Review Article

An Overview on the Veracity of Intraoral Digital Scanning System and Utilization of iTero Scanner for Analyzing Orthodontic Study Models Both *In-Vivo* and *Ex-Vivo*

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Abstract

In the domain of orthodontics, plaster models are contemplated as one of the important tools for diagnosis and treatment planning. In Dentistry, technological advancement has developed in the section of diagnostic devices, for example, the utilization of a 3D intraoral scanner, which can convert plaster models into digital models. With in-office utilization of this system, orthodontists can more meticulously and precisely construct custom braces, clear aligners, and orthodontic appliances. The digital data can be stored as a stereolithography file; it eliminates the disadvantages encountered with the storage of plaster models like breakage, space required, and distortion of the plaster models. ITero®element is the intraoral laser scanner (ILS) which utilizes parallel confocal scanning technology which maximizes the accuracy of the scan. By utilizing the iTero scanner, the dental measurement can be performed in OrthoCAD™ software which is highly accurate. The objective of the contemporary study is to review the literature of studies on *in-vivo* and *ex-vivo* scanning with the iTero system.

Keywords: *Braces, dental care, intraoral digital scanning, orthodontic appliance, orthodontics, stereolithography*

Introduction

Extensive diagnosis and treatment planning are the key factors to achieve favorable orthodontic treatment results. Tooth width, arch form, and its measurements, tooth-size discrepancies, and also spacing situation are some of the prime components to determine the diagnosis.[1] Although the analysis of the model is a time-consuming method, it plays an integral role in the process of diagnosis and treatment planning system of an orthodontic patient.[2,3] Since many years plaster study cast is considered as the "gold standard" in diagnosis and treatment planning, the model analysis is usually performed with the assistance of needle-pointed dividers or Vernier caliper.[4] Alternately analysis of photos, photocopies, and holograms on the cast had been proposed but all these techniques exhibited inaccuracies.[5-11] Plaster models have certain disadvantages like when measured frequently they tend to tear and physical and chemical damage can take place in due time as well. Long-term storage of plaster casts is required for medico-legal purposes which in turn leads to the inconvenience in terms of cost and space.[12,13] Therefore, to determine all these complications, digital models were imported in the 1990s. The earliest company to propose digital models was OrthoCAD™ in 2001. This helped orthodontists to overcome many limitations associated with plaster casts, eliminate alginate impressions, and accumulate casts electronically.[14] The in-office iTero digital impression scanning system was updated by Cadent in 2006, and it was efficient in scanning full-arch intraorally by 2008. For diagnostic purposes, digital models were being utilized by 2014 among 21% of the Northeast orthodontic systems and 55% of the Pacific orthodontic systems.[15]

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Search strategy

To evaluate and design relevant data related to intraoral digital scanning and iTero scanning system, an electronic bibliography search was conducted by applying the MEDLINE database. Publications until February 2020 were included. The terms that were included in the search were "Intra-oral digital scanning" combined with "intra-oral laser scanners," "Accuracy," "Reliability," "Digital models," "Orthodontics," "Extra-oral digital scanning," and "iTero scanner." Five hundred thirty-three articles were retrieved from bibliography search and among them, 93 full-text articles were reviewed.

Intraoral digital scanning

The requirement for conventional impression taking technique can be eradicated with the utilization of chair-side oral scanners as it grants the direct procurement of clinical condition in the mouth.[16,17] As the digital scanners are designed and constructed in consonance with specifications of ANSI/IEC 60601-1, they are deliberated as Class I medical electrical devices.[18] There are three primary components for every intraoral digital scanner that is to support the entry of the data, a wireless mobile workstation for the approval of scans, to enter prescription and to review the digital files, a computer monitor, and lastly in order to collect the scanned documents in the patient's mouth, a camera wand with a handle. In contemporary clinical practice, four types of imaging techniques are utilized: Triangulation utilized in CEREC,[19] Parallel confocal, Accordion fringe interferometry (AFI), and Three-dimensional in-motion video. The utilization of digital models for orthodontic treatment planning has risen from 6.6% to 8.8% according to the postal survey conducted in the USA from 2002 to 2008.[15] Digital scanners can be utilized for various functions like clear aligner mechanics, design and construction of customized palatal and lingual appliances, wafer construction and orthognathic surgery simulation, fabrication of tray in indirect bonding, treatment planning, and more currently for surgical results score among patients with cleft palate and cleft lip abnormalities.[20-24] Scanner and its application type should be considered for efficient use. There is minimal data available regarding the intraoral scanner's degree of accuracy required for treatment planning in the orthodontic patient. According to one study, to assess cleft palate and cleft lip patient's arch form, the minimum degree required for a 3D model scanner is 20 μm.[25] Most of the research studies in orthodontics focused on the accuracy of digital models over plaster models and the results suggested proportionate accuracy.[26] But in the domain of restorative dentistry, there are investigations done extensively on accuracy and the results suggested that point and stitch reconstruction mechanics are less accurate than video capture mechanics.[27-29]

Storage of digital data

The electronic techniques can be utilized for the storage of digital study models, transportation, and retrieval; as a result, it helps in overcoming the requirement of large storage areas, damage to study models, and transportation problems. This increases the competence of various practices and decreases the cost of transportation.[30] Storage of digital data can be accomplished on compact storage gears, computer or scanning unit's hard disk, local fundamental aid, or "cloud" slots. According to Oxford English Dictionary, 2014 the cloud storage is defined as *the use of networked facilities for the storage and processing of data rather than a user's local computer, access to data or services typically being via the Internet*. Digital model storage must reconcile to the Data Protection Act (1998) as it is a segment of the patient's classified medical record. Various security measures should be designed for storage and transportation of digital models; however, the retention time for storage of digital and plaster models is analogous. The size of the digital file may range from lesser than 1–25 MB and it fluctuates corresponding to the scanner's resolution and dental arch dimensions. In addition, the digital spaces required by a software program to view and boost the functionality of digital models may range from 8–12 MB.[14] To view the digital models for free, practitioners can use free software applications like Meshlab (http://www.meshlab.sourceforge.net).

Advantages of intraoral digital scanning

There are many advantages with the use of digital intraoral scanners but one of the prime advantages is the elimination of drawbacks identified with traditional impression-taking which is known to be technique sensitive.[31] Various issues had been reported with the use of PVS and alginate impressions such as improper tooth-to-tray union, segregation of the material from impression tray, bubbles formation, tearing of the material, pull, voids formation, temperature susceptibility, confined working time, shrinkage of material, improper pouring, over trimming of the study model, and damage during transportation.[32] Intraoral impression-taking increases the anxiety and inconvenience for the patients of all age groups and specifically to the patients who have higher gag reflexes. According to some studies, digital impressions do not have all these drawbacks and are as accurate as tradition impression-taking method.[33] Current studies had revealed digital scanning is more satisfactory to

the patients than traditional impression-taking because of its approach and convenience.[34] Various elements of impression materials are believed to cause minimal allergies in very few patients but this can be eliminated with the use of digital scanning.[35] Utilization of digital scanning is also advantageous to orthodontics in various aspects like decreased treatment time, enhanced diagnosis and treatment planning, user-friendly, refined appliance efficiency, rapid data compliance to the laboratories, and improved system. Intraoral laser scanners (ILS) can be utilized to scan both white and yellow dental casts. Few studies noted that lesser scanning time was required to scan the yellow dental casts compared to Orthodontic type III white casts.[36] One of the important advantages of intraoral digital scanning is that it prevents the cross-infection which can occur during intraoral impression taking and extraoral manufacturing process with the use of conventional alginate impression material.[37]

Review of literature on the accuracy of digital scanning

If the substance is precise and accurate, it can be considered to produce desirable results. In order to be utilized in the contemporary orthodontic system, intra oral scanners are satisfactory in clinical practice for treatment planning And diagnosis according to the results of various investigations[39-42] The comparison of accuracy must be carried out with the present standards of alginate impressions and digital model, in order to utilize this new technology in contemporary practice.[42,43] According to one study, full-arch digital dental models obtained from intraoral scans were relatively accurate because they had limited bias.[38] Various studies also agree with the greater accuracy and limited bias of intraoral digital scanning but most of them have been restricted to particular components in the field of dentistry.[44-46] Studies about intraoral scans in the field of restorative dentistry confirmed that these digital scans can be utilized for restorative purposes and are sufficiently accurate when compared to the associating models. Likewise, few investigations focused on the accuracy of full-arch intraoral oral digital scans and concluded that it can be utilized for treatment planning, diagnosis, and construction of removable orthodontic appliances.[47-50] A study carried out by Seelbach *et al*. concluded that the fabrication of fixed prosthodontic restoration can be accomplished with intraoral scanners as executed by utilizing two-step putty and wash technique.[51] Many investigations reported that because of its accuracy, digital models obtained from digital scanning can reinstate conventional plaster models. Various techniques of digital model recovery were tested such as alginate impression scanning, polyvinylsiloxane (PVS) impression scanning, plaster model scanning, and intraoral scanning.[48,52-57] In a clinical investigation, the results concluded that the biases ranged from −0.05 mm to 0.21 mm for respective tooth position, whereas it ranged from −0.10 mm to 0.17 mm arch width, and − 0.017 mm to −0.025 mm for arch length.[38] However, the agreeable value standardized by the American Board Of Orthodontics objective grading system in the sections of "marginal ridges" and "alignment" is 0.5 mm.[58] According to a study, it was noted when scanning of orthodontic models was performed with different types of brackets applied like ceramic, metal, and resin brackets and orthodontic models with no brackets, the higher discrepancy values were found with models that had metal and resin brackets.[59] When scanning the prepared teeth with a different type of intraoral and extraoral scanners, the results were found to be similar for prepared teeth with both methods but on the occlusal and cervical region of prepared tooth, higher discrepancies were anticipated.[60] One study reported that without acquiring serial impressions or taking radiographs, the serial orthodontic movement of teeth can be evaluated during the treatment process by utilizing an intraoral scanner.[61]

iTero scanner and its use in the orthodontic domain

Cadent's iTero (Align Technologies, San Jose, Calif) is the only intraoral digital scanner that utilizes the parallel-confocal imaging technology and point-and-stitch reconstruction to generate digital impressions which are accurate and powder free. Hence, it is considered as the pacemaker of intraoral digital scanning mechanics. Confocal imaging technology is established on a ray of light that moves by a pinhole and later flash off its destination object.[18] The iTero unit comprises a liquid crystal display monitor, a handheld scanning wand, and a sealed and built-in keyboard which is antiseptic. The unit can be moved with the help of a mobile cart which is very advantageous for both the patient and practitioner and the data synchronize with the cloud system by the wireless router. The basic images will be accessible for chairside observation in 2 min of intraoral scanning and then it is sent to Align technology via Internet, where they are converted and accessible for downloading at doctor's site as stereolithography (STL) file within 48 h. Initially in orthodontic practice, these mechanics were utilized to construct digital models and later to generate a fundamental structure for indirect bonding. The iTero intraoral laser scanner and Invisalign (Align Technology, Inc., San Jose, CA; www.invisalign.com.) program were unified in the year 2011 January. In some practices, the use of conventional PVS impressions has been replaced by intraoral scanning and is also used for orthognathic

cases, for the production of surgical splints by utilizing digital STL files.[62,63] Various studies had confirmed that intraoral digital scanning can be utilized in diagnosis and treatment planning.[39,41] Intermolar width and intercanine width can be measured with the buccal and lingual brackets attached intraorally and according to one study carried out on study models, iTero scanner was more precise in this particular measurement when compared to other intraoral scanners.[64] Crowding measurements and linear measurements such as mesiodistal width, buccolingual height, and vertical height of the teeth can also be measured with iTero scanner.[65] By utilizing digital intraoral scanning, diagnosis and treatment planning can be done and digital models are known to be an accurate device for constructing elementary diagnostic measurements like overbite, overjet, arch width, arch length, tooth size, and Bolton's ratio.[66-68] According to a study, peer assessment rating (PAR) score can be measured by utilizing digital models and this computerized-based method is accurate and predictable.[69] The units of PAR index contain midline, overjet, overbite, left and right buccal occlusion, and mandibular and maxillary anterior sections. In an investigation, the iTero scanner was utilized for the *in vitro* tests performed on dry mandibles and according to the results, it was highly precise and reliable.[65] Few studies concluded that linear dental measurements performed on digital models are accurate and reliable as the conventional method and are noted in Table 1.[38,47,70] According to a study, the scanning time for a single capture scanner was relatively slower than the continuous capture scanner with trueness and precision showing significant difference.[71]

Reliability of iTero scanner for extraoral scanning

As the name suggests, intraoral scanners can be utilized for intraoral scanning but various studies also suggested that iTero scanner can be utilized for extraoral scanning of orthodontic plaster or stone casts; hence, practitioners can store the digital data and save the time and space. According to one investigation, the accuracy of extraoral scanning with iTero was more when compared to intraoral scanning, i.e., 25 μm and 50 μm respectively, regardless of indistinguishable scanning order.[48] The factors believed to alter the accuracy of intraoral scanning may be a flow of saliva, humidity in the intraoral atmosphere, concise available space to perform the scan, and movement of the patient. In this particular study, there were relatively higher alterations in intraoral digital models related to molar space indicating that the patient associated circumstance had an active effect on the quality of scans. The higher precision of extraoral scans with iTero scanner may also attribute to the better ability to place the scanning wand adjacent to the orthodontic study cast. Various *in-vitro* investigations have shown that requirements for clinical utilization of extraoral and intraoral scanning mechanisms are met. One of the previous studies had confirmed that iTero scanner can

Figure 1: Intraoral scanning with iTero scanner

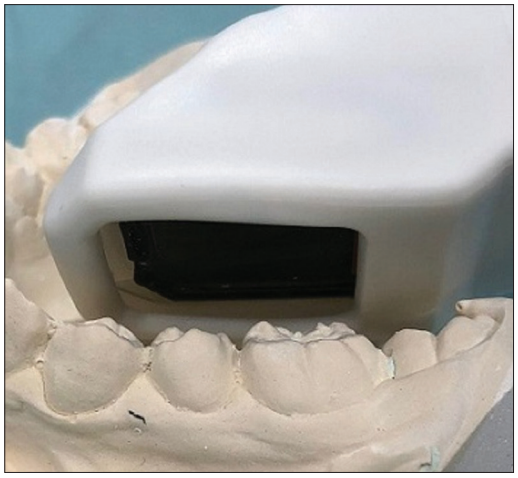

Figure 2: Extraoral scanning with iTero scanner

Table 1: List of the studies on the accuracy of digital scanning

Study	Year	Results	Conclusion
Grünheid *et al*.[40]	2014	Orthodontic study models obtained from alginate impressions and intraoral scanner did not vary significantly.	Digital models are as precise as conventional plaster models.
Naidu and Freer[49]	2013	The discrepancies were clinically insignificant and intraclass correlation coefficient (ICC) value surpassed 87%.	The digital system is accurate and reliable to measure tooth widths.
Jacob *et al*.[70]	2015	The intraclass correlation coefficient (ICC) values ranged between 0.926 and 0.999.	Measurements created from digital models were highly reliable.

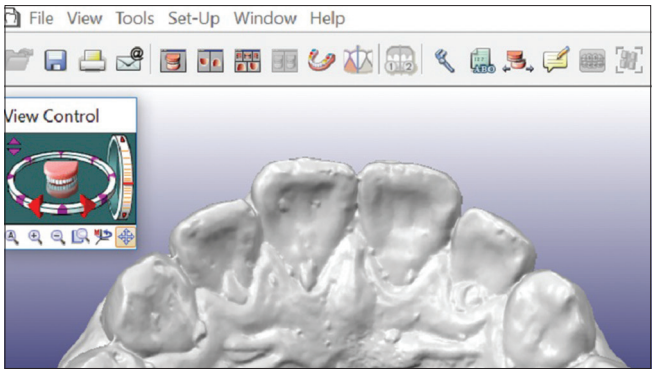

Figure 3: Digital models constructed in OrthoCAD™ software

be utilized both *in-vivo* (intraoral scanning) [Figure 1] and *ex-vivo* (extraoral scanning) [Figure 2] to construct essential models for diagnosis and designing the treatment plan in the orthodontic domain.[48] One study confirms that the iTero scanner can be utilized for extraoral scanning of orthodontic models because the results obtained were more accurate and reliable when compared to other intraoral scanners.[72] In another study conducted on dental casts, iTero scanner was highly accurate and reliable in *ex-vivo* scanning of both the buccal and lingual brackets on the dental casts and also linear measurements were precise.[61] According to various studies, measurements performed on digital models in OrthoCAD™ software [Figure 3] obtained from iTero scanner are as reliable as traditional plaster casts obtained from alginate impressions.[73-76]

Summary

Orthodontists will contemplate utilizing intraoral scanning method only if it determines to be precise, adequate, and favorable for the practitioner and patient. The contemporary review states that the digital ILS, iTero has higher accuracy and reliability for both intraoral and extraoral scanning also in performing linear measurements on the digital dental models. For the construction of orthodontic appliances, fundamental models generated with iTero can be utilized as it has shown higher precision in its mechanical features when used for extraoral scanning.

Ethics approval and consent to participate

Not applicable.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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