October University for Modern Sciences and Arts University
MSA Dental Journal

https://msadj.journals.ekb.eg/ PRINT ISSN: 2812 – 4944 VOL. 2, Issue 2, 49-53 April, 2023

Digital Orthodontics: An overview

Kholoud A. Ramadan[1*], Ahmed Kamal[2], Mina Ibrahim[2], Monia Hatem[2], Youmna Roshdy[2], Mona M.Salah Fayed[3]

ARTICLE INFO.

Keywords:

Digital orthodontics, Digitized dentistry ,Digital models , Clear aligners , Digital imaging, digital workflow

Abstract

Orthodontists were the pioneers in adopting a digitized workflow and coping with the rapidly growing digital era worldwide. Digital transformation in the orthodontic field fundamentally alters the way in which orthodontic treatment is perceived, delivered, and helps in creating individualized orthodontic appliances. Fully equipped orthodontic office with intraoral scanners and 3D printers enhances diagnostic procedures and treatment planning abilities through implementing digital photos digital models, digital cephalometric analysis, and virtual setups, ending up with dental monitoring software analyzing tooth movement using artificial intelligence, manufacturing of custom-made brackets, robotically bent wires, 3D printed appliances like 3D printed facemask, which makes the device more comfortable to the child's face with sensors allows orthodontist to measure compliance, clear aligners, indirect bonding trays, and retainers. In a short while, orthodontic specialists will only be required to be clinically involved in management of complicated malocclusions and more work will be performed in front of computers, tablets, and mobile devices.

* **Corresponding author**.
E-mail address: Khaziz@msa.edu.eg

1 Teaching assistant, orthodontic Department, Faculty of Dentistry, October University for Modern Sciences and Arts
2 Student at Faculty of Dentistry, October University for Modern Sciences and Arts
3 -Professor, orthodontic Department, Faculty of Dentistry, Cairo university
-Vice dean, Postgraduate studies and Research, at Faculty of Dentistry, October University for Modern Sciences and Arts

Introduction

In the last 3 decades, digital dentistry has become a term frequently used and rings a bell among dental field practitioners. Digital dentistry is defined as the use of any dental-related technology or device that has built-in digital or computer-controlled elements rather than being operated electrically and/or mechanically alone. In dentistry, digital technology relying on computer-based algorithms is indispensable, offering improved accuracy when compared to traditional methods and a high level of predictability. Historically, digitalized approaches were limited to imaging, practice/patient management systems, and CAD/CAM systems (computer-aided design/computer-aided manufacturing), introduced in the 1970s by the "godfather" of digital dentistry, the French Professor Francois Duret. Recently, digitized work flows have been implemented in a vast array of disciplines [1].

Orthodontists have been early adopters of digital technology, (figure1) summarizes the various technological applications in contemporary orthodontics [2].

Primarily, digital technology was used foremost to improve diagnosis accuracy; as a result, work- flow became more streamlined.

The next wave of technological advances will focus on improving treatment results and shortening chair-side time as well as treatment time [2]. In orthodontic office digital work flow is crucial to deliver efficient orthodontic therapy starting from personal data collecting, practice management, collecting diagnostic records through photos ,2d radiographs eg. orthopantograms and cephalometrics. In more sophisticated cases like canine impaction CBCT (Cone Beam Computed Tomography) is recommended. Finally, 3D digital model is integrated into treatment planning, and orthodontic appliances fabrication which entails aligners, indirect bonding trays based on 3 printing concept [3].

This article reviews the most commonly used applications of digital orthodontics, especially in diagnosis and treatment.

A. Applications of digital orthodontics in diagnosis:

I. Digital photos

Basically, orthodontic patients have 2D extraoral and intraoral photos of good quality, precision, and correct posture. As a baseline reference for facial structure and soft tissue, 2D photos are simple and intuitive, but they lack enough diagnostic information and are affected by several aspects, including the distance and angle at which the photo is taken. Recently, facial scanners have provided a standardized 3D topography of a patient's facial surface anatomy, which, when combined with a digital model and CBCT image, will give a complete 3D virtual patient. [4]

Currently, the digital paradigm has changed how we do cephalometric analysis.

Four ways can be recognized for the interpretation of cephalometric x-rays [7]:

1. Traditionally, it was done manually. Using an acetate over the cephalometric radiograph to trace patient 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.

More fascinating is the implementation of artificial intelligence to enable the automation of landmark identification. Reasons behind these developments emerge from the numerous benefits achieved through digitization and automation ranging from easy manipulation of x-rays anytime and anywhere through laptops or even mobile phones, fast acquisition of results, less needed resources, and increased accuracy.

III. Digital models

They have typically been made of stone or plaster. 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

A *Apps*	*I* *Imaging*	*R* *Rapid prototyping*
A number of apps on the Android and iOS platforms for management, diagnostics, communication and professional interactions	*CBCTs *Facial 3D WL scans *3D photography *Intra oral scanning *E models	Various applications in orthodontics *Aligner fabrications *Surgical splints *Bruxism splints *Auto transplantation templates
Appliances/adjuncts *CAD CAM customized appliances *Aligners *Robotic arch−wires *Customized adjuncts	*Volumetric data sets and integrated wraps* *Professional Companies/software that integrate data and provide 3D volumetric data sets are a great potential for research and planning in orthognathics.	*Customized appliances *Indirect bonding trays *Diagnostics for impacted teeth *3 D printed jaws (orthognathics) *Cranofacial/cleft planning

Fig 1: Broad overview of technological applications in Orthodontics cited from "APOSTrends in Orthodontics". Vaid NR. Up in the Air: Orthodontic technology unplugged [2]

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.

These can be obtained directly by intraoral scan [8] or indirectly by scanning an impression or plaster model. Software enables free toggling in all planes of space and even opened to allow upper and lower models to be viewed and manipulated separately [9].

Fig 2: 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.

One of the commonest scanners is the iTero Element 5D by Align Technology that provides Invisalign result simulator feature which gives full scan of the mouth in 1 min and the patient can see an example of a possible result after orthodontic treatment [1].

B. Applications of digital orthodontics in treatment:

I. Indirect bonding

One of the imperative phases of orthodontic treatment is the finishing and detailing phase, which involve a series of steps that essentially begins with ideal bracket positioning.50 years ago Lawrence F. Andrew advocated six keys of normal occlusion [10] and based his straight wire appliance (SWA) to achieve minimal wire bending never the less controlling tooth movement and alignment in three spatial planes through ideal bracket positioning. ideal bracket positioning is the ultimate treatment outcome providing shortest treatment time together with minimal bracket repositioning, eliminating wire bending as well and definitely reducing relapse chances. Brackets can be positioned clinically either directly with an instrument or indirectly with a transfer tray. Indirect bonding (IDB) was first proposed in 1972 Silverman and Cohen [11] described the indirect bonding technique for the first time and identified Few years later the claimed advantages of indirect bonding were questioned in a roundtable discussion. Gorelick and co-workers [12] responded rationally that having the teeth in your hand looking freely from any direction would facilitate ideal bracket positioning. Several publications were conducted to evaluate (IDB) accuracy, chair time and bond failure. Previous studies of Aguirre [13], Koo et al [14] were consistent with Sabbagh [15], findings in systematic review that indirect bonding as a technique allowed achieving planned bracket positions with high overall accuracy. However these conclusion were inconsistent with Hodge etal [16], that stated that there were no significant difference between mean bracket placement errors of both techniques . Conversely in, a systematic review by Li and his colleagues [17] presented weak evidence that the direct and indirect bonding techniques had no significant difference in bracket placement accuracy. Upon studying bond strength, according to several studies, indirect bonding had a similar or lower bond failure rate than conventional direct bonding [18,19].Also, claims of reduced chair time [13,20] were inspected, to truly conclude that chair time is reduced, but on the expense of extra laboratory working time with additional equipment. This overly complex chairside and laboratory phase contributed to minimal percentage of orthodontists that employ indirect bonding as part of their daily practice, with prevalence of only 18% among clinicians. Other advantages included less physical stress and improved productivity of orthodontist as all bracket placement decisions have been previously made in the laboratory [14].

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 [11] as OrthoAnalyzer [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 [14]. As reported by various studies computer aided indirect bonding has less total treatment time [1,15,21] assuming higher bracket positioning accuracy [22] and less chair time [23] contradicting some studies that stated no significant difference interims of accuracy [24,25].Despite the latter studies, the accuracy of computer aided indirect bonding remains questionable.

i 3Shape, Copenhagen, Denmark
ii Cadent, Inc., Carlstadt, NJ
iii Orametrix, Inc., Richardson TX

II. Aligners

By the late 1990s, clear aligner therapy was introduced by Align Technology as Invisalign and led the way in using a virtual model, creating a virtual treatment plan, virtual setups, and manufacturing appliances3 with the help of software developers. Currently, many companies, like clear correct, 3M™ (3M ESPE) and Clarity™ (Straumann) Aligners, and many others are offering the same service. The digital workflow enabled clinicians to design and create their own in-house aligners. A low to moderate level of evidence exists regarding the efficiency of clear aligner therapy for certain tooth movements, especially rotational and extrusive movements. Overall orthodontic outcomes are acceptable according to Robertson et al. systematic review [26], which is inconsistent with the systematic review Papageorgiou et al [27] that reported that current evidence does not support the clinical use of aligners as an orthodontic approach that is as effective as the gold standard of conventional orthodontic treatment. On-going studies are working on adding attachments with the help of software predictability to control tooth movement in three spatial planes; hopefully in few years, well-conducted trials will provide a robust conclusion. 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). The treatment time required to achieve similar results (compared to fixed appliances) has not been investigated yet.

Fig 3: Clear aligner. Cited from: Applications C, Jain P, Gupta M. Digitization in Dentistry.; 2021

III. Retainers

Relapse has been one of the most distressing processes for orthodontists for decades. there is significant variation regarding the protocol regimen followed worldwide, although both fixed and removable regimens are in vogue globally no robust evidence about which is the best retainer [28]. However, removable clear retainers seems to the most commonly used and advocated by most orthodontist [29]. Commonly clear retainer is vacuum formed/thermoformed on plaster model and have acceptable level of accuracy and mechanical properties. Latest evidence proved that 3D printing with integration of digital models enhanced accuracy [30] and mechanical properties obtained from 3D printed removable retainers and also 3D printed fixed retainers [31].

Conclusions

Conventional techniques in dentistry have worked successfully for decades and are still being used effectively. However, 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.

In this context, 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.

References

1. Applications C, Jain P, Gupta M.: Digitization in Dentistry. Digitization in Dentistry. 2021.
2. Vaid NR.: Digital technologies in orthodontics À An update. Semin Orthod [Internet]. 2022;24(4):373–5. Available from: https://doi.org/10.1053/j.sodo.2018.10.001
3. Tarraf NE, Ali DM.: Present and the future of digital orthodontics☆. Semin Orthod [Internet]. 2018;24(4):376–85. Available from: https://doi.org/10.1053/j.sodo.2018.10.002
4. Almulla S, Premjani P, Vaid NR, Fadia DF, Ferguson DJ.: Evaluating the accuracy of facial models obtained from volume wrapping: 2D images on CBCT versus 3D on CBCT. Semin Orthod [Internet]. 2018;24(4):443–50. Available from: https://doi.org/10.1053/j.sodo.2018.10.008
5. Broadbent.: A NEW X-RAY TECHNIQUE and ITS APPLICATION TO ORTHODONTIA. Angle Orthod. 1931;1(2).
6. Subramanian AK, Chen Y, Almalki A, Sivamurthy G, Kafle D.: Cephalometric Analysis in Orthodontics Using Artificial Intelligence - A Comprehensive Review. Biomed Res Int. 2022;2022.
7. Leonardi R, Giordano D, Maiorana F, Spampinato C.: Automatic cephalometric analysis: A systematic review. Angle Orthod. 2008;78(1):145–51.
8. Kravitz ND.: Intraoral digital scanners. 2020;(June).
9. El-Beialy AR.: Planning Digital Indirect Bonding with Root Awareness. Biomed J Sci Tech Res. 2018;5(2):4451–5.
10. Andrews F, Diego S.: The six keys to n , ormal occlusion. 1964;
11. Silverman E, Cohen M, Gianelly AA, Dietz VS.: A universal direct bonding system for both metal and plastic brackets. Am J Orthod. 1972;62(3):236–44.
12. Albertini P, Mele L, Palone M, Cremonini F.: Direct and indirect bonding techniques: A systematic review. Pesqui Bras Odontopediatria Clin Integr. 2021;21:1–10.

13. Aguirre MJ, King GJ, Sc DM.: Assessment of bracket placement and bond strength when comparing direct bonding to indirect bonding techniques. 1982;82(4).
14. Koo BC, Chung C-H, Robert L. Vanarsdall.: Comparison of the accuracy of bracket placement between direct and indirect bonding techniques. :346–51.
15. Sabbagh H, Khazaei Y, Baumert U, Hoffmann L, Wichelhaus A, Rankovic MJ.: Bracket Transfer Accuracy with the Indirect Bonding Technique—A Systematic Review and Meta-Analysis. J Clin Med. 2022;11(9).
16. Hodge TM, Dhopatkar AA, Rock WP.: A randomized clinical trial comparing the accuracy of direct versus indirect bracket placement. 2004;31:132–7.
17. Li Y, Mei L, Wei J, Yan X, Zhang X, Zheng W, et al.: Effectiveness, efficiency and adverse effects of using direct or indirect bonding technique in orthodontic patients: a systematic review and meta-analysis. BMC Oral Health. 2019;19(1).
18. Lagravère MO, Major PW, Flores-Mir C.: Skeletal and dental changes with fixed slow maxillary expansion treatment: A systematic review. Vol. 136, Journal of the American Dental Association. 2005. p. 194–9.
19. Kalange JT, Thomas RG.: Indirect Bonding: A Comprehensive Review of the Literature. Semin Orthod. 2007;13(1):3–10.
20. Owens AM, Johal A.: Near-end of treatment panoramic radiograph in the assessment of mesiodistal root angulation. Angle Orthod. 2008;78(3):475–81.
21. Alford TJ, Roberts WE, Hartsfield JK, Eckert GJ, Snyder RJ.: Clinical outcomes for patients finished with the SureSmile 2 method compared with conventional fixed orthodontic therapy. 2011;81(3).
22. Oliveira I, Bruno C, Gribel F, Helena A, Alencar G De, Estrela C.: Evaluation of crown inclination and angulation after orthodontic treatment using digital models Comparison to the prescription of the brackets used. 2018;
23. Czolgosz I, Cattaneo PM, Cornelis MA.: Computer-aided indirect bonding versus traditional direct bonding of orthodontic brackets: Bonding time, immediate bonding failures, and cost-minimization. A randomized controlled trial. Eur J Orthod. 2021;43(2):144–51.
24. Kim J, Chun Y, Kim M.: Accuracy of bracket positions with a CAD/CAM indirect bonding system in posterior teeth with different cusp heights. Am J Orthod Dentofac Orthop [Internet]. 153(2):298–307. Available from: https://doi.org/10.1016/j.ajodo.2017.06.017
25. Israel M, Kusnoto B, Evans CA, Begole E.: A comparison of traditional and computer-aided bracket placement methods.
26. Robertson L, Kaur H, Fagundes NCF, Romanyk D, Major P, Flores Mir C.: Effectiveness of clear aligner therapy for orthodontic treatment: A systematic review. Orthod Craniofacial Res. 2020;23(2):133–42.
27. Papageorgiou SN, Koletsi D, Iliadi A, Peltomaki T, Eliades T.: Systematic review Treatment outcome with orthodontic aligners and fixed appliances : a systematic review with meta-analyses. 2020;(November 2019):331–43.
28. Littlewood S, Millett D, Doubleday B, Worthington H.: Retention procedures for stabilising tooth position after treatment with orthodontic braces - Cochrane Database of Systematic Reviews - Littlewood - Wiley Online Library. Cochrane Database Syst Rev. 2016;(CD002283.pub4.):1–135.
29. Al-Moghrabi D, Salazar FC, Pandis N, Fleming PS.: Compliance with removable orthodontic appliances and adjuncts: A systematic review and meta-analysis. Am J Orthod Dentofac Orthop [Internet]. 2017;152(1):17–32. Available from: http://dx.doi.org/10.1016/j.ajodo.2017.03.019
30. Nasef AA, El-Beialy AR, Eid FHK, Mostafa YA.: Accuracy of Orthodontic 3D Printed Retainers versus Thermoformed Retainers. Open J Med Imaging. 2017;07(04):169–79.
31. Firlej M, Zaborowicz K, Zaborowicz M, Firlej E, Domagała I, Pieniak D, et al.: Mechanical Properties of 3D Printed Orthodontic Retainers. Int J Environ Res Public Health. 2022;19(9).