Digital Technology Support In Orthodontic Care: A Literature Study

Eka Erwansyah, Mulyati Yunus, Fuad Husain Akbar, Nadiah Hulwah, Eryanti Abbas

Abstract: Technology that has developed and integrated with digital solution in personal practice has changed the diagnosis and planning for treatment from two dimension (2D) traditional approach into three dimension (3D) developed techniques. In this generation of technology, the use of Smartphone and tablet has made life simpler. Smartphone provide routine access to seek for information, including medics and dental education. This study aimed to browse a variety of scientific information to understand digital technology support in orthodontic treatment. Digital technology in orthodontic practice could help orthodontics in examination and straightening diagnosis on patients, increase efficiency, accuracy, consistency, and certainty on the results of treatment. Digital technology also could help patients to obtain information, and monitor the treatment teleorthodontics.

Index Terms: Digital Technology, Examination, Diagnosis, Education, Orthodontic Appliance, Orthodontic Treatment, Teleorthodontic

1 INTRODUCTION

Dentistry is undergoing significant changes due to digital technologies, which are influencing how dentists diagnose, plan treatment, and deliver care to patients[1]. The rapid development of medical diagnosis, teaching tools, treatment modality and surgery techniques have been introduced during the last two decades. Digital technology started to enter dental and orthodontic practices by the introduction of computerized scheduling in 1974[2]. Emerging technologies and integration of digital solutions in personal practice have transformed diagnosis and treatment planning from traditional two-dimensional (2D) approaches to sophisticated three-dimensional (3D) techniques. The use of digital technology meets the demands of multi-doctor practice, multi-location practice, growth of the number of patients, and enables the storage, retrieval, and sharing of information in an efficient and convenient way. Orthodontics quickly embraces new material and advanced technology, making 3D complete orthodontic offices a reality[3]. Recent developments and introduction of intraoral scanners, cone-beam computed tomography (CBCT), improving efficiency, accuracy, consistency, and certainty of treatment results[1]. In this generation of technology, the use of smartphones and tablets has made life simpler[4]. Smartphones provide regular access to information, including the medical and dental education fields. Dental applications have now become one of the fastest growing categories mainly covering various programs specifically designed for Orthodontics[5].

2 LITERATURE REVIEW

2.1 Digital Technology in Orthodontic Examination and Diagnosis

Successful orthodontic treatment is dependent on the disciplined approach to record taking and diagnosis as well as careful monitoring of progress in treatment[6]. Orthodontic diagnosis includes three components such as facial, dental and skeletal. The main task of an orthodontist is to rearrange craniofacial complex components that are anatomically different, balance their position dynamically and have good esthetics. This process requires information about the relationship of all these craniofacial complex components in three spatial fields. Most conventional diagnostic aids only provide patient representation in 2 dimensions. Sophisticated technology provides dentists with high quality diagnostic information in three areas that helps in designing patient care plans[7]. Here is a digital technology that supports orthodontic examination and diagnosis:

2.1.1 Intraoral Scanner

Intraoral scanners (IOS) are devices for capturing direct optical impressions in dentistry[8]. Similar to other three-dimensional (3D) scanners, they project a light source (laser) onto the object to be scanned, in this case the dental arches, including prepared teeth and implant[9][10]. The images of the dentogingival tissues captured by imaging sensors are processed by the scanning software, which generates point clouds. These point clouds are then triangulated by the same software, creating a 3D surface model (mesh)[10][11]. The scanning process is more comfortable for the patient because it reduces the gag reflex[8]. Easily stored and shared with any dental laboratory via the internet without packing and shipping of molds. This also eliminates two possible sources of error and material variability in printing and casting and manipulation of casts. Digital files can be sent to a lab, which can print them into physical models or use them to design and manufacture digital devices directly. Furthermore, the model can be analyzed immediately. These models can also be used for various platforms of orthodontic software to enable orthodontists carry out virtual treatment plans and explore various treatment plans in minutes. This digital method not only allows doctors to explore a number of treatment options in a simple way, but also facilitates better communication with other dental professionals especially in cases that require a combination of orthodontics and restorative care. Virtual care planning also allows for better communication with patients and allows them to visualize the results of care and also understand the care process[2].

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Figure 1 : *The Lythos™ Digital Impression System[3].*

2.1.2 Cone Beam Computed Tomograph

Craniofacial CBCT was developed to overcome some of the limitations of conventional CT scanning devices. In craniofacial CBCT, the object to be evaluated is captured when radiation falls into a two-dimensional retractor. This simple difference allows the one-round radiation source to capture the entire region compared to conventional CT devices where several pieces are stacked to get a complete picture. Cone beams also produce more focused light and far less radiation compared to conventional fan shaped CT devices[6]. This significantly increases the utilization of x-rays and reduces the X-ray tube capacity needed for volumetric scanning. Radiation exposure is 20% from conventional CT or equivalent to peri-apical radiographic exposure[12]. Orthodontic CBCT can be used to view impacted teeth and oral disorders, airway analysis, alveolar bone height and volume assessment, TMJ morphology, lateral and frontal cephalogram display, skeletal appearance, facial analysis, and view of teeth in 3D[13]. The ability to rapidly and accurately assess the tooth and bone position and condition in all three dimensions is invaluable for accurate diagnosis and treatment planning[2].

Figure 2 *: CBCT Machine[7].*

Figure 3 *: Superimposition of initial and final CBCT images using Anatomage software[2].*

2.1.3 Digital Study Model

The study model is an integral part of orthodontic treatment diagnosis and planning. The study model also provides a record of malocclusion before, in the stages, and the final outcome of treatment[6][7]. In the expansion of computer technology, the introduction of digital study models is an alternative to the plaster study model. This digital study model has many advantages over plastic models such as: no laboratory procedures are needed, no storage space is needed, fast and efficient retrieval, and there is no possibility of physical damage and easy transportability[7]. Precision in measurements taken from these models such as tooth size, arch length and width, midline discrepancy, space analysis, overjet, Bolton analysis, overbite, molar and canine relationships, thus they are valid for clinical use[7][14]. Digital models can be made from alginate prints or with intraoral scanners[15].

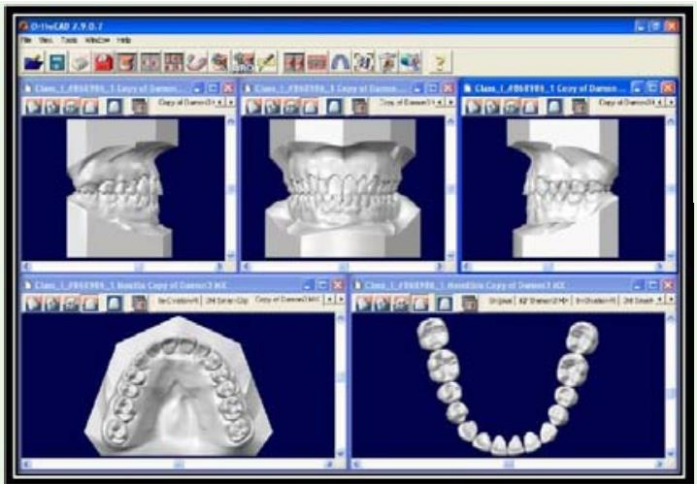

Figure 4 *: Digital study model[7].*

2.2 Digital Technology in Orthodontic Examination and Diagnosis

2.2.1 Digitalization of orthodontic appliance manufacturing

CAD / CAM technology has existed in dentistry for more than three decades and in orthodontics can be used through printing models for aligner therapy, direct printing brackets Incognito system (3M-Unitek, Monrovia, Calif) and robotic wire bending Sure Smile system (Orametrix, Richardson, TX)[2]. With these tools, orthodontic treatment may become safer, more efficient, and more effective[1]. In 1997, Align Technology© (Santa Clara, CA) released the Invisalign® system. the clear aligner as it is now known[16]. At the beginning, the Invisalign® system was used to treat simple tooth movement. However, as it developed, the manufacturer began using attachments and intermaxillary elastics to obtain different movements, so Invisalign® became a viable alternative to fixed appliances[17]. Clear aligner therapy using virtual models, creating virtual arrangements of desired results and making tools from digital models to provide predetermined maintenance results. Placement of attachments to control gear movements, the need for interproximal reduction and / or extraction and planning for mechanics inter-arching is done first. This process allows visualization of the gear movement process and allows operators to visualize the mechanism of their care and for patients to review results before starting treatment. Until now aligners are still printed on individual print models but it is expected that direct printing aligners with biocompatible materials will be introduced in the near future[2]. The making of digital appliance has also changed the therapy of fixed appliance. Starting with lingual appliances more than 15 years ago when Dr. Wiechmann combined virtual settings, customized bracket printing, and robotic wire bending to create customized lingual appliance[18]. Virtual setup is made with the desired treatment results and then the bracket is digitally designed to fit as close as possible to the lingual surface of the teeth and 3D printed with wax and then cast in gold. This makes it possible to make a low profile lingual appliance similar to the surface of a lingual tooth by reducing discomfort to the tongue. Meanwhile, the wires are bent to match the shape of the lingual arch to achieve the desired results. The result is a customized appliance with a high degree of precision and reduces discomfort[19]. This technology has also been utilized for labial appliances with the introduction of Insignia by ORMCO (Ormco, Glendora, CA, USA)[20]. SureSmile has provided a digital platform that allows intraoral scanning with fixed appliances in place[21]. The model is then used to make the desired results and the wire is bent at good precision to achieve the desired results. The advantage of this system is that it allows for all brands or types of fixed appliances to be used. In addition CBCT data can be combined to show the position of the roots. Combining face photographs allows smile design to be done in 3D[22].

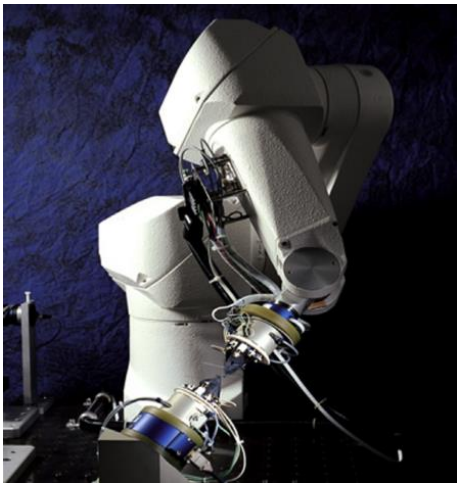

Figure 5: *SureSmile wire bending robot (Orametrix, Richardson TX)[2].*

2.2.2 Remote Monitor

The term “Teledentistry” was used in 1997, when Cook defined it as “the practice of using video-conferencing technologies to diagnose and to provide advice about the treatment over a distance”[23]. Tele-orthodontics is a term used for long-distance orthodontic treatment through information technology media, not directly through personal contact with a dentist. Tele-orthodontics facilitates consultation in orthodontic treatment. With the presence of tele-orthodontics and more specifically remote monitoring by dentists and patients, scheduling visits at the clinic can be done personally by the patient, so the orthodontic treatment process becomes more efficient. This can save patient time and increase comfort[24]. Important applications that facilitate this technology are Dental Monitoring™(DM™) which helps patients accurately record occlusion using a smartphone. Nowadays technology is becoming the main media by using applications in smartphones[25,26]. Scans performed by patients using smartphones are analyzed by DMTM and seen by dentists that can monitor patient care time remotely. This is very useful in areas with limited access to orthodontic treatment. Likewise, patients with a busy schedule can benefit greatly from tele-orthodontics. Other benefits include closer management through remote monitoring, saving time, transportation costs, and increasing patient comfort[27].Tele-orthodontics has an approval and training sheet for patients prior to treatment in order to get a better understanding and cooperation[24]. Dental Monitoring™(DM™) is a software based program that allows practitioners to monitor the development of patient care remotely. It consists of three integrated platforms, namely[24]:

- Mobile application (mobile app) for patients

DM™ application currently available in Android and iOS. This application guides patients through the process of taking pictures with special cheek retractors on the schedule suggested by DM™ and will be seen by a doctor for treatment that is appropriate to the patient's case[24]. The doctor defines the frequency of control to suitably monitor the treatment. The recommended frequency is every 2 weeks for active treatment and every 2 months for contention. At a predetermined interval, the application will automatically remind patients to take a series of ten intraoral photographs: three in occlusion, five with the mouth slightly open, and two occlusal views. In the case of treatment by removable devices, additional views

are to be provided with the device in the mouth. These photographs are automatically sent via the mobile application to the DM computing platform[28].This application makes it easy for patients to review photos of the past, see the progress of patient care, and receive notifications from their dentist[24].

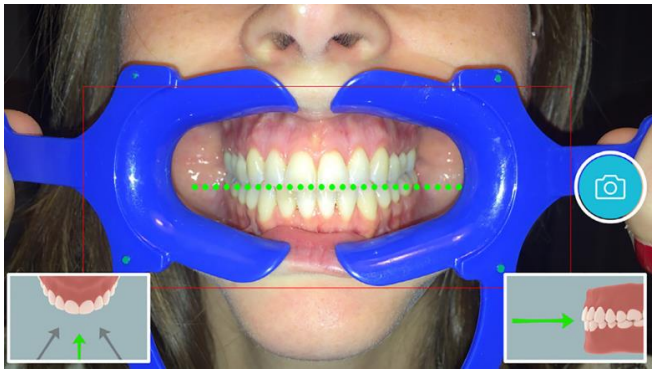

Figure 6 *: Use of the Dental Monitoring, and calibrated cheek retractor mobile app, to take pictures[24]*

- **Patented tracking algorithm**

A 3D model of a patient's teeth is uploaded to the doctor's dashboard. This 3D model serves as an initial reference point for tooth position. When a patient sends an occlusal photo, the image is uploaded to the server and verified to ensure the appropriate quality to be processed by DM^{TM} algorithm. After that, this algorithm can calculate the movement of individual teeth in all spatial planes[24]. The measurement of the movements is thus established very precisely, 0.05 mm on the anterior teeth and 0.07 mm on the posterior teeth[28].

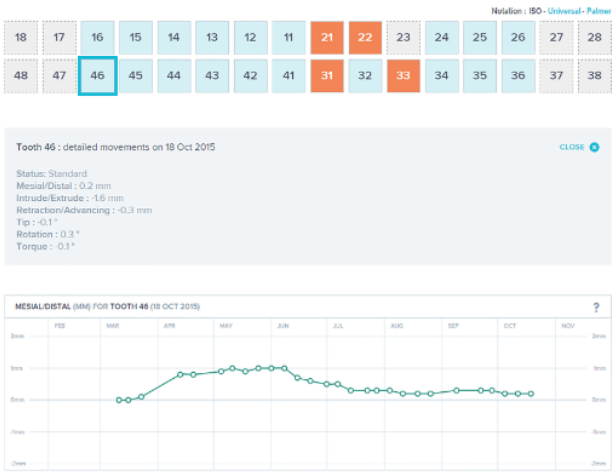

Figure 7: *Visualization of individual gear movements in all fields, with claimed linear accuracy of 0.1 mm, and 0.5 ° tip and torque[24].*

- **Online doctor dashboard**

The doctor dashboard is web-based and requires no additional software. After the analysis by the algorithm is complete, the results are checked by the DM^{TM} doctor and displayed in graphical form, as well as 3D visualization photos of the current gear position[24][28].

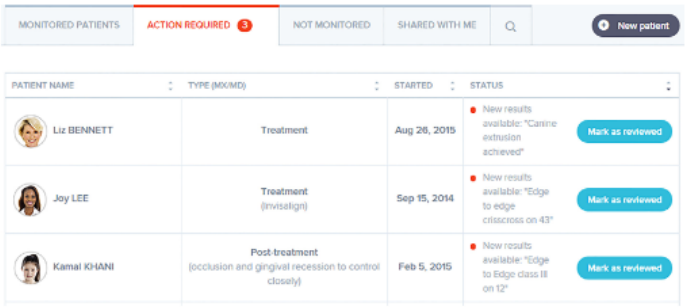

Figure 8 *: Warnings and notifications in the Doctor Dashboard[24].*

2.3 Digital Technology in Orthodontic Education

More and more orthodontists are turning to social media as a forum for discussion and access to knowledge and information. Video lectures and direct communication via the internet are the mainstay education[2]. Orthodontic applications introduced at Apple and Google Play Store can also help patients to remind their appointments, track the progress of their care and a variety other information[4]. There are applications that can be used in orthodontic education for patients such as learn about braces that educate patients about malocclusion and conditions that can cause discomfort and pain and the advantage of using orthodontics. Straighten Me provides information on how to treat emergency orthodontics. iBrace Help is an informative application regarding the use of braces. Invisible Braces Scan app allows patients to take a scan of their teeth to check whether the patient is suitable for the use of invisible braces[5].

3 CONCLUSION

Digital technology in the practice of orthodontics can help orthodontists in examining and enforcing diagnoses in patients, increasing efficiency, accuracy, consistency, and certainty of treatment results. Digital technology can also help patients obtain information, and monitor their treatment through teleorthodontics

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