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ARTIFICIAL INTELLIGENCE IN ORTHODONTICS: CURRENT PRACTICE AND FUTURE PROSPECTS

Dentistry

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ABSTRACT

Artificial intelligence is a significant advancement in technology that imitates human intelligence (AI). This technology is a tool for finding visions in different bits of medical and dentistry knowledge. The purpose of this article was to give a brief overview of how AI is used in orthodontic therapy. Artificial intelligence (AI) has various benefits across a wide range of businesses, but it is particularly beneficial in the medical sector, where it is utilised to improve diagnoses and treatments using patient data gathered over time as well as virtual assistants. When employed in medicine and dentistry, AI has the potential to significantly change the healthcare sector and enhance patient care.

KEYWORDS

Artificial intelligence, Dentistry, Medicine, Diagnosis, Orthodontic Treatment

INTRODUCTION

Artificial intelligence is a recent development in technology that imitates human intelligence (AI). To help people complete jobs more effectively, AI models are developed through training and programming using a variety of datasets[1]. These models are then put into action to turn the data into information that can be used for a specific task. The term "AI" is used when a computer mimics analytical abilities that humans typically attribute to other human brains, such as learning and problem-solving. Thanks to the excellent capabilities and capacities AI techniques have established in identifying significant data patterns, many studies have been conducted using clinical trial tools, specifically to aid in decision-making for prognosis and projection, as well as each stage of diagnosis and subsequent therapy [2]. In order to improve patient care and treatment outcomes, healthcare professionals have been employing AI models to increase the accuracy of diagnostic, decision-making, and prognosis prediction. Furthermore, AI models have demonstrated capabilities comparable to those of trained and seasoned medical professionals.[3]. AI technology is widely used in dentistry. These models are created using algorithms that can be trained on different types of data sets and then tested and evaluated on new sources of data. They have an ML (machine learning) foundation. ML-based AI models have proven to be very accurate in making predictions based on datasets without the involvement of a human. [4]. Artificial neural networks (ANNs) are an umbrella name for AI models based on Deep Learning (DL), a recently developed and highly advanced system that aims to mimic the neural system of the human brain[5]. In order to correct inappropriate growth patterns and dentoalveolar component development, orthodontic treatment seeks to alter how teeth fit together. Detailed examination of these problems.

Key elements of artificial intelligence systems

Artificial intelligence:
AI is the capacity of a machine to demonstrate intelligence by resolving issues using data.

Machine Learning:
Algorithms are used in machine learning to predict results from a set of data. Making it simpler for machines to learn from data and solve issues without human input is the aim.

Neural Network:
Artificial neurons that function similarly to human neurons are used in neural networks to compute signals.

Deep Learning:
To increase feature recognition, deep learning with numerous computational layers creates a neural network that automatically recognizes patterns.

Data Science:
Data analysis and information extraction are the processes involved in data science.

Big Data:
By analyzing a sizable, timely data set that has been steadily developing for years, big data gives users reliable information **(Fig 1).**

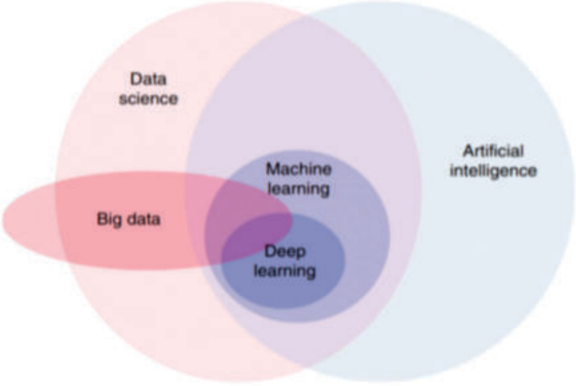

Figure 1. Key elements of Artificial intelligent systems[6]

Machine Learning

Artificial intelligence's machine learning field uses computers to comprehend the built-in statistical structures and patterns of data and derive rules from them (Fig. 1)[6]. Despite being a subset of artificial intelligence, machine learning also has linkages to a wide range of other fields, including statistics, information theory, and cognitive psychology.

Machine learning has been used in the healthcare industry for a variety of purposes, including information extraction from medical records and the prediction or diagnosis of diseases. Machine learning algorithms' capacities to evaluate and provide more precise information are continuously improved through testing and refinement.[7].

Deep Learning

Deep learning is the process of continuously training neural networks with labels and data to increase the model's accuracy. Without the need of human feature engineering, deep learning analyses input data by applying representation learning approaches with several degrees of abstraction. By mapping these structures onto a lower-dimensional manifold, this enables DL to automatically recognise complicated structures in high-dimensional data. Medical imaging analysis has been the principal use for DL systems in healthcare, and they have proven to have exceptional diagnostic performance in this area.[8].

Artificial Neural Networks

An Artificial Neural Network is a computer or mathematical model based on the biological signal of the human brain (ANN). Assuming that computation is distributed throughout the networked processing units known as neurons or nodes, it operates in parallel. Biological neural network mechanisms and functions are combined with structural learning and analysis to create an ANN model. The synapses on the dendrite or the neuronal membrane are where the neuron, the basic unit of the neural network, receives messages. The signal is powerful enough to excite the neurons, and as a result, the signal spreads via the axon and stimulates the other neurons via a separate synapse.[9].

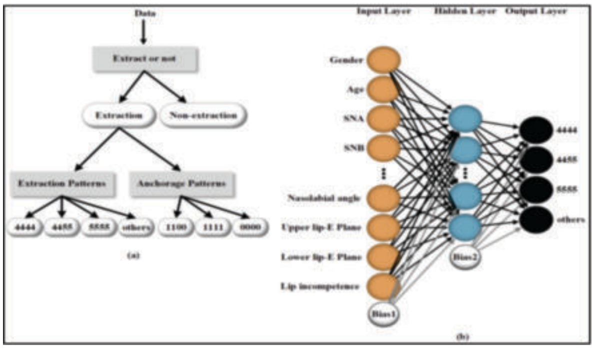

Figure 2: Data processing flowchart (a); neural network structure (b) designed to forecast extraction trends. A three-layer fully linked multilayer perceptron makes up the network, which has 24 input nodes, 10 hidden nodes, and 4 output nodes**.**[9].

Up until the output of the network matches the target, the neural network regulates itself based on comparisons between the target and output. The network must be trained using a variety of input/target pairs, sometimes referred to as Artificial Neural Networks. The layers of neurons and their connections, which are linked to learning algorithms, make up the structural design.

Utilizing weight factors, the connections that move the output nodes from one layer to the next strengthen or weaken the outputs. Each node's net input is the total of all of its outputs in the levels above it, excluding those on the input layer. The neural network regulates itself based on comparisons when the output is in line with the goal (Fig2).

The network, also known as an artificial neural network, must be trained using a range of input/target pairs. The structural design is made up of the layers of neurons and their connections, which are connected to learning algorithms.

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Clinical decision support system (CDSS):

A CDSS is a system that combines a sizable dynamic (medical) knowledge database with an inferencing output mechanism, which is a collection of algorithms drawn from evidence-based medical practice and carried out by medical logic modules. Product owners, project managers, system architects, system designers, system developers, system administrators, and a system maintenance team are frequently included on CDSS product development and maintenance teams.

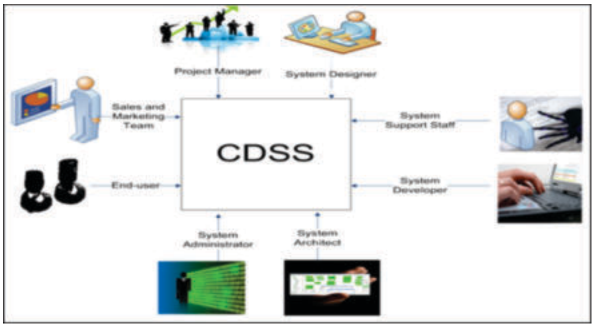

Figure 3: Computerized clinical decision support systems[13]

Currently, the time-saving and cost-effective clinical dentistry practice is developed to help the healthcare professional perform more productively using the intuitive interphase with voice commands. To generate quicker, more systemic, and superior dental health outcomes, clinical decision support systems deliver useful information to dental professionals, patients, or individuals or populations.[Fig.3][13].

Augmented Reality And Virtual Reality

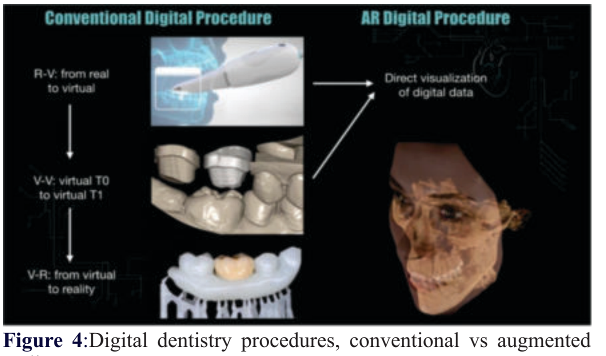

Figure 4:Digital dentistry procedures, conventional vs augmented reality[15]

AR and VR are used in a number of dental specialisations, as can be shown in [Fig 4]. Virtual and augmented reality have the potential to be beneficial for dental technologies. Details on its application to oral health Using augmented reality technology, a user's vision of the real world is composited with a computer-generated image. The AR system has a display that mixes real-world images with data generated by computers.

Display alternatives include glasses, a HUD (heads-up display), contacts, tablets, a virtual retinal display, an eye tap, spatial projectors, and a heads-up display.Augmented reality provides computer-generated virtual knowledge of the real world, creating new opportunities across a range of industries.

The usage of augmented reality technologies in medical education is widespread[14].Using AR and a mannequin, students may practise techniques while getting immediate feedback as their actions are recorded.

They are better able to swiftly identify their areas of need and develop their skills as a result. It can also be used in orthodontic therapy and aesthetic procedures to assist patients understand how they will look following treatment[15].

These augmented reality applications overlay simulated images of the improved set of teeth prior to treatment using the camera on the user's phone or tablet. Before they enter the virtual operating room, patients and professionals can adjust dental aspects like height and spacing thanks to this.

Figure 5: Virtual reality Headset with a 360-degree VR environment [17]

A human can interact with a computer-generated reproduction of a three-dimensional (3D) image or environment in a real or physical way by employing appropriate electrical equipment. We call this reality. With virtual reality (VR), the user is completely cut off from the outer world and immersed in a virtual environment. Wearing such a headset allows patients to visualise a peaceful environment while sitting in the dreaded dentist's chair and students and aspiring dental surgeons to travel to the operating room from their couches (Fig5). Instructors can help students and PG residents gain accuracy in pre-clinical and clinical abilities by using 3D real-time digital simulations to improve the quality of dentistry education and training. Understanding and recalling human anatomy[16]. To perceive all related muscle, neuronal, vascular, and other aspects, however, is extremely difficult for students to do and is useless [17]. During the COVID-19 pandemic, students suffered from a shortage of learning opportunities and from being unable to advance their pre-clinical skills because they were unable to train at their institutions without the instructor's direct supervision. The hardest task for the colleges has therefore been helping these kids learn while halting the growth of COVID-19. In an effort to find better teaching methods, one group introduced a novel approach to teaching clinically relevant anatomy to dentistry students that substitute dissected and sliced plastinated specimens for cadavers. An interactive 3D augmented curriculum and digital technologies were however utilized in a recent study. [18].

Application Of Artificial Intelligence In Orthodontics

1. Analysis of Cephalometry in Orthodontic Diagnosis

Another field where artificial intelligence is widely used and has shown to be useful for accurate diagnosis and effective management is orthodontics. Holly Broadbent Sr. originally proposed the use of radiographic evaluation of the sagittal and vertical skeletal structures in 1931 for assessing growth and monitoring changes during therapeutic procedures. It is still utilized today to arrange orthodontic treatment. By doing quantitative and qualitative evaluations and superimposing sequential radiographs, they are used to determine the growth trend. A typical cephalometric analysis method involves finding anatomically significant landmarks, measuring various angles and distances between these landmarks, and then qualitatively evaluating diseases based on these angles and distances. The biggest drawback of manual cephalometry is the identification of landmarks. The accuracy and consistency of landmark recognition determine the analytical value as a diagnostic tool. Growing computer power and algorithms lead to improvements in accuracy, dependability, and efficiency. Standard neural networks were utilized by Arik et al. to identify cephalograms. The study's findings showed that using AI to identify landmarks was more accurate than using conventional techniques by 5 to 15%[19]

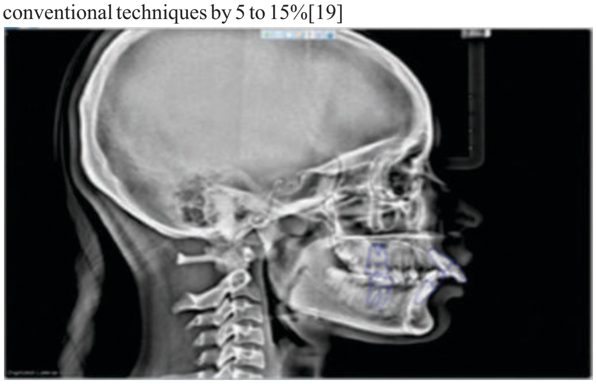

Figure 6; Cephalometric tracing is done using Dolphin Imaging technology.

In computerized cephalometric analysis, landmarks are manually located using one of two methods: either overlay tracing of the radiograph to identify anatomical or constructed points, then transferring it to the digitizer, or direct digitization of the lateral skull radiograph using a digitizer connected to a computer, and then the location of landmarks on the monitor(Fig 6). The accuracy of Kunz et al AI's for automated cephalometric analysis based on widely-used orthodontic parameters was examined in their 2020 study [20]. Out of twelve distinct orthodontic characteristics, including skeletal sagittal, skeletal vertical, and oral parameters, the authors were able to demonstrate that only one was determined to be significantly different from the human gold standard. For all metrics, the average differences between the AI's assessments and the gold standard set by humans were far below one degree. Therefore, it may be presumed that any discrepancies between the AI's forecasts and the gold standard set by humans are, at worst, minimal.

Figure 7 The process of selecting observational perspectives for 3D landmark pointing while taking into account the anatomical properties of the landmarks. Blue points represent the reference places chosen by medical experts. Multiple-stage directed sequence (A–C) in the right orbitale. The front view, right lateral view, and left lateral view with a sagittal cut are shown in (A), (B), and (C), respectively. a few different directions for the sella point from (D to F). (D) A semi-lateral 3D picture of the transparent side of the skull. both (E) sagittal cut right view and (A) axial cut top view [21].

The main goal of cephalometric landmarking is to get angular and linear measurements that will ultimately provide clinical guidance. In order to evaluate the treatment effectiveness of our DL-based technique, our outcome set comprised three additional frontal measurements in addition to the lateral cephalometric measurements that are frequently seen in R&R research (van Bunningen et al., 2022). They chose to conduct 2D cephalometric measurements based on orthogonally projected landmarks because 3D cephalometric analysis is still challenging and outside the scope of our work. Although these measurements don't completely utilise 3D cephalometry's capabilities, we believe they nonetheless provide insight into the method's potential clinical utility[21].

2. Growth Evaluation

For a clinical orthodontic practise, comprehension of growth events is essential. Biological age, bone age, skeletal age, and skeletal maturation are terms used to describe the stages of a person's development. Skeletal age evaluation is essential for creating effective orthodontic treatment plans because of individual variations in the timing, course, and rate of growth. The diagnosis, treatment objectives, planning, and ultimate outcomes of orthodontic therapy can all be significantly influenced by the patient's developmental stage. An important sign of a child's growth and development is their bone age, which can be determined from radiographs of their left hand and wrist and evaluates skeletal maturity. The Greulich and Pyle atlas and the Tanner-Whitehouse methodology are the two primary techniques for evaluating bone evaluation. It is simple to employ in clinical practice because the Greulich-Pyle-based bone age estimation approach just involves comparing a patient's left-hand radiograph to example radiographs in the Greulich-Pyle atlas. Before assigning a score, the Tanner and Whitehouse (TW) method meticulously inspects each bone. [23]. There are also more recent techniques to increase effectiveness, such as the TW3 technique. However, it is not frequently used in clinical settings due to its complexity and limitations. There are several automatic computerized methods for assessing bone age, including computer-assisted skeletal age scores and computer-aided skeletal maturation evaluation systems. Concerns about interobserver variability in manual bone age estimates led to the development of a number of automatic computational methods for determining bone age starting in 1992. These methods include computer-assisted skeletal age scores and computer-aided skeletal maturation assessment systems. In the medical industry, notably in radiology, artificial intelligence (AI), which has a significant potential to minimise labour needs and intra- and inter-observer differences, is growing in popularity. One of the most sophisticated AI methods is deep learning. Instead of requiring clearly defined rules, deep learning approaches, as contrast to typical machine learning techniques, allow an algorithm to self-program by learning from the images given a large collection of labelled samples [24].

3. Making choices regarding extraction

The study, prevention, and treatment of malocclusions are under the purview of orthodontics. The two types of orthodontic malocclusion therapies are extraction treatments and non-extraction treatments. Extractions rank among the most important and contentious decisions made during orthodontic treatment since they are irreversible. These decisions are based on clinical evaluations, patient photographs, dental study models, radiographs, and, to a large extent, the clinician's experience and expertise.

A bad choice could lead to a number of unwanted outcomes, including poor aesthetics, an incorrect bite, functional problems with speaking and mastication, and, in the worst-case scenario, an incomplete course of therapy. So, new methods are needed to standardize the decision-making process. One of the computational methods that have garnered the most interest in the field of artificial intelligence is machine learning (ML), where a computer is trained to build a customized model based on a given dataset and then utilize it to generate predictions (AI).

Deep neural networks and neural networks are two common examples of complex machine learning algorithms [25]. For malocclusion patients between the ages of 11 and 15, Xie et al. created a decision-making expert system (ES) to evaluate if extraction is required. In order to reduce the likelihood of error, ANN employs the error backward propagation learning algorithm.

The study's conclusions show that the neural network was 80% accurate in determining whether an extraction or non-extraction treatment was necessary. With an accuracy rate of 84%, Jung et al. were able to predict the precise extraction patterns [26]. In extraction scenarios, ANN was utilised to decide whether anchorage was necessary, and it was effective 83 percent of the time. Kong et al. used a multilayer perceptron artificial neural network to predict the treatment method, determine whether or not extraction is required, determine the pattern of extraction, and determine the anchorage pattern.

The accuracy for extraction and non-extraction predictions was found to be 94%, for an anchorage pattern to be 84.2%, and for extraction patterns to be 92.8%. The most important factors for prediction are crowding, upper arch, ANB, and Spee's curve. The neural network can be used to direct less experienced users, it is concluded. With an accuracy rate of 84%, Jung et al. were able to predict the precise extraction patterns [26].

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5. During orthognathic procedures

By addressing bone malocclusion, dentofacial deformity, facial asymmetry, and other issues, orthognathic surgery can enhance masticatory function and appearance. Historically, two-dimensional cephalometric study, a clinical examination, and handcrafted splints have been used in surgical planning. However, 2D cephalometric analysis has known drawbacks, including projection and recognition problems, particularly in patients with face asymmetries. These methods, however, need a great deal of labor and are inaccurate. The majority of patients' appearance and attractiveness improved following orthognathic treatment, according to research by Patcas et al. using a computational algorithm based on a Convolutional Neural Network. These results are consistent with the majority of "classic" clinical studies[28]

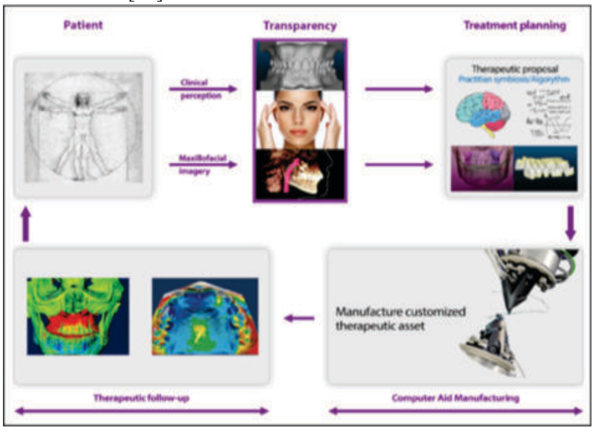

Figure: 8 Digital workflows on surgical-orthodontic protocols [29]

Due to the rapid advancement of technology and materials, 3D printers, digital software, and machine learning (ML) are increasingly being used in orthognathic surgery. 3D printing is commonly used to produce 3D models from digital photographs for surgical planning, specialized surgical equipment, and doctor-patient communication.

To present, 3D digital models have been used in a variety of methods to improve overall orthognathic surgery procedures and provide better planning and simulation that is more efficient, affordable, predictable, and useful.

The following 4 domains represent the effects of digital solutions on surgical-orthodontic protocols. (Fig. 8):

1. Increased diagnosis accuracy using maxillofacial imaging assisted by AI;
2. CAD/CAM (Computer Aided Design, Computer Aid Manu facturing) production of specialized surgical and orthodontic instruments
3. Treatment planning using 3D models;
4. Improved therapy follow-up as a result of using image superimposing to compare results at finer intervals**.**

The interval comparison of results by photo superimposing has improved therapy follow-up. ML has been proven to be a useful tool in orthognathic surgery for obtaining an accurate diagnosis, evaluating whether surgical intervention is required, and anticipating the course of treatment..[29].

6 Clear Aligners

It's become popular to use AI to help with orthodontic treatment planning. Numerous manufacturers of aligners claim to use AI algorithms to streamline orthodontic planning and save up orthodontists' time. The most popular aligner system, Invisalign®, has evolved into a catch-all name for a variety of high-end CAD-CAM technologies. Invisalign® is a market leader in aligner therapy with automated virtual treatment planning and fabrication using stereolithographic prototyping.

The Clincheck® program from Align Technology, located in Santa Clara, California, determines the movement required for each tooth, the mechanical AI is increasingly being used to support orthodontic treatment planning. Many companies that produce aligners assert that they use AI algorithms to speed up orthodontic planning and save orthodontists' time. The most well-known aligner system, Invisalign®, has developed into a generic term for a number of expensive CAD-CAM techniques.

With automated virtual treatment planning and manufacture using stereolithographic prototyping, Invisalign® is the market leader in aligner therapy. The Santa Clara, California-based company Align Technology's Clincheck® algorithm determines the movement necessary for each tooth, the mechanical

Figure 9: Align Technology, a feature of ClinCheck software, was used to design the best treatment configuration (Invisalign)

principles used to carry out this movement, and the shape of the aligner (Fig.9). These products include bonded resin attachments, 3D CAD/CAM tooth motions, computerized 3D interactive treatment planning and appliance design, Invisalign, ClearCorrect, ClearPath, eCligner, K Line, and Orthocaps, among others. They include better control over tooth position in all spatial planes and are intended for more intricate, complete tooth movements[30].

7. Temporary anchorage device (TAD)

Temporary anchorage devices (TADs) were introduced in orthodontics for anchorage about 20 years ago. For the precise positioning of TAD, a lot of approaches have been described in the literature. It has been successfully positioned using CAD/CAM technology. Inappropriate placement may lead to inadequate primary stability, root or even sinus rupture, and mini-implant failure. To reduce risks, TAD implantation now follows insertion criteria.

The most popular kind is static computer-aided guided surgery (s-CAIS), which uses static implant guides. With the aid of the virtual planning computer, the precise anatomical placement of the TADs is confirmed. The employed software enables both the virtual design and installation of TADs in a variety of lengths and diameters as well as the accurate positioning of the screws in line with the anatomical variations of each patient. The most popular kind is static computer-aided guided surgery (s-CAIS), which uses static implant guides. With the aid of the virtual planning computer, the precise anatomical placement of the TADs is confirmed (Fig 10). The employed software enables both the virtual design and installation of TADs in a variety of lengths and diameters as well as the accurate positioning of the screws in line with the anatomical variations of each patient.

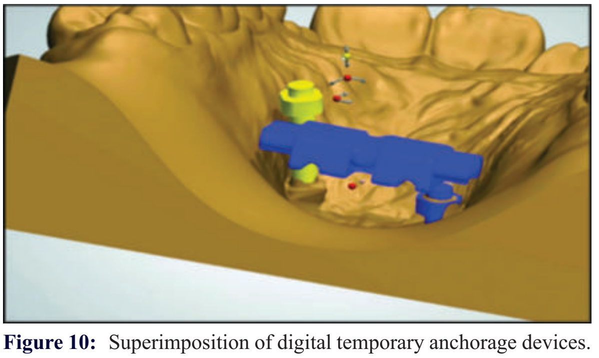

Figure 10: Superimposition of digital temporary anchorage devices. Including the analog to digital with an expansion screw inserted for virtual appliance design [31].

Wilmes B et al. uses the patent-protected software Easy Driver V 2.0.2019 (Uniontech, Parma, Italy) to insert small screws for only mini-implant mounted fast maxillary expanders. The Easy Driver System provides a kit for inserting the mini-implants that is specifically designed to fit the placement parameters with very minimal tolerance, comparable to those used with dental implants, to simplify the precise insertion of the mini-implants into the specified site [31].

8. Forecasting of treatment results

Artificial intelligence is useful in modeling diverse clinical scenarios during the three important stages of diagnosis, treatment planning, and therapy. This increases monitoring and accuracy while requiring less work and time. A key element of the orthodontic diagnostic and treatment plan is the evaluation of the facial profile. Nanda SB et al. [32] showed that ANN could predict changes in lip curvature after orthodontic treatment, with or without extractions. The predicted change and actual change for the upper and lower lips were 29.6% and 7%, respectively. To compare face attractiveness before and after orthognathic surgery on a scale of 0 to 100, There have also been reports on predictions of treatment results for patients in classes II and III. A technique to forecast outcomes in untreated class III patients.

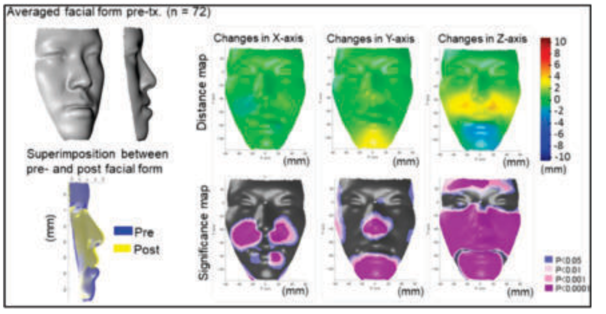

Figure 11: Creation of cutting-edge artificial intelligence tools to forecast patient face morphology following orthognathic surgery and orthodontic treatment[33]

Patients were classified as hyper mandibular, hyper divergent, or balanced using unsupervised learning based on cephalometric features. Following treatment, the method was applied to a sample, and the results showed that all of the unsuccessful cases belonged to either the hyper mandibular or the hyper divergent cluster. To demonstrate the key differences between class II and class III malocclusions by showing that class II subjects showed few highly connected orthodontic features while class III patients showed a more compact network structure with a strong co-occurrence of both normal and abnormal clinical functional and radiological features (Fig 11).The study's conclusions suggest that network analysis could assist orthodontists in visually assessing and forecasting the co-occurrence of auxological defects during a patient's particular craniofacial maturation and possibly localizing reactive regions for a malocclusion treatment[34].

9. Robotic wire bending

The most successful method for treating malocclusion at the moment is fixed orthodontic treatment. In this procedure, the force generated by the distorted archwire is used to correct the misaligned teeth. This is why the archwire bending technique is essential to orthodontic treatment. How effectively the manual archwire bending operation goes depends on how well the doctor can bend the wires. Archwires with different features are also required for the treatment of a variety of illnesses. The archwire must be bent repeatedly for the best therapeutic result. Orthodontic archwires can be bent using robotic technology to successfully treat these problems. Thanks to improvements in imaging and three-dimensional construction, orthodontic therapy is now more adjustable. It is possible to develop instruments that will increase the effectiveness of treatment. Two patient-explicit items—like the insignia system—have been created as a result of technology breakthroughs that employ computers to create full treatment regimens.[35].

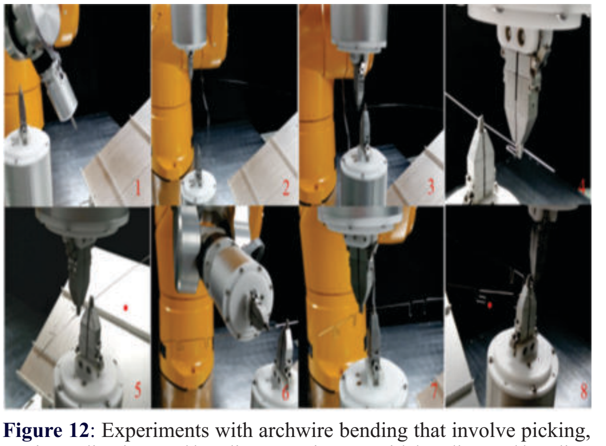

Figure 12: Experiments with archwire bending that involve picking, cutting, adjusting, and bending experiments with bending and bending on actual robotic systems for bending archwire [35].

For the first time ever, a CAD/CAM system was developed with the Bending Art System specifically for the purpose of producing specialized orthodontic archwires. This was created in 1984 by Professor Helge Fischer-Brandies and a collaborator; the hardware and software were developed in conjunction with an engineering firm. A BAS prototype was created initially. In order to make orthodontic wires, it is used for the lingual and labial arches. This system consists of a computer program, an electronic oral endoscope, an archwire bending machine, and a bending machine. Each patient receives customized fixed orthodontic equipment thanks to robots and an all-digital technology called Suresmile. Suresmile utilizes cutting-edge 3-D imaging technology and computer algorithms for diagnosis and treatment planning. The Cartesian archwire bending robot system consists of several parts. The accompanying software, which is also used to evaluate the bending technique, is used to generate the structural layout of the archwire. The results of orthodontic therapy using a robot or machine to twist the archwire used in fixed orthodontic equipment would be considerably better with noticeably shorter treatment times. (Fig 12)[36].

10. Customized wire and bracket positioning

A specially created orthodontic appliance is created for only one patient to achieve a specific orthodontic outcome. A bracket that has a groove designed to suit a specific archwire and a customized bracket bonding pad for attaching the bracket to a patient's tooth may be included in the system. The brackets created using CAD/CAM are the result of a unique process that makes them particularly resistant to de-bonding and consequent bracket loss. Furthermore, they can be used with a real straight wire, enabling the use of prefabricated standard cables**.**

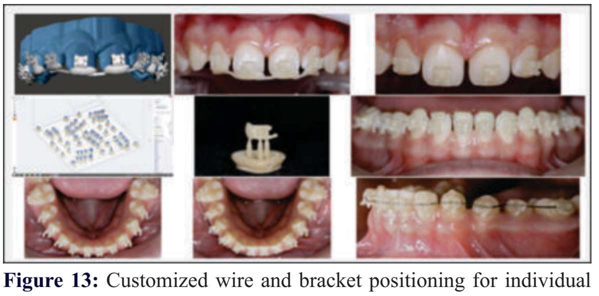

Figure 13: Customized wire and bracket positioning for individual patients based on tooth position

When the tooth is in its final position, the bracket slot and archwire can be positioned approximately next to the tooth surface to minimize bracket thickness and virtually parallel to the directly adjacent portion of the tooth surface to limit vertical inaccuracy The bracket slot can also be created with a bracket slot width that substantially matches the cross-sectional dimension of the archwire to further enhance the end-of-treatment tooth position and shorten treatment times. This will restrict rotational torque about the axis of the archwire. (Fig 13). A 3D computerized treatment control is employed throughout the entire assembly line to ensure complete accuracy in the bonding site. Appliances are completely customized for each patient, taking into consideration unique anatomical characteristics and medical advice [37]. As a result, practitioners will have access to certain theoretical advantages that will improve therapy at every step and make it more functionally seamless.

11. Customized lingual brackets

In straight-wire orthodontic devices, the three planes of tooth alignment can be altered over the course of therapy by strategically setting the brackets. Accurate bracket placement is necessary for successful orthodontic treatment. The ideal bracket location, according to Carlson and Johnson, needs the following four elements: The bracket base needs to be adjusted to the dental surface first. The position of the rotating bracket concerning the occlusal plane should then be assessed. Third, each bracket's vertical placement needs to be established.

The position of the roots should be taken into consideration while determining the slot angulation [38]. Indirect bonding on labial appliances may be more accurate than direct bonding, with a decrease in bracket position errors in each of the three orientations looked at, according to many studies. By reducing the need for repositioning, accurate bracket placement can hasten the therapeutic process. In terms of treatment duration and positioning accuracy, the findings of these trials, which concentrated on labial rather than lingual appliances, are preliminary and not conclusive. The reduction of chairside time can be considered the main genuine benefit of indirect bracket placement [39].

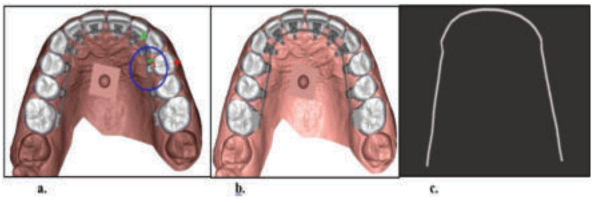

Figure 14 a. A bracket is attached to an archwire. Use of a manipulator to place the brackets precisely in three dimensions. **b.** a unique base that will be bonded to the base of the bracket using composite materials. **c**. Customized export archwire

Due to its outstanding aesthetic requirements and increased practicability, lingual orthodontics accounts for an increasing percentage of orthodontic treatments, and more research has looked at its several components. Although there are several aesthetic advantages to lingual orthodontic treatment, its adoption has been constrained because of the lengthier chair periods and more difficult mechanical control (Fig 14). Placing lingual orthodontic equipment, however, might be made simpler by contemporary technologies such as intraoral scanning, virtual bracket positioning, and computer-aided transfer tray construction [40]. The Insignia system, a cutting-edge computerized orthodontic technology, is used to create custom appliances. The Insignia technique begins with precise polyvinyl siloxane (PVS) impressions, extremely precise computed tomography (CT) scans of the impressions, computerized modeling of the dental arches, and a virtual setup for optimal arch shape and occlusion. The Insignia system reverse-engineers the brackets to the right specifications in one of two ways, depending on the type of brackets the orthodontist chooses, in contrast to computerized systems that just change the thickness of the bracket adhesive. Unique Insignia metal twin brackets are created by precisely milling slots into the faces. The Damon Q self-ligating model's metallic bases' thickness and angulation are changed to produce Insignia SL brackets. The "Overcorrection" capability has been introduced as a significant improvement to the Insignia system. This program calculates the rotational orientation of each tooth concerning third-order constraints by monitoring the three-dimensional movements of the center of the bracket slot and the roots' centers of resistance. The customization of the arch form, which is based on skeletal mapping of the cortical restrictions of the mandibular bone at the level of the teeth's center of resistance, is another distinctive quality of the Insignia system. Insignia archwires are particularly constructed, not off-the-shelf, to keep the teeth as much as possible in trabecular bone. Bracket-transfer jigs are built from a high-tech, spongy material and meticulously machined to fit the occlusal surfaces of the teeth to assure precise and consistent bracket installation. The jigs are made so that during bonding, three-quarters of the bracket-pad edges are visible to make it simpler to remove surplus composite material before polymerization. If a bind breaks during treatment, the jigs can be disassembled and utilized again to reposition and rebond individual brackets [41]. Therefore, this approach increases the effectiveness of fixed orthodontic therapy for each patient at the moment of first bracket insertion.

CONCLUSIONS

Orthodontists may be given more efficient and useful tools by artificial intelligence (AI), a collection of problem-solving technology, to provide improved levels of care. While artificial intelligence (AI) can assist orthodontists in selecting the ideal path to relocate a tooth or group of teeth, it now completely ignores oral diseases, does not fully incorporate face analysis into its algorithms, and is unable to take functional difficulties into account. AI has been integrated into imaging diagnosis at the same time to increase sensitivity and specificity in a range of disorders. In the dentistry sector, artificial intelligence (AI) has potential uses in clinical decision-making, patient diagnosis, and failure prediction. The results of the numerous investigations that formed the basis of this assessment suggest that the accuracy of AI-based systems is highly reliable and encouraging. Despite AI's ongoing growth, the variety of cutting-edge dental models is expanding as a result of AI. More study is required to assess the clinical efficacy of AI techniques in orthodontics. The results of the numerous investigations that formed the basis of this assessment suggest that the accuracy of AI-based systems is highly reliable and encouraging. To evaluate the therapeutic effectiveness of AI approaches in orthodontics, more research is necessary.

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