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Digital versus conventional implant impressions-Finding the evidence

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Abstract

Purpose: Digital technology has been revolutionary in the recent past and has made various dental procedures easier, better and more efficient. Accuracy of impression procedure is very crucial in implant prostheses fabrication, which affects the final result. Digital implant impression accurately locates the three-dimensional implant position in relation to the other structures in mouth. However, there is a lack of evidence on the accuracy of digital versus conventional implant impressions. Therefore, the purpose of this systematic review is to evaluate the accuracy of digital implant impression when compared with conventional impression as reviewed from several studies.

Method: A literature search was conducted electronically in PubMed, using the terms such as digital implant impression, intraoral digital implant impression, conventional implant impression, accuracy and intraoral scanner. Out of 87 articles, 19 relevant articles were identified within 10 years limit based on the inclusion and exclusion criteria. Out of 19 articles, 15 articles were based on in vitro studies and other 4 were clinical studies. The pooled data was analysed and then relevant data was extracted.

Result: Out of 19 articles, 7 articles concluded that accuracy of digital impression is better, 6 articles demonstrated that accuracy of both impressions are same and according to 6 articles accuracy of conventional impression is better.

Conclusion: On the basis of studies performed during the last 10 years, it can be concluded that digital implant impressions offer a reliable alternative to conventional impressions.

Keywords: Digital implant impression, intraoral digital implant impression, conventional implant impression, accuracy, intraoral scanner

Introduction

Digital technology has been revolutionary in the recent past and has made various dental procedures easier, better and more efficient. Impression procedure is the starting point and a crucial step in implant prostheses fabrication. For a successful outcome in implant supported prostheses, it is essential to have an accurate transfer of three-dimensional implant position and angulation from the patient's mouth to the master cast via impression. [1&2]

The primary aim of dental impressions whether conventional or digital, is to obtain the imprint of the required site, the adjacent and antagonist teeth, as well as the interocclusal record relationship.[3] From the very beginning the conventional implant impression techniques have been a standard procedure in fixed prosthodontics. There are various factors which can affect the accuracy of the implant impression like number and angle of the implants which can cause distortion of the impression material upon removal, splinting, depth of the implants, machining tolerance of components and type of connection. [4-6]

The two commonly used impression techniques for the transfer of the intraoral position of implants to working casts are the direct and indirect conventional impression techniques. But none of the techniques has been without flaws like there might be errors in selection of tray and impression material, the type of impression technique used, time consumption, disinfection of impression, transportation, and storage issues, application of inadequate adhesive or poor haemorrhage control. [7&8] To overcome such flaws, various innovative methods in digital dentistry were introduced in Prosthodontics. The use of intra-oral scanners and related systems by many clinicians is on an increase as an alternative to the conventional impression materials and techniques.

The first commercially available intraoral scanner was introduced about two decades ago, which has resulted in an increase in precision and efficiency.[9] The intraoral scanning devices utilize a sophisticated optical surface scanning technology that works similarly to a camera, but instead of simply capturing lights and colours, the sensors measure light reflection times from various surfaces through processes to capture the object three-dimensionally.[10] This information is then captured by the three-dimensional software that utilizes specific alignment algorithms to allow for registration of the object. Three of the common scanning principles used today by intraoral dental scanners on the market are: [11&12]

1.Triangulation,

2. Active wave-front sampling

3. Parallel confocal laser scanning.

Each of these techniques utilize a combination of these various imaging capturing methodologies to collect the surface data of the teeth and mucosa so that the information can be registered and stitched together through an alignment process in order to create the virtual three-dimensional model.

Digital impression making provides several advantages over the conventional like- visualization of real-time image while impression making, selective capture of the relevant areas, easy repeatability of the flawed areas without remaking the complete impression, reduced gag reflex, improved patient acceptance, reduced chair-time, no need for tray selection, no need for waiting the cast to set, reduced distortion of impression materials, reduced storage requirement, disinfecting the impression and cast and transport it to the laboratory, rapid access to three-dimensional diagnostic information and easy and rapid transfer of the digital information for communication between the clinician and patients.[10 & 13]

Digital implant impression accurately locates the three-dimensional implant position in relation to the other structures in the mouth. However, there is a lack of evidence on the accuracy of digital versus conventional implant impressions. Therefore, the purpose of this systematic review is to evaluate the accuracy of digital implant impression when compared with conventional impression as reviewed from several studies.

Materials and methods

Search strategy: An electronic search was conducted using PubMed database. The keywords used such as "digital implant impression", "intraoral digital implant impression", "conventional implant impression", "accuracy" and "intraoral scanner".

Inclusion and exclusion criteria

Criteria used for inclusion of studies were:

1) Comparison of accuracy of digital impression with conventional impression regardless of method used for measurement.
2) Partially or completely edentulous dental arch or replica with implants
3) Either in vivo or in vitro studies
4) Articles published in last 10 years (2011-2020)

Criteria used for exclusion of studies were:

1) Incomplete articles such as abstracts only
2) Dual publications
3) Case reports
4) Expert opinions
5) Technical and clinical reports
6) Review articles

Selection strategy and collecting data

The search strategy followed a 3-stage selection process to investigate each database that subsequently considered titles, abstracts, and full texts.

First stage: The list of titles obtained from the database was screened and those titles that clearly did not refer to digital or conventional implant impressions were excluded.

Second stage: The abstracts of the selected titles were analyzed and those studies that did not deal with the comparison between digital and conventional implant impressions were excluded.

Third stage: Full-text of selected articles were examined carefully based on inclusion criteria and verified whether the studies were relevant or not. Final selection of articles was based on full-text reading.

Only relevant articles were added to this review. (Figure 1)

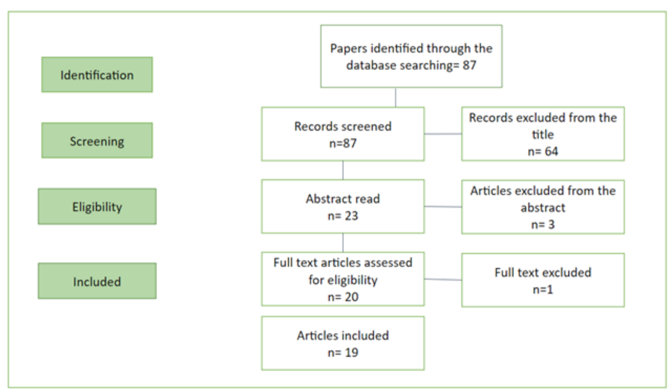

Figure 1: Flow diagram of articles selection.

Results

Out of 87 articles, 19 relevant articles were identified based on the inclusion and exclusion criteria. Out of 19 articles, 15 articles were based on in vitro studies and other 4 were clinical studies. The pooled data was analysed and then relevant data was extracted and is summarised in the table-1.

Table 1: Data summary of the articles included in the study.

Author	Study design	Sample size	Scanner used	Factors evaluated	Result
Marghalani et al. [14] (2018)	In-vitro	60	White light IOS (CEREC Omnicam; Dentsply Sirona) and Blue light IOS (True Definition; 3M ESPE)	Difference in 3-dimensional (3D) deviations (median ±interquartile range) among the 3 impression groups for 2 different implant systems (Replace Select RP; Nobel Biocare and Tissue level RN; Straumann) in Two partially edentulous mandibular casts with 2 internal connection implant analogs with a 30-degree angulation	When the 3 different impression techniques were compared in regard to the Nobel Biocare implant system, True Definition scans were the most accurate, followed by Omnicam scans with no statistical significance, and last, conventional impressions (Impregum;3M ESPE) with a statistically significant difference compared with both digital scanners.
Alshawaf et al. [15](2018)	In-vitro	10	White light IOS (CEREC Omnicam) And Active Wavefront Sampling technology IOS (True Definition)	Difference in 3-dimensional (3D) deviations among the 3 impression groups in mandibular stone cast with Kennedy class II edentulism fabricated using two internal connection tissue-level implants at 30 degrees to each other (Replace Select RP, Nobel Biocare)	Printed casts generated from digital impressions for partially edentulous posterior mandibular arches had inferior accuracy to conventional stone casts fabricated from splinted open tray impressions.
Lee et al. [16] (2015)	In-vitro	30	Digital impression i-Tero (cadentiterotm,	Average volumetric deviations in a	Milled models from digital impression (i-Tero;

			Carlstadt, NJ, USA) and Laboratory scanner (Lava Scan ST; 3M ESPE, Seefeld, Germany)	customized maxillary model containing a single implant (Bone Level, Regular Crossfit; Straumann, Basel, Switzerland) located in the maxillary left second premolar position	cadentiterotm, Carlstadt, NJ, USA) are comparable to gypsum models from conventional impression with vinyl polysiloxane material (Aquasil Ultra Monophase/LV; Dentsply,York, Pa) in most anatomical areas except the secondary anatomical areas, such as grooves and fossae, where gypsum models represented more details and prominent anatomy.
Alikhasi et al. [17] (2018)	In-vitro	90	Intraoral scanner (Trios 3Shape)	Angular and linear distortion differences among three impression groups, angular distortion differences between internal and external connections, and between straight and tilted implants for either linear or angular distortion in Two maxillary edentulous acrylic resin models with two different implant connections (internal or external) served as a reference model.	Digital impression is better than the direct technique in the edentulous arch with straight and tilted implants, and both of them are more accurate than the indirect technique.
Papaspyridakos	In vitro	10	Digital intraoral scanner	Three-dimensional (3D)	Digital implant

et al. [18] (2016)			(TRIOS; 3shape, Denmark)	deviations from cast of an edentulous mandible with five implants	impressions are as accurate as conventional implant impressions
Gherlone et al. [19] (2016)	In vivo	25	Intraoral scanner TRIOS (3 shape)	Presence of voids at the bar implant connection and any variation on marginal bone height over time were measured in patients underwent full arch immediate load rehabilitations which were fixed to a total of four implants (two axial and two tilted)	Greater efficacy when using digital impressions rather than conventional impressions
Tan et al. [20] (2019)	In vitro	36	Intraoral scanners (TRIOS and True Definition) and dental laboratory scanners (Ceramill Map400, ineos X5 and D900)	Defined Linear distortion and global linear distortions (d_r) and 3D reference distance distortions between implants on two completely edentulous maxillary arch master models (A and B) with six or eight implants respectively.	Digital impressions poor accuracy than conventional impressions
Menini et al. [21] (2018)	In vitro	35	Intraoral digitizer system [True Definition Scanner, 3M ESPE].	Measure implant angulation and interimplant distances on casts. The best and the worst impressions made with TI and DI were selected to fabricate four milled titanium frameworks.	Digital impression showed better accuracy compared to conventional impression.

				Passive fit was evaluated through Sheffield test, screwing each framework on the master cast.	
Liu et al. [22] (2019)	In vitro	10	3D printer (Lingtong II, shino)	The interimplant distances and interimplant angulations for each implant pair were measured to assess 3D deviations.	Multi-implant impressions using 3D -printed custom trays and splinting could yield an impression with similar accuracy as that obtained with conventional techniques
Cappare et al. [23] (2019)	In vivo	50	Carestream CS 3600 (Version 3.1.0 Acquisition Software, Carestream Dental LLC, Atlanta, GA, USA).	Accuracy of the framework-implant connection, check for the presence of voids at the bar-implant connection and measure bone level. Criteria used to assess success at the prosthetic level were the occurrence of prosthetic maintenance, the absence of fractures of the acrylic resin superstructure and voids.	Satisfactory accuracy and predictability of the IOS to be a reliable alternative in clinical practice to the conventional workflow for implant full-arch rehabilitations. The accuracy of CAD/CAM systems has shown to be compatible with conventional impressions.
Kim et al. [24] (2019)	In vitro	10	Intraoral scanner (TRIOS 3; 3Shape) and scan bodies (truscan body; truabutment)	The linear and angular displacements of each implant replica were evaluated	Intraoral digital scan resulted in less accurate Trueness than the conventional open-tray impression technique
Chochlidakis et al. [25] (2020)	In vivo	16	Intraoral (True Definition, 3M, St Paul, MN) and extraoral	3D deviations between virtual casts from intraoral full-arch	Full-arch digital scans and a complete digital workflow in the

			scanners (STL file 2)	digital scans and digitized final stone casts generated from conventional implant impressions Correlation between number of implants and 3D deviations was investigated	fabrication of maxillary fixed Complete dentures may be clinically feasible.
Ferrini et al. [26] (2018)	In vivo	24	3MTM True Definition Scanner	Framework-implant connection accuracy was evaluated by means intraoral digital radiographs at 3, 6, 12, and 36 months of follow-up examinations. Outcome considerations comprised implant and prosthetic survival and success rates, marginal bone level changes, and required clinical time to take impressions for posterior maxillary restorations supported by an upright and a distally tilted implant supporting 3-unit or 4-unit screw-retained prostheses at 3-year follow-up.	The digital scanning could be considered a reliable alternative to the traditional impression. The whole digital workflow mayshorten clinical time and improve the patient acceptance.
Abdel-Azim et al. [27] (2014)	In vitro	24	Itero digital scanner	Marginal fit measurements were made	The conventional pathway resulted in a smaller marginal discrepancy for single-implant

					frameworks. In contrast, the digital pathway resulted in a smaller marginal discrepancy for full-arch implant frameworks.
Basakiet al. [28] (2017)	In vitro	10	Intraoral scanning device (itero intraoral scanning device, Cadent itero, Align technology)	The inter-implant distances and interimplant angulations for each implant pair were measured for the reference model and for each definitive cast. Clinical qualitative assessment of accuracy was done via the assessment of the passivity of a master verification stent for each implant pair, and significance was analyzed using chi-square test	Definitive casts fabricated using the digital impression approach were less accurate than those fabricated from the conventional impression
Huang et al. [29] (2020)	In vitro	16	3Shape TRIOS scanner and newly designed CAD/CAM titanium alloy scan bodies were used	Trueness and precision assessment by the median and interquartile range (IQR) of the RMS values	Conventional splinted open-tray impressions were more accurate than digital impressions for full-arch implant rehabilitation.
Rech-Ortega et al. [30] (2019)	In vitro	20	True Definition	The XYZ module parameter was analyzed as this indicated the real distances in millimeters between the analogue centers.	In cases of rehabilitations involving more than four implants, neither technique can be considered accurate.

					For adjacent analogues, the direct technique (EIM) can be considered the most accurate. Between intermittently positioned analogues 1-4, the intra oral scanner True Definition (3M ESPE) (SDM) provided accurate data. For the 3-6 distance, both techniques obtained significantly different values from the master model
Eliasson et al. [31] (2012)	In vitro	15	Healing abutment (Encode®) provided with digitally coded information on length and diameter on the top	The center point of each implant analogue fitting surface was measured with a laser measuring machine in the x-, y-, and z-axis, as were also the angular direction of the center axis and the position of the antirotational hex.	Working cast fabrication using Encode abutments and a Robocast analogue placement technique was less accurate than the conventional impression technique
Amin et al. [32] (2017)	In vitro	10	Intra-oral scanners (CEREC Omnicam and True Definition)	The 3D Deviations were recorded as root-mean-square error.	Full-arch digital implant impressions using True Definition scanner and Omnicam were significantly more accurate than the conventional impressions with the splinted open-tray technique

Discussion:

The introduction of intraoral optical scanners, especially into fixed and implant prosthodontics has been advantageous in many ways. These includes the elimination of tray selections, decreased risk of distortion during impression making, pouring, disinfecting, shipping to dental laboratory and increase patient comfort and acceptance.[33]

But there is a lack of evidence that may suggest the superior accuracy of digital implant impression over the conventional implant impression techniques. Therefore, the purpose of the present study was to find the evidences that determine the accuracy of digital implant impressions in comparison to conventional impression regardless of the methodology and study design.

The studies which are included in this are mentioned in the table-1. From total 19 included studies, 15 articles were based on in vitro studies and other 4 were clinical studies. Critical evaluation of the above articles show that Digital implant impressions are reported to be a viable alternative to conventional techniques, but these statements are mostly based on in-vitro study results. [14-18,20-22,24,27,29-32]

Marghalani et al. [14] compared the accuracy of digital vs. conventional implant impressions for partially edentulous posterior mandibular arches analogs with a 30-degree angulation from 2 different implant systems (Replace Select RP; Nobel BioCare and Tissue level RN; Straumann) and reported that the digital technique had the fewest 3-dimensional (3D) deviations (15 ±6 mm) compared with the conventional techniques (39 ±18 mm). However, the accuracy of all impression techniques was within clinically acceptable levels.[14] This is in contrast to the in vitro study of Alshawaf et al. [15] which showed that digital impressions for partially edentulous posterior mandibular arches had inferior accuracy to conventional methods (splinted open tray impressions) with 3-D deviations as measured by root mean square (mean ± SD) are 120.39 ± 5.91 μm and 53.49 ± 9.47 μm respectively.

Lee et al. [16] compared the accuracy of gypsum models acquired from the conventional implant impression with a vinyl poly siloxane material (Aquasil Ultra Monophase/LV; Dentsply, York, Pa) to digitally milled models created from direct digitalization by three-dimensional analysis (i-Tero; Cadenti Tero TM, Carlstadt, NJ, USA) and evaluated that there is no significant difference in accuracy of milled models from digital impression and gypsum models from conventional impression. However, accuracy in the secondary anatomical areas, such as grooves and fossae and vertical displacement of the implant position from the gypsum and digitally milled models are significantly different from master model ($P < 0.001$, $P = 0.020$, respectively). While Basaki et al.[28] assessed the three-dimensional accuracy of implant definitive casts fabricated using a digital impression approach and compared with those of a conventional impression method in a partially edentulous condition and found that definitive casts fabricated using the digital impression approach were less accurate than those fabricated from the conventional impression approach with mean ± standard deviation (SD) error of 116 ± 94 μm and 56 ± 29 μm for the digital and conventional approaches, respectively ($P = .01$). However, Implant angulation did not have a significant influence on definitive cast accuracy in either technique ($P = .64$).

Alikhasi et al [17] compared the three-dimensional accuracy of digital impressions versus conventional impressions technique for the maxillary full arch with tilted implants of two connection types (internal or external) and demonstrated the digital impressions have significantly higher accuracy than conventional methods with significant angular and linear distortion differences among impression groups (P < 0.001), angular distortion differences between internal and external connections (P < 0.001), and between straight and tilted implants for either linear (P < 0.001) or angular (P = 0.002) distortion. They further noted that connection type and implant angulation did not affect the accuracy of digital impressions (p > 0.05) whereas these two factors affected the accuracy of conventional impressions. The findings of this study are in disagreement with the study performed by Lin et al. [17] who concluded that the digital impressions produced less accurate definitive casts than conventional impressions. They reported that divergence between two implants ($0, 15^0, 30^0, 45^0$) did not affect the accuracy of the definitive cast created through conventional impressions, but it significantly affected the accuracy of milled cast through digital impression. They further reported that, at lower level of divergence (O^0 to 15^0), conventional impressions displayed more accuracy than digital impressions. However, at higher divergence (30^0 to 45^0), the differences in accuracy between conventional and digital impression were less apparent.

Sarah Amin et al. [32] compared the accuracy of digital full arch impressions with Omnicam and True definition scanners versus conventional implant impressions. The findings of their study indicated that digital full arch impressions using digital scanners were significantly more accurate with 3-D deviations 46.41 um ± 7.34 (Omnicam) and 19.32 um ± 2.77 (True Definition) than the conventional impression with the splinted open tray technique (167.93 um ± 50.37). The results of this study are in partial contrast with a previous study by Papaspyridakos et al.[18] who compared the accuracy of digital implant impression using digital intraoral scanner (TRIOS; 3shape,Denmark) at implant level versus conventional impression technique with polyether impression material (3M ESPE; Impregum, St. Paul, MN, USA) with five implants in edentulous mandible and concluded that digital implant impressions were as accurate as conventional open tray splinted implant level impressions (mean value of 3D deviation -17 um) and both are more accurate than open tray non-splinted technique (P < 0.0001). The different findings of the two studies can be attributed to many factors such as use of different scan bodies, different IOS systems, different reference scanners and differences in scanner precision as well as the different method of superimposition of test groups.

Abdel-Azim et al. [27] demonstrated that the conventional pathway resulted in a smaller marginal discrepancy for single-implant frameworks (24.1 um) compared to digital impression/fabrication pathway (61.43 um) while the digital pathway resulted in a smaller marginal discrepancy (63.14 um) for full-arch implant frameworks compared to conventional technique (135.1 um). Similar results were demonstrated by Rech-Ortega et al. [30] and they found that for adjacent analogue, the direct technique is most accurate when compared with the digital impression technique as no statistically significant differences were found for distances between adjacent analogues between elastomeric impression material (EIM) data and the master model for the adjacent distance, (p=0.146; mean= 0.0203; standard deviation (s.d.) = 0.074). Between intermittently positioned analogues, SDM did not present significant differences, obtaining values close to the master model for the distance 1-4 (p-value = 0.255; mean = -0.021; s.d. = 0.056). Statistically significant differences were found between results obtained by both techniques in comparison with the master model for the distance between distal analogues and all other distances (*p*<0.05). So in cases of full arch rehabilitations (> four implants), neither technique can be considered accurate although error falls within the tolerance limits (30-150µm) [30].

However, the findings of the studies by Abdul Azim et al. and Rech-Ortega et al. are in partial disagreement with the study performed by Papaspyridakos et al. [18] who compared the intraoral scanner Trios with two conventional direct technique (splinted and non-splinted) and concluded that in cases of two- or three-unit bridges, the digital system is as accurate as the conventional technique.

Huang et al. [29] compared the accuracy of two newly designed CAD/ CAM scan bodies (with and without extensional structure) used in digital impressions with one another as well as with conventional implant impressions (splinted open-tray impressions) and found that conventional splinted open tray impressions were more accurate than the digital impressions with trueness ($p = .001$) and precision ($p < .001$) for full-arch implant rehabilitation.

Menini et al. [21] evaluated and compared the accuracy of digital impression with seven conventional impression techniques by coordinate measurement machine and found statistically significant differences in accuracy ($p < 0.01$) with digital impression showed better accuracy. While Kim et al.[24] compared the accuracy of conventional impressions and intraoral digital scans at the implant level in a complete arch model and concluded that conventional open-tray impression technique gave more accurate values than digital scan obtained using an intraoral scanner ($P<.001$) for all the implant replica locations and also significantly smaller angular deviations than the intraoral digital scan in 3 of 12 projection angles ($P<.05$); however, the amount of angular displacement was less than 1 degree.

Eliasson et al.[31] compared the accuracy of implant analogue placement in working casts using a robot technique and an impression of Encode healing abutments mounted on the test side , with the conventional technique (pickup impression copings were inserted on the control side) and the center point of each implant analogue fitting surface was measured with a laser measuring machine in the x-, y-, and z-axis and concluded that working cast fabrication using Encode abutments and a Robocast analogue placement technique was less accurate than the conventional impression technique with mean center point deviation for the test and control side was 37.4 mm versus 18.5 mm ($p = .001$) in the x-axis, 47.3 mm versus 13.9 mm ($p < .001$) in the y-axis, and 35.0 mm versus 15.1 mm ($p < .013$) in the z-axis and Mean angle error was 0.41 degrees for the test and 0.14 degrees for the control side ($p < .001$). Mean rotation of the hexagon was 2.88 degrees for the test side and 1.82 degrees for controls ($p < .001$).

Most of the studies evaluated accuracy based on the difference in 3D deviations among digital and conventional impression groups. Marghalani et al [14] showed that digital impressions group show less deviation [Omnicam (20 ±4 mm) and True Definition (15 ±6 mm) groups}. In contrast Alshawaf et al. [15] found that conventional impression group had lower 3-D deviation 53.49 µm (SD 9.47), while Lee et al. showed that no statistical difference between the gypsum and digitally milled models ($P = 0.159$ and 0.158, respectively).

Alikhasi et al. [17] evaluated the linear distortion differences for implants among conventional and digital impressions and found minimum linear distortion was seen in digital impression group (0.16 ± 0.1 mm), while Tan et al. [20] and Kim et al. [24] found conventional impression demonstrated minimum linear distortion (10-20 um).

Some authors evaluated the effect of implant angulation on the accuracy of different impression techniques. In one such study, done by Papapyridakosa et al. [18] it was found that the implant angulation up to 15° did not affect the accuracy of implant impressions. Basaki et al. [28] also concluded that Implant angulation did not have a significant influence on definitive cast accuracy within either technique ($P = .64$). While Alikhasi et al. [17] showed digital techniques produced better results than conventional direct and indirect techniques with either straight ($P < 0.001$) or tilted ($P < 0.001$) implants.

Chochlidakis et al. [25] investigated the correlation between number of implants and 3D deviations and found that deviation increases with increase in no of implant. Azim et al. [27] found that for single implants, the conventional impression/fabrication pathway resulted in less marginal discrepancy (24.1um) compared to digital impression (61.43um) while for full arch frameworks, conventional resulted in more marginal discrepancy (135.1 um) compared to digital technique (63.14um).

On the other hand, all of the four in vivo studies [19,23,25,26] included in this review compared the digital and conventional implant impressions outcomes and found that there was no significant difference ($p > 0.05$) between the accuracy of digital and conventional impressions. However, due to improved patient acceptance and reduced clinical time, the digital impressions proved to be a reliable alternative to the conventional impressions.

The digital impressions are advantageous in many ways but have been found to be inconsistent in terms of accuracy when compared with conventional impression technique because different researchers have used a variety of digital scanner like intraoral scanner (3M True Definition Scanner, Cerec Omnicam , TRIOS Scanner 2 , and CS 3600 , iTERO) , extraoral scanner and laboratory scanner and it has been shown that accuracy of scanner differs from each other for implant impressions.[14,20,25] These differences in accuracy can be attributed to the fact that different methodologies have been used in accuracy measurement with different scanners which could result in some error related to different precision of each method. Moreover, difference in size of scan bodies and uneven spraying of scan bodies with powder (which are used to reduce the reflections) could potentially affect the accuracy of scanning. [14,15]

Whereas in some in vitro conditions [15,20,24,28,29,31] results are superior to conventional impressions which may be due to avoidance of conventional error sources. Although results varied significantly based on methodology, study designs type of scanners, intra oral situation and clinician ability to perform scan. As fewer studies are available in the literature which compared the digital and conventional techniques, therefore, additional in vivo and in vitro research is required to compare the accuracy of digital impression in prosthodontic field.

Conclusion

On the basis of evidences found within the limitation of this review (15 in vitro studies and 4 in vivo studies), following conclusion can be drawn.

1. Digital implant impressions offer a reliable alternative to conventional impressions.
2. Implant inclination does not affect the digital implant impression accuracy while at higher divergence accuracy of conventional impression is affected.
3. Factors which can affect the accuracy of digital implant impression must be identified and investigated extensively through clinical studies.

4. A universally accepted well defined methodology should be developed which can be applied with all available IOS software and hardware to improve the reliability of implant impression accuracy.

5. There are only few in-vivo studies related to accuracy of the digital implant impressions. Therefore, more in-vivo as well as in-vitro studies are recommended to investigate the accuracy of digital impressions in comparison to conventional impressions.

6. Digital implant impression technology still require further improvement to fully substitute conventional impression techniques.

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