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Evaluation of the Marginal Fit of CAD-CAM Provisional Restorations Constructed After Using Two Intra Oral Scanners: A Narrative Review

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ABSTRACT

The purpose of this narrative review was to assess the internal fit of provisional restorations by evaluating the accuracy of two representative IOSs for single crowns and 3-unit FPD preparations. Relevant articles were gathered from a variety of sources, including manual cross-reference searches and textbooks, as well as electronic databases like PubMed, Scopus, Embase, the Cochrane library, and Science Direct. MeSH terms and keywords pertaining to "*marginal fit*," "*primescan*," "*omnicam*," and "*intraoral scanner*" were used in the search. The inclusion criteria were English language articles that fit the study's objectives and that were published between June 2022 and July 2007. Articles with low sample sizes and/or insufficient reporting and obscure methodology were excluded from selection. Following a comprehensive evaluation of all the included papers, 40 excellent articles were chosen for this review. The chosen articles explain the features of an intraoral scanner and help answer our stated questions about the most accurate method and appliances to use for scanning to best serve the prosthodontist.

KEYWORDS: Internal fit, Primescan , Omnicam, Intraoral scanner.

1. INTRODUCTION

Recent years have seen a rise in the use of digital technology in dentistry, with various CAD-CAM (computer-aided design and manufacture) systems being utilized to fabricate prostheses. A workflow that begins with either direct or indirect digitalization can be followed with CAD-CAM technologies [1]. When it comes to the fabrication of crowns and fixed partial dentures (FPDs), digital scanning techniques using intraoral scanners (IOSs) have been found to produce clinically acceptable results when in contrast to conventional impression techniques. These techniques also save time, reduce the possibility of error resulting from the distortion of elastic impression materials, and increase patient acceptance [2]. Trueness and precision are two characteristics of accuracy. While accuracy is the variability of repeated measurements of a fact, trueness is the similarity between the test object and the reference object. A successful prosthesis in a fully digital procedure depends on an accurate digital scan [3]. The ambient light, the IOS head size, the scanning technology, the scanning protocol, the scanner software, the limited spacing, and the length of the edentulous span all affect how accurate a digital scan will be. A reflective powder may also be necessary. Reports have surfaced of variations in digital scan accuracy based on the scanners utilized [4]. Multiple techniques have been used for measuring the marginal gap, such as the direct-view technique, Scanning Electron

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Microscopy (SEM), Cross sectioning method, Replica Technique, 3-D marginal fit analysis, as well as tomography (Micro CT) [5].

2. METHODOLOGY

A search was conducted in April 2022 across various electronic databases, including PubMed, SCOPUS, Google Scholar, and Science Direct. The search utilized MeSH terms/keywords such as "*Internal fit*", "*Primescan*", "*omnicam*", "*intraoral scanner*". In addition to the electronic searches, cross-references and textbooks were manually searched for relevant articles. Articles published in English between the years 2007 and April 2022 that fulfilled the study's objectives were included. The article selection process involved assessing the criteria for inclusion and exclusion and conducting a quality assessment. After evaluating the full texts and applying the inclusion and exclusion criteria, 40 articles that meet the study's criteria were chosen for the review.

3. OVERVIEW OF INTRAORAL DIGITAL SCANNING SYSTEMS

3.1. CAD/CAM in Dentistry

During the last quarter of the 20th century, there was a breakthrough in dentistry regarding introducing a new technology called Computer-Aided Designing - Computer Aided Manufacturing (CAD/CAM), which has grown in popularity during the previous 25 years as a component of dentistry [6]. The data acquisition device directly creates virtual impressions by intraoral means after gathering data from the preparation area, neighboring structures, and opposing structures. The program that computes milling techniques following the creation of virtual repairs on a virtual working cast. Intraoral scanners (IOS) and digitally captured dental images are produced using additive manufacturing or a computerized milling machine that creates the restoration from a solid block of restorative material. Dental prostheses can be created using these scanners either directly or indirectly; an imprint can either be instantly scanned in a dental laboratory without the need to create a cast, or it can be traditionally poured into a die stone in an indirect digitalization approach [7].

3.2. Conventional Impressions and Digital Impression

Intraoral scanners can create digital photographs of a patient's teeth using digital imprints. Because of this, making conventional impressions is no longer necessary, which calms patients and makes them feel more at ease. This process can also minimize the amount of time needed to select a tray, make an impression, pour the cast, clean the cast, and transport it to the lab. It also reduces the amount of time spent on the lab worktable. Furthermore, research done in the clinical context has demonstrated that using digital impressions rather than traditional impressions improves the accuracy of the fit of indirect restorations [8].

The advancement of intraoral scanning equipment and CAD/CAM technologies in dentistry has several advantages. Intraoral scanners were developed to overcome the drawbacks of the traditional impression. The 3-dimensional (3D) scanners have been utilized for digital impressions in dentistry for over 20 years, and they are constantly changing [9]. The advantages of digital impressions include greater patient comfort and ease of use. Using the digital impression eliminates the possibility of mistakes like creating air bubbles during the impression-taking process, repositioning the tray, deflecting the tray during insertion, using

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insufficient impression material or adhesive, or distorting the imprints during cleaning. By using a digital impression, the chance of contamination is reduced, and there is no need to clean the impression. Additionally, digital scans can be permanently preserved on hard drives, whereas conventional models require more office space for upkeep and carry a risk of breaking or chipping when handled roughly. For dental lab personnel, the biggest benefit is that digital technology can replace investment materials and several lab activities, like pouring cast and base [10]. Furthermore, precise preparations are necessary for both procedures. Digital impressions do not allow for approximations in crucial regions like traditional impressions do—particularly when it comes to gingival sulcus preparation. The registration of subgingival preparations and the gingival sulcus may impair the restoration's marginal adaptation, which could result in therapeutic failure. The scanner records exactly what the doctor sees; visibility is required to replicate the gingival limit and can be improved by using a rubber dam or retraction wires to improve isolation. Furthermore, data-capturing technologies differ greatly from currently in use systems [11].

Chochlidakis KM. *et al*. [12] compared the marginal and internal fits of fixed dental restorations made with digital methods to those made with traditional impression methods in order to ascertain the impact of various factors on fit accuracy. Dental restorations made using digital impression techniques showed marginal misfits that were comparable to those made using traditional impression procedures. Stone die casts had more internal and marginal discrepancies than digital dies, which yielded restorations with the least amount of variation. Misfit values were intermediate when stereolithographic (SLA)/polyurethane dies were created using a digital impression. The approach produced improved marginal and internal fit of fixed restorations than standard procedures, despite the fact that conclusions were mostly based on in vitro investigations. The intraoral scanner is a piece of medical hardware consisting of a portable camera (hardware), software, and a computer. The goal of IOS is to precisely capture the three-dimensional geometry of an item. Regardless of the type of image technology employed by iOS, all cameras must project light. Following the program's identification of the POI (points of interest), the light is then captured and combined into individual images or videos. As for digital data that has been recorded, the most widely used format is either closed STL-like or open STL (Standard Tessellation Language). Many industrial fields are already using this format, which shows a sequence of triangulated surfaces where each triangle is specified by three points and a normal surface [13]. The methods that many FDPs employ to take digital intraoral impressions are essentially similar. For example, the patient received a standard abutment tooth preparation and underwent a single all-ceramic crown scan. To reveal the edge of the preparation, two retractive cords of varying diameters were inserted into the gingival sulcus. Before the scanning process, the area around the abutment tooth was well cleaned and let to air-dry for approximately five minutes, or until the sulcus had adequately enlarged [14].

3.3. Scanning Strategy

For every IOS, the vendor specifies a scanning strategy. The manufacturer's instructions, however, were vague about the starting point for scanning. Additionally, because of the cumulative mistakes that may be noticed with the stitching approach, surface sweep during scanning may result in overlapping areas with a high point density or poor areas with a low point density, which can lead to variances in accuracy between the regions where scanning starts and finishes [13]. Müller P. *et al*. [15] described an ideal sphere surrounding the scanned

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object; the object should be positioned in the center of the capture region. While recording, practitioners also need to keep a consistent distance from the tooth and use a smooth technique. This study evaluated the effect of the scan path and the accuracy scanning approach on the data accuracy that was recorded. They added that the camera should be held between 5 and 30 mm from the scanned surface, depending on the scanners and technologies used. On all occlusal and palatal surfaces, there is a linear movement that is followed by the buccal surface. Another method is to use an S-sweep motion on the lingual, occlusal, and vestibular surfaces of each tooth.

3.3.1 Accuracy of IOS Technologies

According to ISO 5725, the accuracy of the virtual model can be defined in terms of two techniques for measurement: trueness and precision. Trueness shows how much the dimension of the digital model is close to the real object. Precision shows how much the repeated digitization values are close to each other [16].

3.3.2 Accuracy of Intraoral Scanners Systems (IOSs)

When compared to traditional impressions, the mean trueness of different IOS technologies ranges from 20 to 48 µm, while the precision falls between 4 and 16 µm when the impression is partial. The accuracy of the current IOS devices is at least comparable to that of traditional impression-taking, and they are clinically approved for routine use [17]. Jivănescu A. *et al*. [18] examined whether there are significant variations in the accuracy of the short span fixed partial denture between the four intraoral scanners and whether these variations affect the quality of the final digital impression. In this investigation, four intraoral scanners were used: Planmeca Planscan, Cerec Omnicam, Medit i700, and Cerec Primescan. Geomagic Control X was utilized to process the scanned data. With a median value of 23.25 µm, the Medit i700 group displayed the best level of trueness; the Primescan group with a median of 25.55 µm, Omnicam group with a median of 32.3 µm; and the planscan group displayed the lowest level of trueness, with a median value of 75.8 µm.

3.4 The Main Intraoral Digital Scanner Systems:

3.4.1 CEREC Bluecam:

The CEREC system was the first to use the CAD/CAM idea chairside when it was originally released on the market in 1985. The business claims that the CEREC Bluecam uses a blue diode and a strong LED to take high-resolution pictures. Fast and easy outcomes are the consequence of high CAD/CAM quality, assurance, accuracy, and productivity. Blue light with a short wavelength is produced by the high-performance diode [19].

In less than a minute, CEREC Bluecam can automatically record optical imprints of a single quadrant. It takes only a few moments to achieve the opposite-arch effect. The CEREC Bluecam's blue light emits the perfect amount of illumination for the treated area, enabling the possibility of capturing images from even the most difficult access points. The camera may not even make contact with the tooth surface, or it may be only a few millimeters away. The camera determines when to start the exposure automatically. The expert must move the CEREC Bluecam gently across the required area. With a single, potent therapy, a full quadrant can be gained. This method requires a non-reflective surface for accurate imaging. The contrast layer needs to be continuously thin to enable the final image to be distortion-free [20].

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The restoration can be machined using a variety of equipment, a process known as an "*open scanner*," and the CEREC Bluecam generates a document in STL format that can be edited in any suitable software. Using this intraoral scanner, single crowns, FPDs, and FPDs supported by implants can all be scanned. Either the prepared abutment or the implant surface can be digitally scanned before crowns are placed over implants [21].

3.4.2 iTero System

After five years of intense research, Cadent, Carlstadt, New Jersey, released the visual impression iTero System in 2007. A digital picture is taken. Parallel confocal imaging uses the iTero system in conjunction with laser and optical scanning to digitally capture the surface and contours of the tooth and gum anatomy [22]. A laptop, display, mouse, built-in keyboard, pedal, and scanner are included with the iTero. The disposable scanner cover can be changed to immediately sterilize it. With the application of this technology, precise castings for the conventional laboratory process and virtual 3D representations of the dental preparation—from which CAD/CAM systems may produce restorations right away—can be produced [23]. The iTero technology was first restricted to a small percentage of dental implants. However, a recent collaboration with Straumann has resulted in a major advancement in the clinical state of the implants. The preparation for the visual impression must be captured by the camera. and the scan is carried out by the voice-activated system. It shows the best location for data collection till all margins and structures are precisely registered [24]. Furthermore, any application that is suitable can process the data in STL format. After the optical imprint, data is sent to the software to begin the restoration-drawing process. The fix has been customized with all the required elements, and the finish line has been marked. The designs must be inspected from many angles in order to identify errors [25].

The developed prototype is delivered to the appropriate milling facilities. An exclusive transfer is carried out over the implants with three spheres at the superior surface in order to allow the proper positioning of the implant for the visual impression of implant location. The implant is covered by the iTero System camera, and data is gathered in the manner previously described. Data are gathered and delivered to the relevant drawing program in STL format. The same procedure used when placing the restoration over the tooth structure is used to send prototypes to a milling center [26].

3.4.3 E4D System

D4D Technologies (Richardson, TX) created this method that does away with the requirement for powdering to optically record dental preparation, bite registration, stiff structures, and soft tissues. Dental impressions are quickly converted to digital casts by the gadget upon scanning them [27]. Nevertheless, powdering is required for both of these technologies. Although CEREC Bluecam produces a thin, uniform coating and guards against data aberrations, it must be used with caution. Another limitation of these systems is the need for gingival tissue movement to visualize the finish line accurately; this can be achieved the conventional way using cotton cords [28]. The method uses a red laser to take a sequence of pictures while vibrating micro mirrors at 20,000 cycles per second to produce a 3D representation. The user has two choices when it comes to shooting pictures: manually centering the picture while depressing the foot pedal or having the picture take itself as soon as it focuses. Typical casts can be scanned using this method. Similar to CEREC AC, this technique eliminates the need for a laboratory step and allows for one appointment restorations thanks to chairside milling equipment. Using this method, the patient can acquire the final

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restoration much more quickly. When the structure needs to be repaired, Dentalgia software receives the optical impression data and creates a virtual cast where the restoration will be made [29].

3.4.4 Omnicam System

CEREC Omnicam works with a combination of optical active triangulation and confocal microscopy technology, with which images are captured in live streaming video format to create a 3D model [14]. The manufacturer has designated a scanning strategy for each IOS. The manufacturer's instructions, however, are unclear as to where scanning should start, which is problematic, particularly when both quadrants have prepared teeth. Because cumulative mistakes may be noticed between the regions where scanning begins and ends, there could be differences in accuracy due to the stitching procedure as the scanning moves from the starting point towards proximal places [4].

3.4.5 Primescan System

The scanning exhibits outstanding trueness and precision. With the innovative Smart Pixel Sensor and the dynamic depth scan technology for perfect sharpness, even in up to 20 mm depth. Ender *et al*. [30] analyzed the precision of six newly released intraoral scanners (IOSs) for preparations of individual crowns that are separated from the entire arch. The entire arch with the left and right canine preparations for single crowns was used as a study model in order to ascertain the impact of the scanning procedure on accuracy. The reference dataset was acquired by the use of an extremely precise industrial scanner (ATOS Core 80, GOM GmbH) to scan the whole arch. The model was scanned ten times by each of six distinct IOSs: Trio, iTero, Planmeca Emerald, Cerec Omnicam, Primescan, and Virtuo Vivo. Depending on whether the scanning sequence began in the left or right quadrant, each IOS's scans were split into two groups (n=5). Software designed for three-dimensional analysis was used to assess the digital impression's correctness. The precision ranged from 18.8 (CI) to 58.5 µm (T-Tray), with the highest precision in the CI, T-Def, BC4.0, TRC, and TRI groups.

3.4.6 Provisional Restoration

For the prosthetic treatment strategy to be successful, temporary restorations are essential. A properly suited and well-executed temporary restoration serves a variety of purposes, such as protecting the pulp, stabilizing the abutment placement, and restoring both function and appearance. In cases of oral rehabilitation, they also serve a crucial clinical function since they offer a viewpoint simulation of the eventual restoration [31].

Temporary repairs can be categorized according to their polymerization method or their chemical composition. Polymerization Method: Provisional restoration could be chemically activated, also named cold cured acrylic resin (auto-polymerized), heat-polymerized acrylic resin, light-cured acrylic resin, and finally dual-cure acrylic resin. Chemical Composition: Provisional prostheses are fabricated from different materials. Most materials are typically based on one of two types of polymers. Vinylemthacrylates, polymethylmethacrylate (PMMA), and monomethacrylates are members of the methacrylate family. The other family consists of light-polymerized bisacryle-based composite resins, like urethane dimethacrylate (UDMA) and bisphenol A-glycidyl methacrylate (Bis-GMA). Every material has a unique mechanical composition and polymerization process [32]. Additionally, in situations where there has been a loss of vertical dimension and in difficult cases of oral rehabilitation, the temporary restoration offers a useful tool for rearranging the occlusal scheme. During the

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course of treatment to complete the definitive restoration, a provisional restoration is crucial in assessing aesthetics and phonetics [33]. A range of interim restoration manufacturing processes have been employed and developed over time, ranging from conventional techniques using resins or composites to contemporary CAD/CAM fabrication technology. The properties of the materials and the way they are used provide several problems for the conventional ways of creating temporary repairs. Consequently, digital techniques were created to deal with these problems [34].

Recently, digital fabrication methods have become more widespread and effectively replaced traditional ones. These methods enable digital manufacturing, employing CAD software to create restorations with virtual models and dies without the need for a working model, whether by additive (3D printing) or by subtractive (milling) techniques. In certain cases, a working model is still required in the digital workflow [35]. Similar to temporary restorations, provisional restorations are essential to the treatment plan's success in challenging situations. By employing CAD/CAM manufacturing techniques, which produce restorations of a higher caliber, these scenarios can be successfully long-term provisionalized [36].

Many factors may influence accuracy and marginal adaptation, including the final impression's precision, the master cast's production, and the prosthesis' manufacturing procedures. The final impression forms the basis for a precisely fitted restoration and an exact master cast. Numerous studies have compared the accuracy of optical impressions to traditional physical impressions for a correctly matched repair [37]. The ambient light, the IOS head size, the scanning technology, the scanning protocol, the scanner software, the limited spacing, the edentulous span's length all have an impact on how precise a digital scan will be. Reflective powder may also be necessary. Quadrants and FPD have been obtained using intraoral scan protocols as stated by the manufacturer. However, manufacturers have not provided guidelines on which quadrant to begin scanning in during FPD scanning. The impact of the scanning order on the digital scan accuracy in the FPD model has been demonstrated. However, there is not enough information to say if the accuracy of a digital scan is affected by the first quadrant [4].

However, scanning larger areas requires merging of multiple single images; it causes the dataset to become increasingly distorted and more inaccurate as a result. This is corroborated by analysis of whole arch scans, which nevertheless show larger dataset mistakes from intraoral scanning systems than from datasets produced using the traditional method [38]. One of the biggest problems with small scanning fields on intraoral scanners is that it places computational strain on the stitching process because the amount of image overlap is smaller. Simply, sometimes there is no sufficient data left for accurate calculations. Therefore, increasing the scanner capture size helps to preserve more data and thus better full-arch accuracy. The intraoral scanners' accuracy is dependent on the distance and the angle between the scanner head and the scanned surface. Regarding the angle, the curvatures and the inclinations of different tooth surfaces, like occluso-axial areas and occlusal surface slopes, could affect the accessibility of the light around the teeth, the scanned surface, as well as the orientation of the reflected light toward the sensors. As a result, this could have an impact on how much data is recorded about each tooth surface, a thing which could have an impact on how accurate the 3D reconstruction is.

To evaluate two intraoral scanning methods' accuracy regarding marginal fit of multiple single provisional crowns and 3-unit FPD with missing canine, a dental surveyor and a high-speed handpiece were used to prepare the abutments in order to standardize the model

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preparation process. In order to guarantee correctly tapered axial walls matching the taper of the diamond stone, which is 6 degrees on each axial wall for a total of 12 degrees of convergence, the high-speed handpiece was fixed horizontally. This approach followed the guidelines within previous work [39].

5. CONCLUSION(S)

The Primescan intraoral scanner had better accuracy than the Omnicam intraoral scanner, and the provisional restorations scanned with Primescan intraoral scanner had better marginal fit than restorations scanned with Omnicam intraoral scanner.

RECOMMENDATION

More investigations are still required for evaluation of the effect of the integration of different designing software and different milling machines with different intraoral scanners.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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