Int. J Med. Pharm. Res. (P-ISSN: 2958-3675 | E-ISSN: 2958-3683)
Available on: https://ijmpr.in/

International Journal
of Medical and Pharmaceutical Research

REVIEW ARTICLE **OPEN ACCESS**

COMPUTERS IN ORTHODONTICS

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Received: 17-02-2025
Accepted: 04-03-2025
Available online: 24-03-2025

A B S T R A C T

The field of orthodontics in its new era is venturing ahead to more up-to-date technological point of view. Digital technology has a significant effect on our lives ever since the modernization of mobile phones. The advances in technology have remodelled the diagnosis and treatment plan in the field of medicine. Digital workflows are currently increasing in the orthodontic practice and has touched every aspect of orthodontics – with transformations in the documentation, study casts, analysis of a dental malocclusion, smile designing, treatment planning and for fabrication of orthodontic appliances.

Use of computers in orthodontics has mainly changed the possibilities and paradigms in orthodontic treatment. To keep up with changing technologies and a faster, more accurate, and more efficient workflow, there is great potential in digital dentistry. Nevertheless, it is necessary to remain aware that digital smart data and other technologies are unable to substitute humans for providing dental expertise and the capacity for patient empathy. The key still belongs to the orthodontist, who manages and directs the digital applications.

Keywords: Digital technology, Artificial intelligence, Digital workflow

INTRODUCTION

The field of orthodontics in its new era is venturing ahead to more up-to-date technological point of view. Digital technology has a significant effect on our lives ever since the modernization of mobile phones. The advances in technology have remodelled the diagnosis and treatment plan in the field of medicine. Digital workflows are currently increasing in the orthodontic practice and has touched every aspect of orthodontics – with transformations in the

documentation, study casts, analysis of a dental malocclusion, smile designing, treatment planning and for fabrication of orthodontic appliances.[1]

Digital technology had a significant impact on our life since the introduction and sophistication of modern days. Medical diagnosis, teaching tools, treatment modalities and surgical techniques were improved significantly with the help of digital technology in the last two decades. Our review study is based on the orthodontic treatment, which is useful to study precisely the study to achieve proper analysis, and perfect diagnosis. It is now commonplace to perform virtual treatment planning as well as translates the plans into treatment execution with digitally driven appliance manufacture and its placement using various CAD/CAM techniques from printed models, indirect bonding trays and custom-made brackets. furthermore, it became more possible to remote monitor treatment and control it.

Utilization of digital technology, especially artificial intelligence (AI) technology, can help to reduce the cost and duration of treatment, the need for human expertise and the number of medical error cases.[2]

DIGITIZATION IN ORTHODONTICS

A. Applications of digital orthodontics in diagnosis:

I. Digital photos

Direct digital photography, which turns photographs almost instantly into a digital file, has several advantages in dentistry, including the ability to see images almost immediately and the ability to retake images as needed.[3]

Images taken before and after treatment can be effective marketing tools. These same photographs can also be utilised to make advertisements for local media such as newspapers, magazines, and even television commercials to promote the practice. The orthodontic practice could benefit from the use of digital models. with current technology and future uses.[4]

Facial Scanners

3D surface imaging

Initially, 3D surface imaging was used which gives geography of the facial structures and aids in investigation of evenness and stretch of face.

4D facial dynamics

The 4D framework is utilized to evaluate capacitatem of face combined with normal development of head, useful advancement and treatment results and careful intercessions.

II. Digital models

Digital models have been invented to avoid several disadvantages of traditional models in terms of lifetime, portability, and storage and retrieval, offering various advantages namely, no laboratory procedure needed, the ability to create multiple diagnostic setups, no physical storage space required, fast and efficient retrieval at any location, no risk of physical damage, can be used to create indirect bracket bonding setups, precision in measurements such as tooth size, arch length and width, space analysis etc., and can be easily shared with other dental practitioners via email to facilitate interdisciplinary treatment planning, Ideal marketing tool because it enables virtual treatment objective (VTO) communication with patient, visualization of treatment outcome, and help the patient better understand the treatment process.[5]

Fig. 1. A dental cast been digitalized with a conventional scanner.[21]

Model Analysis App

The software does quick and precise mathematical calculations in the following areas:

1. Boltons ratio
2. Boltons ratio for Vidarbha population (SM ratio)
3. Modified Boltons ratio (ViVan ratio)
4. Carey's Analysis
5. Ashley Howe's Analysis
6. Pont's Analysis
7. Tanaka Johnston
8. Peck and Peck index
9. Formula for missing Maxillary Central and Lateral Incisor (ViVan Formula)
10. Formula for missing Maxillary and Mandibular Canine (VM Formula)
11. Formula for missing Mandibular molars (MeeVik Formula)
12. Formula for missing Mandibular Central Incisors (SV Formula)
13. MBT bonding guide

It can also be used as a portable reference for these analyses, making it a useful e-learning tool.[6]

III. DIGITAL RADIOGRAPHY

Four ways can be recognized for the interpretation of cephalometric x-rays:

1. Traditionally, it was done manually. Using an acetate over the cephalometric radiograph to trace patient's skeletal, soft tissue, and dental features, landmark identification, and taking linear and angular measurements between landmark locations.
2. The second way involved a digitizer linked to a computer that converts the traced paper into a digital form.
3. The third way conceived the direct digitization of lateral cephalometric x-rays through a digitizer linked to a computer before landmarks localization manually.
4. Currently, the evolution in the interpretation is heading towards complete automation of landmarks identification through artificial intelligence implementation.

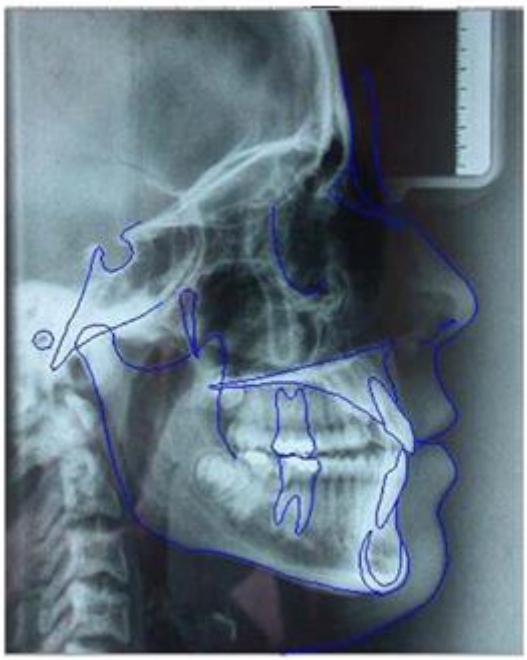


Fig. 2. Digital Lateral measured radiography.[21]

B. Applications of digital orthodontics in treatment:

I. Indirect bonding

The latest advances in digital technology, such as intraoral scanning, 3D printing, and virtual setups, made indirect bonding a much easier and more predictable procedure that was worthwhile for clinicians to explore. STL files is utilized to produce the models needed for indirect bonding techniques. After digital bonding through orthodontic modules

provided by several softwares as Ortho Analyzer i, OrthoCAD®ii,SureSmile®iii (Orametrix, Inc., Richardson TX), a 3D-printed transfer tray or vacuum formed tray on 3d printed bonded models is constructed and delivered to patient mouth.

Fig 3: *Internal view of the virtual indirect bonding tray with gingival open architecture for easy transfer tray removal. Cited from: Applications C, Jain P, Gupta M. Digitization in Dentistry.; 2021*.[22]

II. Aligners

Clear aligners may produce clinically acceptable outcomes comparable to fixed appliance therapy for minor buccolingual inclination of upper and lower incisors (low level of evidence).

It uses a sequence of aligners to move the teeth, which is composed of see through plastic that engages the buccal, lingual, palatal, and occlusal surfaces of the teeth. The duration of wear is 2 weeks and it is changed and advanced accordingly. The movement of teeth is about 0.25 - 0.35 mm and the total duration of treatment is about 9 - 15 months.[1]

Fig 4: Clear aligner. Cited from: Applications C, Jain P, Gupta M. Digitization in Dentistry.; 2021.[22]

USE OF COMPUTERS IN ORTHODONTIC ANALYSIS & DIAGNOSIS

Digital Workflow

The orthodontics office is moving towards a digital workflow with intraoral scans, digital tooth set ups, 3D printers, and CAD / CAM. Few studies have reported that CAD / CAM appliances decreased the duration of treatment and improved the patient outcome.[7] The digital models, documentation and appliance design will be transferred to the digital lab and the process of appliance manufacturing is known as the digital workflow.[8]

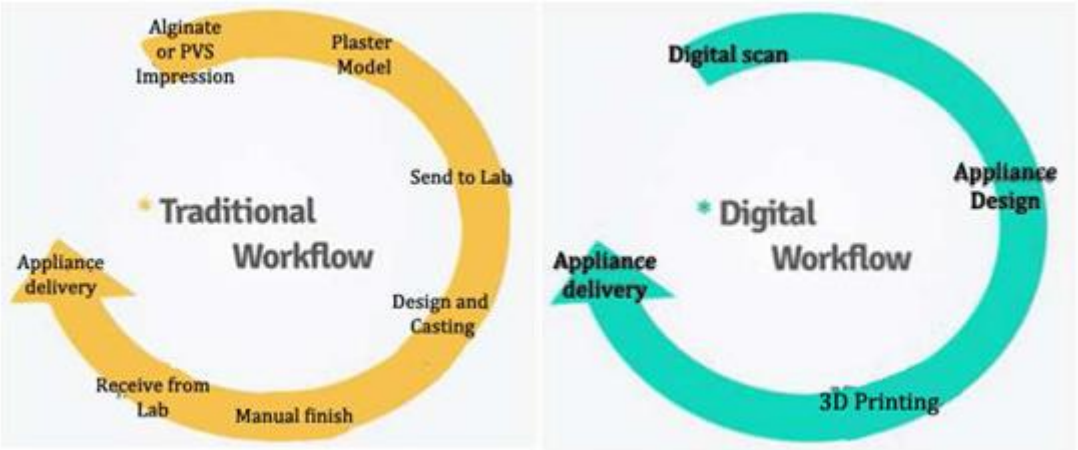


Figure 5: Comparison between the Traditional and Digital Workflow[9]

ROLE OF AI & MACHINE LEARNING IN CONTEMPORARY ORTHODONTICS
ARTIFICIAL INTELLIGENCE

The current paradigm of AI is machine learning. The fundamental distinction between machine learning and symbolic AI is that the former uses a set of rules created by humans, whilst the latter relies on examples to train its models. Algorithms change from rules on how to approach a problem to rules on how to learn from the data at hand in this fashion.[10]

Classification of Machine Learning (ML) Algorithms [11]

Based on the type of learning and the intended result of the algorithm, ML algorithms are divided into different categories:

Supervised learning
Unsupervised learning
Reinforcement learning

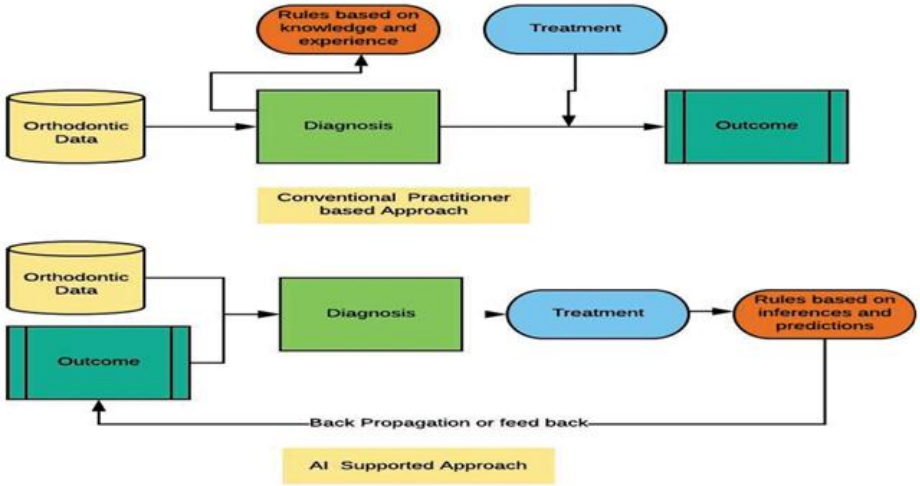


Figure 6: (a) Conventional approach to diagnose and treatment plan an orthodontic case. (b) Artificial intelligence supported approach to diagnose and treatment plan orthodontic cases.[12]

AI showed as accurate an identification of cephalometric landmarks as did human examiners. AI always detects identical position which implies that AI may be the reliable option for repeatedly identifying multiple cephalometric landmarks.

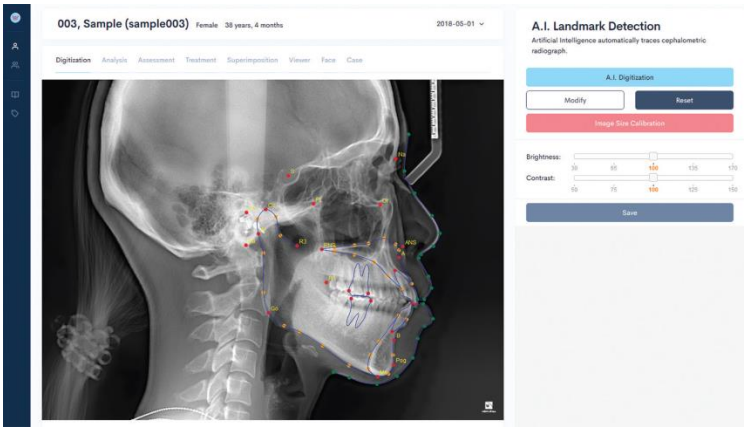


Figure 7: Cephalometric automatic point detection.[11]

Another use of AI is found in the automation of case setups for indirect bracketing or production of aligners.

Figure 8: Indirect bracketing using artificial intelligence.[12]

RECENT ADVANCEMENTS IN DIAGNOSTIC AIDS

Digigraph

It is a sonic digitization technique. This technology helps to register linear distances. They help to reduce the radiation exposure from lateral cephalometric tracings for patient diagnosis. Mesiodistal width of teeth are recorded after digitization of the plaster cast.

A radiograph needed to assess was also provided for inputting lateral cephalograms into the Digigraph.[13]

Rapid Prototyping (RP)

RP is a type of computer-aided manufacturing (CAM) and is one of the components of rapid manufacturing. It is a technology that can make physical objects directly from 3D computer data by adding a layer-upon-layer. First, slicing of the digital model is done, and then through an automated process of layer-by-layer construction, transverse sections are physically produced. These 3D physical structures are known as rapid prototypes.

In the diagnosis and evaluation of the malocclusion in dentistry, necessitates the careful collecting and analysis of a huge amount of data in the evaluation of the patient.[14]

BRACKET MANUFACTURING BY RPT

Biglino G et al. has given the application of rapid prototyping in therapeutic settings. CAD/CAM technology is used to combine the two previously separate activities of bracket manufacture and bracket positioning into a single unit. Brackets for lingual orthodontics are created using digital recording of the malocclusion. The brackets are then individually built and placed in the computer using rapid prototyping.

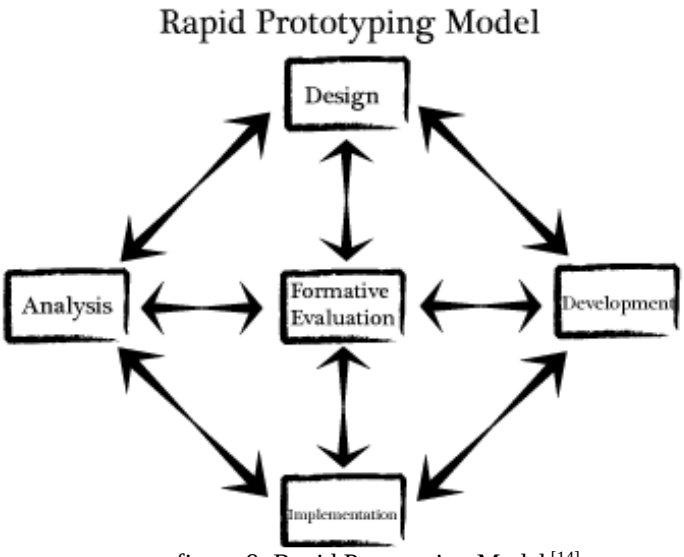


figure 9: Rapid Prototyping Model [14]

STEREOLITHOGRAPHY (SLA)

Stereolithography (commonly known as SLA) is the earliest additive manufacturing technique, which uses an ultraviolet laser to turn liquid photopolymer into solid cross-sections. Despite being the oldest technology, it remains the most important since no other additive manufacturing technique covers a wider range of applications for exceptionally precise and long-lasting prototypes of all shapes and sizes.

Software's Developed in India

Digiceph[15]

Method for computerized digitization analysis and superimposition:

- 13 cephalometric analysis
- Developed by the centre for Bio-Medical Engineering, IIT Delhi and Dept of Dental Surgery AIIMS

Digital Imaging and Communications in Medicine (DICOM)

A DICOM image file includes an x-ray image or series of images (such as a numerous slice CBCT imaging study) as well as patient-related information from a "library" of pre-selected preset terminology (for example, patient name, identification number, and acquisition modality, to name a few).

Ortho Cad

Cadent is the company behind this piece of software (computer-aided dentistry). An optical scanner is used to capture the model's picture from a plaster equivalent. Using the patent OrthoCad software user interface, they are then shown to the orthodontist, who may manipulate the models in virtual space as well as gather data using a variety of diagnostic instruments.[16]

Geo Digm

These scanners employ digital cameras to scan the cast and look for any distortions in a laser stripe that is projected onto the surface. To expose the cast for scanning, it is orientated in all four directions. Through the use of thousands of interconnected triangles, the 3D image is built up from these 3D vertices. Each triangle in the e-model is given a colour based on its distance from a digital light source on the computer display when it is generated in software.

In the end, you will have a 3D image that you can hold in your hand and alter in real time on your computer screen. It is then sent to GeoDigm, where an e-model is created from the impressions and bite registration, and the e-model is articulated. The model may be fetched from the main server.[15]

Radiovisiography

Imaging system used in dentistry with minimal radiation exposure and it has many advantages over conventional radiography. It produced instant images without the need for a dark room.

ROBOTIC WIRE BENDINGS

The bending art system

BAS utilizes a series of custom-made archwires that are bent to the precise specifications required to move the teeth into their proper position. The BAS approach is designed to provide greater control and predictability in tooth movement, resulting in more efficient and effective orthodontic treatment.[24]

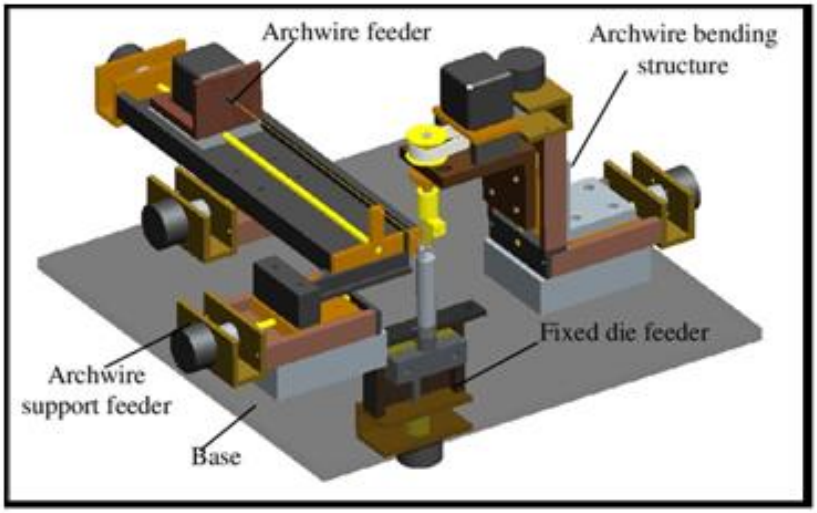


Figure 10: BAS, Bending Art System [24]

LAMDA robotic wire bending system

A lingual archwire manufacturing and design aid (LAMDA) for the precise, fast plan, and bending of orthodontic archwires, which appear in the below Figure. It is a system for rapid and exact bending of the archwire. Developed by Alfredo Gilbert in 2011, the system uses a robot that can bend the archwire in two planes which restricts the applications of the system.[17]

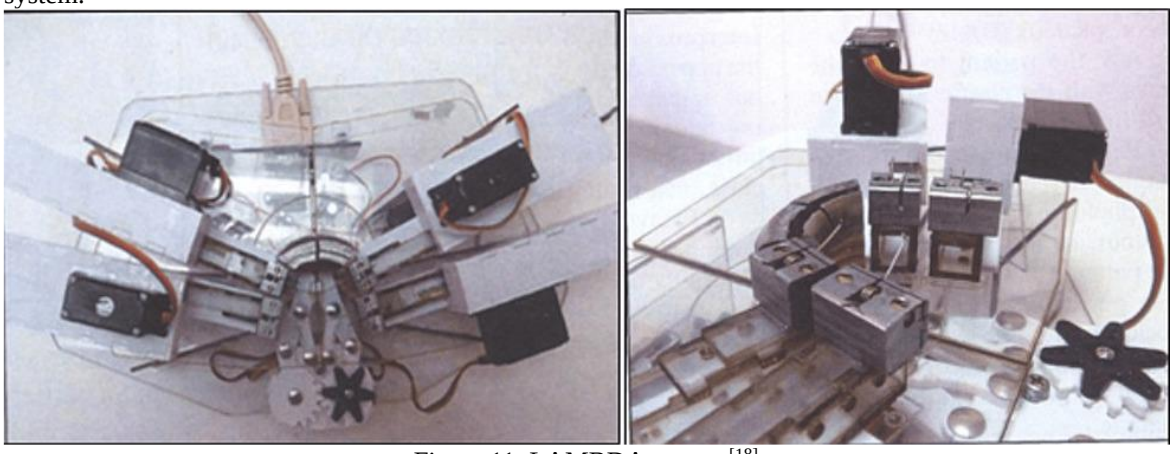


Figure 11: LAMBDA system [18]

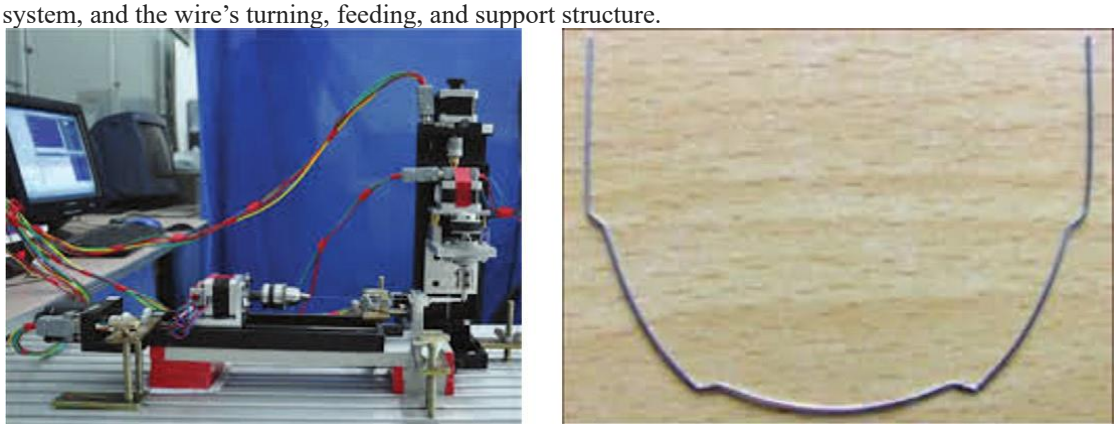
MOTOMAN UP6

A different type of a robot used in orthodontic archwire bending that is based on MOTOMAN UP6. It is composed of a computer and a twisting device for the archwire.[19]

Figure 12: Archwire bending robot based on MOTOMAN UP6.[23]

Cartesian type archwire bending robot

This system of archwire bending uses a robot that has multiple components. The archwire bending system involves a Cartesian type robot comprising various components. These include the bending die, base, feed mechanism, archwire bending system, and the wire's turning, feeding, and support structure.



Figures 13: Cartesian type archwire bending robot.[18]

SureSmile system

SureSmile is an all-digital system which uses new 3-D imaging and computer techniques for diagnostics and treatment planning and uses robotics to customize fixed orthodontic appliances.[20]

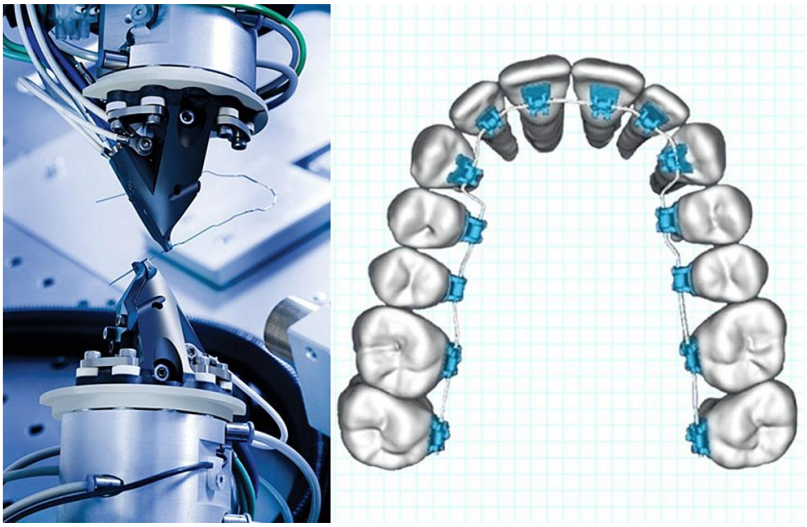


Figure 14: SureSmile system [24]

Insignia

Insignia, a remarkable bracket system, is the pinnacle of digital orthodontics, boasting an array of cutting-edge technologies. This system, unparalleled in its innovation, equips orthodontists to meticulously design and efficiently deliver impeccable results.

The scores of the insignia treated cases were very close to the perfect scores according to the American Board of Orthodontics (ABO). Also, the treatment time was significantly shorter when comparing insignia to other techniques (14.23 months versus 22.91 months).

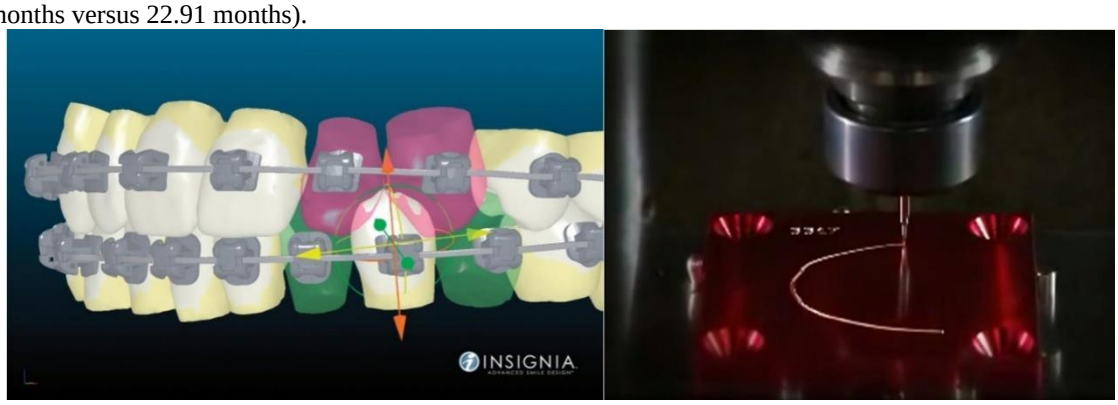


Figure 15: Insignia system software.[23] **Figure 16:** Wire fabrication robot.[23]

CONCLUSION

Use of computers in orthodontics has mainly changed the possibilities and paradigms in orthodontic treatment. To keep up with changing technologies and a faster, more accurate, and more efficient workflow, there is great potential in digital dentistry. Nevertheless, it is necessary to remain aware that digital smart data and other technologies are unable to substitute humans for providing dental expertise and the capacity for patient empathy. The key still belongs to the orthodontist, who manages and directs the digital applications.

The latest trend word created is augmented intelligence, that is, the meaningful combination of digital applications and artificial intelligence paired with human qualities and abilities in order to achieve improved dental and oral healthcare and improve quality of life.

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