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Recent Advances in Orthodontics

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Abstract:- This review highlights the progress in orthodontics. Advances in the field have enhanced diagnostic efficiency and streamlined treatment planning. Modern technologies such as computer applications, electronic dental models, artificial intelligence, and cephalometric applications give orthodontists a significant advantage over traditional diagnostic methods. The stereolithography technique offers valuable diagnostic insights, predicts surgical outcomes, and assists in creating surgical guides. CAD/CAM technology enables the milling of virtual arch forms and lingual retainers, reducing chair time. Laser innovations improve the efficiency of etching, bonding, and even accelerate orthodontic tooth movement. Additionally, developments in brackets and archwires have made significant strides. Ultimately, it is up to the clinician to utilize these advancements wisely to achieve optimal aesthetic results for patients.

I. INTRODUCTION

When Galileo quoted that the **"World was round"** people opposed the idea. Advances and discoveries were always welcomed with disbelief and non acceptance. Constant assurance with proof and experimental studies tunnelled the success of inventions.

From an orthodontist point of view, technology has grown leaps and bounds in the last 20 years. Apps[1], 3D dental imaging, intraoral scanners CAD/CAM, Robotic wire bending[2] ,stereophotogrammetry, additive layer manufacturing are some of the examples of new innovations in orthodontics[3].

Diagnosis and treatment approaches are the two corner stones for any clinician. Newer technologies increase the specificity for diagnosis. From the patient's perspective improved aesthetics and shortened treatment time are the prerequisites. It is the duty of the orthodontists to provide treatment approaches which are the need of the hour and to stay updated.

In this article, we explore the latest advancements in orthodontics.

II. RECENT ADVANCES IN DIAGNOSTIC AIDS

A. Computer Application in Orthodontics :

Walker[4] had classified computer applications into general and specific categories. Bichu et al[4] narrated different explorations of the artificial intelligence(AI) in orthodontics. Expert systems were one of the basic implementations of AI and are essential for diagnosis and treatment planning. Two commercially available softwares for analysing digital study models are Orthocad by cadent and E-Models by orthontechnologies[5]

- *Orthocad:*

Alginate impressions are mailed to lab along with wax bite. The conventional physical configuration of study models is maintained. The programme runs on any MS Window and accessibility is global. The model can be electronically sectioned, sagitally or transversely. Virtual calliper can be used and tooth material can be calculated rapidly[6].

- *E- Models:*

It was found by Geo Digm in 1996. After obtaining the impression, a plaster model is created and then scanned using a non-destructive laser. This laser digitally maps the model's geometry with an accuracy of 0.1 mm[7]. The E Model software enables users to move, rotate, or enlarge the digital models. Bolton analysis, tooth width, arch length measurements can be done using it. The cross-sectioning tool can slice the digital models along any vertical or horizontal plane, allowing for the assessment of symmetry, overjet, and overbite. Occlusal relationships with articulation and jaw movements can be performed. The eplan™ service with E models can help the orthodontist to prescribe a treatment outcome[8].

- *Machine Learning Through Artificial Intelligence:*

It is science that enables computer systems and other mechanical devices to process, analyse, and interpret data, ultimately providing solutions to everyday problems. The algorithm is set up so that computers can forecast outcomes based on previous events. It is the science of enabling computers to acquire new information and interpret it, allowing them to perform tasks automatically. It can be divided into supervised, unsupervised and deep learning[9].

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B. Cephalometric Applications

Convergence, reliability, relevance, accuracy and cost are the factors which determine the selection of cephalometric applications. Also, the integration of cephalometric applications with the invention of artificial intelligence is less spoken about.

➢ *Digigraph :*

Developed by Dolphin imaging system[10] which is non radiographic and video imaging is possible. A digitizing handpiece applied directly to the patient records a series of facial and intraoral landmarks. Tracing can be done in approximately 2 minutes. The program produces any of 14 predetermined cephalometric analysis[11].

➢ *Vistadent Complete :*

It enables tracing and identifying points directly from a scanned X-ray. The VTO feature visualizes soft tissue changes based on measurements from various orthodontic treatments and surgeries.

➢ *Dolphin Imaging Software :*

Non magnified results of the cephalogram are obtained unlike other softwares. Digitization of cephalometric landmarks is done. Analysis of patient's soft tissue profile, treatment simulation procedures such as CO/CR conversion and growth forecasting is done[6]. Mandible can be repositioned in centric relation and indicator values such as condylar position indicator (CPI) or mandibular position indicator value is done.

➢ *Facad :*

It is developed by Swedish company Ilexis AB is a software program for tracing and cephalometric analysis, visual diagnostic imaging, orthognathic surgical planning with soft tissue predictions[12].

➢ *Audaxceph :*

It is the cephalometric program that integrates the knowledge of specialists into computer support and reuse it for cephalometric analysis. It is also possible to carry out photometry of face, vertebral cervical analysis, morphometric parameters of diagnostic models. It is also used in medical field that includes consultative, scientific and educational work. Growth analysis, cephalometric automated landmark marking and analysis, Visualised treatment objective can all be performed[13].

C. 3D Technology :

The 3-dimensional records are the current inventions. Integrated 3D model of craniofacial structures[14] is formed using lateral, frontal cephalograms, photographs and 3D models of dental cast. Laser scanners can image a face in approximately 0.6 seconds as the beam is straight and multiple scans stitch together to produce a composite image[15]. Profile scanners is a light based technology[16] where object to be scanned is placed on a turntable. It calculated the profile by looking for the transition in background. The non background colours are used to create a texture map of the object. To synthesise 3 dimensional images the X ray sensors, include charge – couple devices (CCD), photostimulable phosphors (PSP) and amorphous silicon plates[17].

➢ *Cone Beam Computed Tomography :*

Three-dimensional cephalometry can be performed using CBCT (Cone Beam Computed Tomography) for a comprehensive assessment of craniofacial structures[18]. Quantification of asymmetries, longitudinal growth and subtle occlusal changes can be assessed using CBCT. CBCT is an efficient tool to diagnose the position and angulation of impacted canines and surgical prediction. The pharyngeal dimensions and airway volume can be efficiently quantified using CBCT[19].

➢ *3-Dimensional Scanner:*

The first digitation system was developed by Cadent in 1999. The clinician can create a three-dimensional structure of the dental arches, either individually or in occlusion, from plaster models or impressions that are directly scanned from the oral cavity[20]. The scanner is a recent innovation used for producing clear aligners, surgical guides for miniscrew placement, indirect bonding procedures, and predicting tooth movement in three dimensions. Clear aligners are recent innovation which uses 3D technology, especially CBCT and intraoral scanners. It is manufactured according to the sequence of the tooth movement. Each model in 3D is transformed into a Standard Triangle Language format. The intraoral scanner can also be used for fabrication of guides for miniscrew placement, surgical splints[21].

III. STEREOLITHOGRAPHY:

Introduced by Charles W. Hull, this technology builds 3D objects layer by layer using photosensitive material that is cured by UV light[22]. It is a 3D printing process where liquid polymer or monomer resin, mixed with a photoinitiator, undergoes irreversible photopolymerization when exposed to targeted irradiation. It provides diagnostic information, surgical prediction, fabrication of surgical guides.

IV. RECENT ADVANCES IN TREATMENT AIDS

A. CAD/CAM :

Computer aided design and manufacturing consists of data acquisition unit, a software and a computerized milling device. It can mill virtual arch forms and customize the brackets in ideal positions, on each tooth. Ormco's Insignia is one of the examples where CAD/CAM is used. It also mills lingual retainers with appropriate placement and less irritation of the tongue and prevention of excusive interference.

B. Lasers In Orthodontics:

Light Amplification by Stimulated Emission of Radiation (LASER) is a device that generates and amplifies a focused, intense beam of coherent light. In the field of orthodontics, it is used for debonding, etching, bonding, exposure of infected teeth, TMJ management.

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➢ *Laser Etching:*

Initially lasers were used for soft tissue procedures[23]. Thermally induced changes within the enamel, extending to a depth of 10-20 µm, cause localized melting and ablation of the enamel surface. This process etches the enamel through continuous vaporization and micro-explosions, caused by water trapped within the hydroxyapatite matrix. Erbium-doped Yttrium-Aluminum-Garnet and Er,Cr:YSGG laser systems are capable of ablating both hard and soft tissues, respectively. It is painless and causes microcracks to facilitate resin penetration and modifies calcium phosphate ratio[24].

➢ *Laser Bonding:*

Study by Kuchak[25] stated that Argon lasers can be used for bonding the adhesive precoated brackets. Bonding with Argon lasers for 10 seconds achieves bond strength comparable to that of light curing for 20–40 seconds.

➢ *Bracket Mesh Designing Using Lasers :*

Laser-reinforced structured bases allow forces to be applied even closer to the crown[26]. Compared to conventional markings, laser markings cannot be abraded and do not contain harmful colouring agents

C. Low Level Laser Therapy:

This procedure accelerates tooth movement by increasing RANKL levels in the periodontal ligament (PDL), which boosts osteoclastogenesis and elevates M-CSF levels [27]. Additionally, there is a significant rise in the number of osteoclasts, osteoblasts, inflammatory cells, chemical mediators, capillary vascularization, collagen fibrils, and matrix deposition. It reduces orthodontic post adjustment pain. It has got stimulatory effects on bone regeneration during mid palatal suture during expansion[28].

➢ *Laser Welders:*

Orthophaser is the latest commercially available Argon laser welder. Larger than conventional welder and biocompatible. All metals including titanium can also be welded. Consists of working microscope with integrated eye protection, flexible handpiece[29]. The advantage is that the metal is subjected to very minimal heat influence. Intraoral laser microwelder[30] is a high-power industrial neodymium laser incapable of delivering 20J/Pulse for maximum of 6 milliseconds at wavelength of 1.06 microns. It is used in the placement of space maintainers, retainers, orthodontic splint, periodontal splints, archwire, brackets to bands or auxillaries. It eliminates time consuming procedures like ligature tying of archwire, crimping, clamping.

➢ *Innovation in Brackets, Archwires :*

Ceramic, plastic brackets are in a rapid pace of growth due to increase in need of esthetics Ceramic brackets are highly aesthetic, exhibit low water absorption, and are biocompatible. Plastic brackets, on the other hand, exhibit excessive creep deformation and have poor torque capacity[31]. Self-ligating brackets are a type of bracket system which utilizes permanently installed movable component to entrap the archwire[32]. The innovations include Edgelock Ormco – 1972[33], Damon system (SL1,SL2,SL3)[34], In- Ovation – 2000, Smartclip[35] (2004), Clarity SL (2007). They have a faster ligation, ease of use reduced friction and efficient alignment of severely crowded teeth[36]. The recent advancements in archwires include thermoelastic and niobium Niti. Shape of the archwire can be incorporated thermally in thermally activated archwires. Nitro aniline – 2 chloro – 4 – Nitro aniline alloy can be used to fabricate loops, weldable and solderable[37].

V. CONCLUSION

Recent advances in orthodontics have significantly enhanced diagnostic precision, treatment efficiency, and patient outcomes. Innovations such as digital scanning, 3D printing, and advanced imaging technologies like CBCT have revolutionized the field, enabling more accurate assessments and tailored treatment plans. The integration of artificial intelligence and computer-aided design (CAD) has streamlined procedures and improved the customization of appliances like clear aligners and surgical guides. Additionally, advancements in materials, such as self-ligating and ceramic brackets, have enhanced both the functionality and aesthetics of orthodontic treatments. These technological strides not only improve the effectiveness of interventions but also contribute to a more comfortable and efficient patient experience. As the field continues to evolve, ongoing research and development will likely drive even further innovations, promising continued improvements in orthodontic care.

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