, studies considered to be up-to-date were referenced in this study.

The main principle above was applied in studies examining the developments in other branches of dentistry and the artificial intelligence process. The following additional processes were applied when needed.

While searching for studies in the field of smile design, academic articles were examined together with current websites and company statements. While examining the use of articulators, face bows and 3D simulations, which are part of this process, articles published in 2019 and later were included in this study.

When searching for studies in the field of orthodontics, additional keywords such as orthodontic diagnosis, orthodontic treatment planning, transparent plate and patient follow-up were used. Articles published in 2022 and later were included in the study. Websites determined to be up-to-date were included in the study.

An additional search was performed with the keyword surgical guide in surgical and prosthetic rehabilitation. Articles published in 2022 and later were included in the study. The websites of the manufacturing companies were evaluated and those determined to be frequently updated were included in the review.

All information obtained was integrated in chronological and methodological order.

3.1. Interpretation of Radiographic Images, Diagnosis and Treatment Planning With AI Support

Nowadays, medical imaging techniques have developed rapidly and have become a very effective tool for physicians and patients. The examination and evaluation of these images, the development of diagnosis and treatment can be of vital importance.

Programs for dental radiological diagnosis with AI support have generally been developed for the detection of periodontal diseases and their severity, caries and their dimensions, lesions, tooth missings, supernumerary teeth, orthodontic and orthognathic anomalies, temporomandibular joint structure and anomalies, bone anomalies, from images obtained with techniques such as panoramic radiography, MR and CBCT. AI supported programs, developed in this area, also provides ease of use, storage capacity and visual reporting capability which can also be counted among the conciniency.

When the process is initiated on the evaluation of radiological images taken from any patient, the program compares the image with others recorded in the database using an advanced algorithm and makes matches for each image/structure/formation. As a result, it presents to the user which image/structure/formation, the image corresponds to, at the highest rate and describes other possibilities. In this way, it actually guides physicians to make a diagnosis [14, 15]. This process is done for all radiological images and so, a very large data pool is created.

Thanks to the use of AI in radiology, minimal changes in the images of patients under medical follow-up can be detected. This is valid for both medical and dental radiology. This feature both strengthens patient follow-up and enables early new diagnosis in case of possible changes [16].

AI-supported programs are particularly valuable in terms of making precise measurements and detecting small abnormalities that may be overlooked. Studies indicate that artificial intelligence programs are more than 90% successful in detecting caries. This rate also exceeds 85% in non-cavity caries [17]. Having a high level of accuracy for complex analyses can undoubtedly provide a great advantage. The ability to perform automatic reporting is an additional advantage for physicians.

AI programs in radiology, speed up the doctor's diagnose and leave the final decision to the him. Although this is valuable for the doctor's practice, it may actually mean that the artificial intelligence cannot make a definitive decision.

It should not be forgotten that this process is in the development phase. Artificial intelligence compares the images with the normal and abnormal ones in its data pool. At this point, if the program does not have enough data or if there is complex data in the system's data pool that shows both normal and abnormal results, there is still a possibility of an incorrect result. Although the database is expanding every day, it can be clearly said that these artificial intelligence programs need an expert opinion.

3.2. Use of AI in Smile Design Programs

AI-supported smile design programs basically promise to perform person-based restoration by analyzing the current status of dental and surrounding tissues. The program suggests treatment options by adding the patient's age, gender and demands to the data it obtains. In addition to this data, some programs can include facial structure, cheek and lip tissues in the planning and offer holistic treatment suggestions that can meet aesthetic expectations. Although the suggestions of these programs extend to very different points due to the diversity of data and demands, they all prioritize meeting functional needs.

These applications include many or all of the features of fast production, strong patient communication, person-based design and treatment planning. The software and devices being developed in this field allow patient demands to be met without exceeding dental needs and limitations. Some of these have their own smile design library and offer the user more than one planning option. These programs, which offer cloud storage and laboratory integration, also promise to work on patient photos, videos and radiographic images [18].

Some programs also state that they can expand treatment suggestions with different types of case content in addition to their extensive libraries. These programs, which have user-friendly and practical interfaces, try to stand out by offering the feature of comparing the design with the photographs of the patients by personalizing the treatment [19]. On the other hand, some programs promise to be user-friendly as their main goal and appeal to every user with simple interfaces. These programs, which base their designs on facial symmetry, shape and facial expressions, may be more suitable for clinics that prefer low-cost, simplified personal smile design [20].

3.3. AI-Based Digital Articulators and Facebows

AI in dentistry has also led to tremendous strides in the development and practical use of digital articulators and facebows. Routine facebow transfer and adjustable articulator use are limited because of their difficulty and lack of practice [21]. However, with the development of digital technology, dentists have found the opportunity to produce restorations that can be considered more accurate in academic and scientific terms. Face arch transfer and adjustable articulator use have become simple and applicable on the digital platform. This technology, which also saves time, has paved the way for maximum compatible treatments that the patient can easily adapt to in terms of physiology and functionality.

3.4. Digital Articulators

Articulators are mechanical structures that mimic the man's jaws and jaw movements. With these devices, all movements of the lower jaw in the sagittal, horizontal and vertical axes can be observed and evaluated. In traditional mechanical adjustable articulators, all jaw movements and limitations are determined by various methods and this situation is fixed with adjustable parts in the articulator. However, almost all mechanical adjustable articulators have omissions or limitations which are ignored [22]. In digital articulators, there is no limit/restriction/ignoring in the data detected. Each region can be recorded separately according to its own characteristics. For example, the anatomical structures such as condylar path inclination, eminence height, medial wall inclination, condylar structure of someone whose right side of the jaw is more developed than the left will be different from each other. While the records of these structures are made with averages in mechanical articulators, they can be recorded with unlimited data in digital articulators.

In addition, digital articulators can simulate jaw movements in a virtual environment. In this way, not only static but also dynamic occlusion data can be examined. Data can also be examined in detail with video animations. Since the centric and eccentric relations of the finished restoration will be at the highest level, interferences are eliminated, functional fit and stabilization are increased.

3.5. AI Supported Face-bows

Facebows are mechanical devices that allow the position of the maxilla on the skull base to be determined by taking some anatomical points as reference. With the development of digital technology, the idea that AI could also be used in facebow transfer emerged right away. The principle of the digital facebow is based on combining the obtained intraoral, occlusal, extraoral and photographic data in a digital environment. The accuracy rate increases as the data variety increases. This method prevents manual errors caused by minimal movements like tissue resilience. At the end of this stage, the system obtain a complete digital reflection of the patient [23].

Digital facebow transfer supplied to expand the working range of digital articulators and the versatile analysis ability of AI. Mandibular movements and their relations with the maxilla can easily be recorded. In this way, even the effects of head and neck movements on jaw movements can be evaluated.

3.6. The Impact of AI on Orthodontic Treatments

One of the most important indicators that AI is rapidly advancing in the field of dentistry is the position reached in orthodontic diagnosis and treatment. Predicting the results of teeth movements, ensured a revolutionary change in orthodontic treatment methods. In this way, these AI programs prevent unwanted surprises after months of treatment by calculating the information using advanced algorithms in the database. This process has not only guided the orthodontist in treatment but has also enabled the replacement of traditional braces with transparent plates [24].

AI applications that can be used in orthodontics can provide the doctor many data including the location of teeth in the bone, extraction and surgical intervention requirements, jaw relationship classification, cephalometric analyses, bone structure and age, and determination of maxillary and mandibular structures [25].

By making orthodontic and orthognathic comparisons in the database, they can determine the dental alignment compatible with the jaw and all other anatomic structures. They can also determine the plate usage stages and durations during the process by including the time factor. These programs also analyze possible deviations by examining the feedback of the treatment and can make updates in transparent plates.

Some of the AI programs developing in this field state that they can process complex algorithms due to their large database and that they can establish cross-relationships by collecting additional data from each case thanks to deep learning. Although the average success rates of these programs, which can create the usage period and appointments of patient plates, were initially found at 78%, it is stated that these rates have increased rapidly thanks to software updates [26].

AI programs that offer cloud-based automatic algorithm suggestions in orthodontic treatment state that they can create feedback within seconds. This feature can be advantageous for new users. These software, which are stated to have interfaces that can perform wax up and include treatment review processes, can provide rapid laboratory integration [19].

AI programs that prioritize patient follow-up in orthodontics benefit from mobile applications and extensions. They follow the process by receiving remote feedback from patients receiving treatment. Despite the additional costs, these systems can be considered advantageous because they reduce the number of appointments and can perform analyses without extra appointments in the clinic [27].

3.7. Use of AI in Implant Treatment and Surgical Guides

Supporting the digital flow with AI has enabled tremendous progress in the diagnosis, planning and treatment processes of implant treatments carried out commonly by prosthetic dentistry and dental surgery [11, 28]. The real secret of success is planning and the operation of this planning.

The first stage is to obtain 2 and 3 dimensional simulations by combining digital measurements and tomographic images [14]. The type of implant treatment is determined on these virtual structures, again with the guidance of AI. Programs offer treatment options to the user by matching anatomical formations, bone density, and bone dimensions with the data storage in their content. Some programs can indicate obstacles and conformities with various colors and warnings. With all this data, the locations, angulations, diameters, and numbers of implants to be placed in the bone can be determined. Subsequently, as part of the digital process, surgical guides and healing plates with a margin of error close to zero can be designed and produced. Moreover, thanks to the obtained data and simulations that are very close to reality, implants can be placed with the navigation technique. In other words, these applications can also minimize any error possibility that can be made manually. Thus, both intra-department and inter-department integration is strengthened increasing the success. Some of these systems can include patient monitoring and recovery control processes in addition to those described above. They can even make treatment modification suggestions depending on the developments in the recovery process. When all this data is evaluated together, it would not be wrong to say that these applications also have educational features for physicians.

While some of the programs used in this field prefer to conduct AI research to increase the success of their implant systems, others, on the contrary, have created an infrastructure that is open to every user [29]. Some programs prefer to create interfaces that will provide easy use for every user. However, this situation may prevent detailed planning and therefore treatment suggestions may be limited. For this reason, programs may prefer to work for educated users and offer additional options to their applications. This may provide the user with unlimited modification opportunities in treatment planning. These multiple options also cause applications to differ economically. It can be said that applications classified as practical and user-friendly are more affordable. Since multiple programs are needed for complex and alternative designs, AI programs with experienced user suggestions may be more costly.

3. Results

AI is rapidly developing in dentistry, as in many other fields, and continues to improve itself with new algorithms and data accumulation. Human-based errors have been largely eliminated by precise calculations. Treatment recommendations and predictions have expanded by simulations. Therefore it can be said that, great convenience have been provided to patients, physicians and laboratory integrations.

The most striking aspect of all these technological developments is that some AI programs perform deep learning. This feature has enabled the creation of a system that constantly feeds and grows itself. AI, which could create ordinary and known answers in the early stages, has transformed into programs that can analyze problems and seek solutions.

The rapid development of AI worries many people with humanitarian concerns. For this reason, people in all areas prefer this technology to make their work easier rather than replacing them. Program libraries, integration between systems and data sharing are factors that expand this ecosystem. However, physicians who use these tools are also the most important assistants of developers. Although they perform detailed analyses, it should not be forgotten that AI tools are still devoid of consciousness. Physicians and developers should continue to be able to control this ecosystem, which is constantly fed by the development of data storage and data processing technologies, with their own experience and intelligence.

The main limitation of the applications mentioned in the article is the feedback limitation. As explained, software needs feedback. In short, whether the answer given to the question is correct or not should be recorded in the software as data again. This feedback will provide deep learning in current terms and finding the most correct one among the truths in mathematical and statistical terms. It is undeniable that time is needed for feedback data to be formed. It can be estimated that AI software, which is still developing, needs this time. All of these programs increase their capacity and success with data and processors.

However, it should not be forgotten that data is created by human hands and this data may or may not be true. Coded answers are essential for AI. It cannot comment and needs the information in the database. As the amount of data and the number of feedbacks increase, it will be possible to reach the most correct answer with filtering and masking.

Another issue that has been ignored or unnoticed during the development of artificial intelligence is patient privacy and data security. It can be said that the necessary sensitivity has not been shown to these issues during the rapid development period. Data security stands out as a serious deficiency due to the software gaps and vulnerabilities of both artificial intelligence programs and other digital platforms included in this process. This deficiency also leaves patient privacy in the background.

Artificial intelligence is now moving towards a universal and holistic process that brings all fields together. Scientific branches no longer work independently on artificial intelligence. This is an inevitable integration process. Every research involving artificial intelligence includes one or even more than one different field. Dentistry practice is also experiencing a process that is intertwined with all vital fields, especially the field of engineering. In the coming days, an innovation emerging in another field may be waiting its turn to be integrated into the field of dentistry, as it was before. For this reason, it can now be considered a necessity to follow the developments of artificial intelligence not only in dentistry but also in all fields. Since every research involving artificial intelligence will include all vital fields in the future, multidisciplinary planning is an inevitable future.

Conclusion

Both digital technology and artificial intelligence are still developing today. It can be said that every stage of this development has managed to surprise and excite people.

It can be said that artificial intelligence is still in a development process that needs people.

The development of artificial intelligence has enabled the dentistry profession to take fast and big steps.

Each department of dentistry has gained great benefits from these developments within its own field.

Decleration of Interest

We the authors declare that we do not have any conflict of interest.

References

[1] R. Cordeschi, "AI turns fifty: Revisiting its origins," Applied Artificial Intelligence, vol. 21, no.4, Apr., pp. 259-279, 2007.

[2] C. Bassett, "The computational therapeutic: exploring Weizenbaum's ELIZA as a history of the present," AI&Soc, vol. 34, no. 4, Feb., pp. 803-812, 2018.

[3] F. Narcross, "Artificial nervous systems—A new paradigm for artificial intelligence," Patterns, vol. 2, no. 6, June, pp. 1-3, 2021.

[4] E. Okewu, P. Adewole, S. Misra, R. Maskeliunas, and R. Damasevicius, "Artificial Neural Networks for Educational Data Mining in Higher Education: A Systematic Literature Review," Applied Artificial Intelligence, vol. 35, no. 13, Oct., pp. 983–1002, 2021.

[5] A. Ossowska, A. Kusiak, and D. Świetlik, "Artificial Intelligence in Dentistry—Narrative Review," International Journal of Environmental Research and Public Health, vol. 19, no. 6 , Mar., pp. 1-10, 2022.

[6] A. Kane and A. Hussain, "Artificial Neural Networks - An overview," Indian Drugs, vol.30, no. 5, Jan., pp.168-168, 1993.

[7] W. Salah Alaloul and A. Hannan Qureshi, "Data Processing Using Artificial Neural Networks," Dynamic Data Assimilation - Beating the Uncertainties, CA: IntechOpen 2020.

[8] N. Ahmed, M. Ş. Abbasi, F. Züberi, W. Qamar, M. S. B. Halim, A. Maksud and M. H. Alam, "Artificial Intelligence Techniques: Analysis, Application, and Outcome in Dentistry - A Systematic Review," BioMed Research International, vol. 2021, no. 22, June, pp. 1-15, 2021.

[9] X. Liu, L. Song, S. Liu, and Y. Zhang, "A review of deep-learning-based medical image segmentation methods," Sustainability (Switzerland), vol. 13, no. 3, Jan., pp. 1-19, 2021.

[10] O. Miloglu, M. T. Guller, and Z. T. Tosun, "The Use of Artificial Intelligence in Dentistry Practices," The Eurasian Journal of Medicine, vol. 54, no. 1, Dec., pp. 34-42, 2022.

[11] M. T. Alharbi and M. M. Almutiq, "Prediction of Dental Implants Using Machine Learning Algorithms," Journal of Healthcare Engineering, vol. 20, no. 1, Jan., pp. 1-12, 2022.

[12] "planet DDS," planetdds.com/apteryx/ai/, para. 1, [Online]. Available: https://www.planetdds.com/cloud9/. [Accessed: Jan. 18, 2025].

[13] W. Stawska, M. Milek, K. Kwaśniak, A. Foryś, M. Banach, A. Niemczyk, M. Ślusarczyk, A. Magierska, Z. Kotowicz and W. Kmiotek, "The use of artificial intelligence in radiology: new possibilities for diagnostic imaging. A literature review," Quality in Sport, vol. 16, no. 1, Jul., pp. 1-14, 2024.

[14] R. H. Putra, C. Doi, N. Yoda, E. R. Astuti, and K. Sasaki, "Current applications and development of artificial intelligence for digital dental radiography," Dentomaxillofac Radiology, vol. 51, no. 1, Jan., pp. 1-12, 2022.

[15] A. Tariq, F. B. Nakhi, F. Salah, G. Eltayeb, G. J. Abdulla, N. Necim, S. A. Khedr, S. Elkerdasy, N. Al-Rawi, S. Alkawas, M. Muhammed and Ş. R. Shetty, "Efficiency and accuracy of artificial intelligence in the radiographic detection of periodontal bone loss: A systematic review," Imaging Science in Dentistry, vol. 53 no. 3, Sep., pp. 193-198, 2023.

[16] D. Ismail and Edi Gunawan, "Study of the Use of AI (Artificial Intelligence) in the Field of Radiology and Imaging," Sriwijaya Journal of Radiology and Imaging Research, vol. 1, no. 2, Nov., pp. 34-38, 2023.

[17] J. Kühnisch, O. Meyer, M. Hesenius, R. Hickel, and V. Gruhn, "Caries Detection on Intraoral Images Using Artificial Intelligence," Journal of Dental Research, vol. 101, no. 2, Feb., pp. 158-165, 2022.

[18] "SmileCloud Biometrics," smilecloud.com, para. 1, [Online]. Available: https://smilecloud.com/#intuitive. [Accessed: Jan. 20, 2025].

[19] “Digital dentistry: definition, advantages and development,” 3shape.com, para 1, Nov. 14, 2024. [Online]. Available: https://www.3shape.com/en/blog/digital-dentistry/intro-digital-dentistry. [Accessed: Jan. 20, 2025].
[20] “Create fully digital 3d mock-ups: Quick and easy,” rebel.dental.com, [Online]. Available: https://rebel.dental. [Accessed: Jan. 19, 2025].
[21] S. A. Yousief, D. K. Gamlo, M. A. Dewan, S. K. Barahim, R. O. Alashbat and I. H. Alhifny, “Significance of Facebow Transfer,” EC Dental Science, vol. 19, no. 2, Jan., pp. 01-05, 2020.
[22] W. Sutradhar, SunilK. Mishra, and R. Chowdhary, “Uses, accuracy and limitations of semiadjustable articulators in dentistry: a systematic review,” Tanta Dental Journal, vol. 16, no. 3, April, pp. 121-135, 2019.
[23] J. C. Kois, D. E. Kois, J. M. Zeitler, and J. Martin, “Digital to Analog Facially Generated Interchangeable Facebow Transfer: Capturing a Standardized Reference Position,” Journal of Prosthodontics, vol. 31, no. 1, Mar., pp. 13–22, 2022.
[24] S. B. Khanagar, A. El-Ehaideb, S. Vişvanathaiah, P. C. Maganu, Ş. Patil, S. Naik, H. A. Baeshen and S. S. Sarode, “Scope and performance of artificial intelligence technology in orthodontic diagnosis, treatment planning, and clinical decision-making - A systematic review,” Journal of Dental Sciences, vol. 16, no. 1, Jan., pp. 482-492, 2021
[25] F. Albalawi and K. A. Alamoud, “Trends and Application of Artificial Intelligence Technology in Orthodontic Diagnosis and Treatment Planning—A Review,” Applied Sciences, vol. 12, no. 22, Nov., pp. 1-20, 2022.
[26] W. Alswajy, H. Baeshen, G. Al-Turki, and F. Alsulaimani, “The Reliability of ClinCheck® Accuracy before and after Invisalign® Treatment—A Multicenter Retrospective Study,” Applied Sciences (Switzerland), vol. 13, no. 8, Apr., pp. 1-8, 2023.
[27] “DentalMonitoring – AI-powered remote monitoring for orthodontics,” dentalmonitoring.com, [Online]. Available: https://dentalmonitoring.com/dental-monitoring/. [Accessed: Jan. 20, 2025].
[28] P. A. Lyakhov, A. A. Dolgalev, U. A. Lyakhova, A. A. Muraev, K. E. Zolotayev, and D. Y. Semerikov, “Neural network system for analyzing statistical factors of patients for predicting the survival of dental implants,” Front Neuroinform, vol. 16, no. 1, Dec., pp. 1-15, 2022.
[29] “Digital solutions,” nobelbiocare.com, [Online]. Available: https://www.nobelbiocare.com/en-int/digital-dentistry-solutions. [Accessed Jan. 19, 2025].