Review Article

A literature review of the current major intraoral digital impression systems and their accuracy

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ABSTRACT

The accuracy of the intraoral digital impression systems has been previously reported to refer to the quality of the obtained data from the related scanning procedures, irrespective of the quality of the clinical outcomes and the estimated costs. Trueness and precision have been frequently found among studies in the literature as two terms describing the accuracy of the intraoral digital impression systems. Various digital impression modalities have been proposed among studies in the literature and were investigated for estimation of their accuracy. The paper aims to review and discuss the most common literature regarding the current common systems and their accuracy among the different studies in the literature. According to the results, Chairside Economical Restoration of Esthetic Ceramic (CEREC) systems appear to have the highest estimated rates of trueness and precision as compared to the other modalities while the iTero system appears to have the lowest estimated rates. However, some studies have reported contradicting results and the current evidence is mainly based on findings from in vitro investigations. Accordingly, further studies might be needed for further validation of the current evidence and strengthening the quality of the future potential implications for clinicians.

Keywords: Dentistry, Digital impression, Scanning, Accuracy, Validation

INTRODUCTION

Based on the recent advances in the field of digital dentistry, more effective and favorable outcomes can be obtained by using computer-aided design (CAD) and computer-aided manufacturing (CAM). Many technologies and modalities have been proposed based on the function and the type of the targeted tissue. Moreover, implications for efficacious intraoral digital impression procedures have aroused to innovate more efficacious modalities that can face the related difficulties. Approval on the application of intraoral digital impression systems was reported by both clinicians and patients due to the related favorable outcomes.[1] Many advantages have been reported with using intraoral digital impression systems as easy repeatability, real-time visualization, cast pouring, being available and easy to conduct with no need to continue cleaning and time consumption, in addition to the selective capturing features of these modalities.[2-5] Accuracy of the intraoral digital impression systems has been previously reported to refer to the quality of the obtained data from the related scanning procedures, irrespective of the quality of the clinical outcomes and the estimated costs.[6] Trueness and precision have been frequently found among studies in the literature as two terms describing the accuracy of the intraoral digital impression systems.[6]

Various digital impression modalities have been proposed among studies in the literature and were investigated for estimation of their accuracy.[7] The aim of the study was to review and discuss the most common literature regarding the current common systems and their accuracy among the different studies in the literature.

METHODS

Evidence from the current literature shows that there are many current intraoral digital impression systems with their different accuracy. Among the reported intraoral digital impression systems. In the current review, it aims to focus on Lava C.O.S., CEREC, and iTero systems. Consequently, this literature review represents an extensive search that gathered data and information from medline, cochrane, and EMBASE databases on 10th May 2021 using the medical subject headings (MeSH) and a combination of all possible related terms. This was followed by the manual search for studies in google scholar. Papers that discuss the major intraoral digital impression systems were screened for relevant information. The papers did not pose any limits on date, language, age of participants, or publication type.

DISCUSSION

Lava C.O.S. system and the its accuracy

According to the manufacturer of the modality, they reported that the modality is designed to be with a small scanner tip that is only 13.2 mm in diameter. Moreover, the system has a touch-screen to display and the images are processed by computer-based approaches while the light source can be observed as a blue light that is pulsating.[8] Many in vitro investigations have previously estimated its accuracy of the modality. In the study by Ender and Mehl, the estimated precision and trueness for the modality were 60.1 and 40.3 µm respectively.[9] Another investigation by Patzelt et al also reported that the precision and trueness for the same modality were 37.9 and 38.0 µm, respectively.[10] Another in vitro investigation by Patzelt et al investigated the accuracy of different digital impression modalities on edentulous jaw models reported that the estimated precision and trueness for the mandible and maxilla were 44.1, and 24.6 µm and 52.9, and 30.8 µm respectively.[11] The accuracy of the Lava chairside oral scanner was also reported in a previous investigation by Patzelt et al which reported that the study was conducted on the full-arch polyurethane case, based on 14 priorly prepared abutments showed that precision and trueness for the modality were 13.77 and 67.50 µm respectively.[12]

This system has been reported as a digital impression system first in 2006 and was found in the market two years later. A sampling of the active wavefront is the mechanism of action of the Lava C.O.S. (Lava Chairside Oral Scanner; 3M ESPE, Seefeld, Germany).[13] This usually refers to the ability to use a single-lens digital impression system to obtain 3D data. Moreover, it has been reported that advanced algorithms for imaging processing are widely used within the techniques. The main functions of which are a generation of surface patches with favorable in- and out-of-focus prospectives. Based on the fact that the technique depends on a three-sensor modality to capture the clinical image from three different and adequate angles.[13] A previous estimate showed that the system can capture 20 3D datasets/second, which has been reported to embody around 10,000 points of data for each captured scan.[14] Accordingly, it has been estimated that the modality can result in the overall production of 2400 datasets of captured precise scans or what has also been previously estimated as 24 million points of captured precise data. The investigation which reported the modality for the first time reports that the modality has been designed to make sure that images and datasets of high quality are obtained due to the unique design of the modality that is mainly based on reducing the workforce that has been previously directed to prevent any potential overlapping of the captured pictures.[14] It should be noted that a powder spray should be used to coat the targeted tooth before using the Lava C.O.S. system for digital impression. After forming a homogenous layer over the targeted tooth, scanning should be approached from posterior to anterior to cover the different aspects of the targeted tooth and obtain high-quality images.[15] Another advantage of the modality is that the obtained images can be timely observed during the operation over the displaying screen, which makes it easy for the performing dentists to decide whether the obtained images were adequate for processing and contain adequate information or not.[15] The software can fix any pitfall of any potentially rescanned areas of the affected teeth to form a perfect image that can be used for adequate processing. Moreover, the system can effectively formulate a buccal image by combining the mandibular and maxillary aspects of the captured images.[16]

CEREC system and the estimated accuracy

Many investigations have also previously evaluated the accuracy of the CEREC system as a digital impression modality. A previous in vivo investigation by Ender et al recruited five individuals with observed complete dentition reported that the precision of the CEREC blue cam was 56.4 µm, while the estimated precision for the CEREC Omnicam was 48.6 µm.[17] Another in vitro investigation by Hack and Patzelt also reported that the estimated precision and trueness for the CEREC AC OmniCam were found to be 16.2 and 45.2 µm respectively.[18] The previous investigation by Jeong et al also reported that the estimated precision and trueness for the used CEREC AC OmniCam that was used in their model of maxillary complete-arch of unprepared teeth were found to be 58.0 and 197.0 µm, respectively while the estimated same variables for the CEREC blue cam system were 116.0 and 378.0 µm respectively.[19] Another in vitro investigation by Renne et al used the custom maxillar- complete arch model that was used to scan complete and posterior sextant arches by CEREC Omnicom and CEREC Bluecam and other systems and found that the trueness and precision for both of these modalities were 101.5, and 133.4 µm and 140.5, and 194.2 µm respectively.[20] In the same context, the accuracy of the same modalities was also investigated by a previous study by Lee et al using a single prepared molar tooth for a crown and reported that CEREC Bluecam and CEREC Omnicam had estimated trueness and precision of 17.5, and 12.7 µm and 13.8, and 12.5 µm respectively.[21]

Recently,The accuracy of CEREC Omnicam was also reported in vitro investigation by Kim et al which reported that using markers, the trueness and precision were estimated to be 31.8 and 10.5 µm respectively.[22] In an in vivo investigation, Kuhr et al reported that the deviation was minimum and less severe as observed within the control group than other groups which included CEREC application; however, they also reported that the least deviation with CEREC Omnicam was observed within the intermolar distance as observed among their population.[23]

iTero system and the reported accuracy

This common digital impression modality was also reported among various studies in the literature; however, most of these studies are in vitro investigations, and validation in human populations is still needed. In an in vitro investigation, Anh et al estimated the accuracy of iTero digital impression systems in their study which included four models with different four arches including an ideal arch, one arch with mild crowding, another with moderate, and the fourth with severe crowding, all of which were maxillary of unprepared teeth.[24] They reported that the accuracy for these four arches was 28.2, 29.6, 28.4, and 33.2 respectively. Another investigation was also conducted in the complete maxillary arch but with multiple cavities preparations to estimate the accuracy of different digital impression systems, including iTero. Kim and colleagues reported that the triangulation was 73.50 µm, wavefront sampling was 43.50 µm, the individual images were 70.55 µm, the video sequence was 56.45 µm, trueness according to confocal microscopy was 49.35 µm, optical coherence tomography was 137.0 µm. The authors also reported that trueness with and without powder coating was estimated to be 46.07 and 79.05 µm, respectively. The estimated accuracy for video sequences and individual images was also reported to be 56.45 and 70.55 µm respectively.[1] The accuracy of the modality was also reported in a previous in vivo investigation by Lee et al that reported that 32 study participants were recruited in the study and the iTero and TRIOS systems were used to scan the mandibular and maxillary arches.[25] They reported that estimated average deviations of 0.057 and 0.069 mm were estimated between the two systems when scanning the maxilla and mandible, respectively. In an in vitro investigation that was conducted on a model of three prepared teeth with a laser-sintered cobalt-chromium master of the maxillary arches and scanning was done by different digital impression modalities including iTero scanner. The authors estimated the trueness for the iTero system to be 24.4 µm, which was higher than the calibrated CEREC Bluecam (16.5 µm), but much less than the decalibrated CEREC Bluecam (108.4 µm), the calibrated and decalibrated lave Chairside Oral Scanner systems (trueness= 34.9 and 80.9 µm, respectively).[26] The in vitro investigation by Patzelt et al also reported that the estimated trueness and precision for the iTero system were 49.6 and 40.5 µm respectively, which were significantly lower than the estimated accuracy for the CEREC Bluecam and zfx intrascan but was comparable with lava C.O.S.

digital impression systems.[10] Although Patzelt et al estimated a higher accuracy for the modality in another in vitro investigation (Trueness= 144.2 for maxilla, and 191.5 µm for mandible; precision= 178.5 for maxilla, and 197.9 µm for mandible), it was still much lower than that estimated for the CEREC AC Bluecam and the zfx intraScan but was higher than the estimated accuracy for the lave Chairside Oral Scanner COS system.[11] On the other hand, other in vitro investigations estimated that the reported accuracy for the iTero system in digital impression and scanning was comparable and even higher than other modalities within the same study, even including the CEREC Omnicam and CEREC Bluecam modalities.[12,18,27] Therefore, it could be concluded that the modality has a middle-ground accuracy as a digital impression system as compared to other systems and modalities, and further investigations with population-based designs are needed for further validation of the accuracy on humans.

CONCLUSION

The literature review discussion summarized the accuracy of the three most common digital impression systems that reported among studies. According to the results, CEREC systems appear to have the highest estimated rates of trueness and precision as compared to the other modalities, while the iTero system appears to have the lowest estimated rates. However, some studies have reported contradicting results that was evident from the findings of in vitro investigations. Accordingly, further studies might be needed for further validation of the current evidence which will strengthening the quality of the future potential implications for clinicians.

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