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Gateway to digital implant workflow: Intraoral Scan Bodies- A Systematic Review

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ABSTRACT
To assess the efficiency of different intraoral scan bodies (ISBs) and to formulate an evidence-based protocol for the selection of a consummate scan body, to obtain precise dimensional coordinates of an implant. An electronic systematic search was conducted on PubMed and Google Scholar, by means of search terms such as intraoral scan body, digital implant impressions, intraoral scanner and accuracy. The main outcome was accuracy of digital implant impression with regards to the various ISB design, material or geometry. Articles commenting on sequel of the ISB charecteristics were critically assessed and eight articles were incorporated based on the inclusion criteria. The available qualitative data was tabulated and critically appraised; the conclusions of these studies ought to be considered and clinical trials are necessary to propose the desirable ISB traits, which augment the accuracy of a digital implant impression. There is limited evidence with regards to the selection of a scan body by virtue of its characteristics, since most of the studies pertaining to the same are non-human based in-vitro experimental trials; whose methods and results cannot be extrapolated onto human subjects equivalently. However, it can be certainly concluded that the variables concerned with an ISB have a definite role in contributing to the validity of a digital implant impression. Based on the results of the included studies, the ideal scan body to be selected can be gauged so as to boost the fidelity of a digital implant impression.
Keywords: *Accuracy, Digital impression, Intraoral scan body, Scan body.*

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INTRODUCTION

Dental implants offer long-lasting tooth replacement outcomes [1,2] while preserving the natural tooth structure of the adjacent teeth, unlike tooth-supported fixed prostheses. A multitude of implant systems with variations in design (geometric and surface characteristics), surgical placement techniques, healing times, and restorative protocols continue to evolve with the goal of achieving long-term success rates.

The success and survival rate of an implant retained restoration depend on two major factors i.e., the accuracy of the impression made [3] and the precise passive fit of the prosthesis [4]. The key to obtaining adequate support for a definitive restoration with passive fitting, as sensibly stated by Conrad et al. (2007), is an accurate recording of the spatial implant position. [5]

With the development of "CAD-CAM" technology, it is currently feasible to create implant-supported restorations using a digital workflow. [6] Intraoral Scan Bodies (ISBs) are components that are connected to the implant body and are detectable by an intraoral/lab scanner. A system-specific digital analogue of the implant can be attached to the Scan Body (SB) in the digital model which relays data such as implant positions, implant angulations, and soft tissue emergence profile. This facilitates the design and subsequently, the fabrication of a restoration. [7-13]

The definition of accuracy is the level to which a quantity value is achieved by assessing the real value of the measurement agreement. Precision is the degree of agreement between the findings of independent tests conducted under predetermined conditions. Trueness refers to the scanner's capacity to reproduce a particular object as accurately and without distortion as feasible, while precision refers to the level of matching images produced with repeated scanning in the same circumstances. [14-19] However, all these terms are used interchangeably in the available literature.

Once the ISBs are captured accurately using an intraoral scanner, a digital implant analogue may then be positioned over the digital model of the SB with particular implant system/ ISB digital libraries. A dentistryspecific CAD ("Computer-Aided Design") software is utilized in the designing of the restoration following which Computer Aided Machining (CAM) assisted fabrication of the framework/prosthesis can be done.

Digital implant scanning has witnessed a remarkable evolution from the photogrammetry technique to the present. The Straumann Group used the term "scan bodies" to describe the first scannable impression copings. These scan bodies were initially only commercially offered for single-implant systems and needed a particular scanner as well as scanning technology. As scanner technology has advanced and grown in popularity, most of the major companies produce ISBs that are compatible with most scanners. [20-22]

Commercially available ISBs vary with respect to shape, size geometry, material, connection, and scalability. [23] The scan region, body, as well as the most apical portion, also recognized as the base, nevertheless, remain to constitute the ISB's fundamental parts. [24] Of these, the scan region is the key element that determines the implant position and angulation.

The scan region could have one or more scan regions, extensions, or asymmetries that could enhance the digital impression accuracy. [25,26] This part is often constructed from the same material as the body but has a distinct form. PEEK (Poly-Ether-Ether-Ketone), aluminium alloy, titanium alloy, and different resins are various materials used to make up the body, which stretches from the scan area to the base.

The scan strategy and the principle of capture of an object are of utmost significance and influence the implant impression's accuracy. [27] The original shape, design, [28,29] manufacturing tolerances [30,31] the application of different torque while connecting the ISBs [32] has been found to have a significant influence on the dimensional distortion of the implant position. [33] The scanner [34,35] and scanning protocol [26] [36] is also found to influence the dimensional coordinates of the implants and thereby affect the passive fit of the prosthesis.

Numerous analyses have compared the precision of digital implant impressions with ISBs as opposed to the conventional technique. However, there is a dearth of studies pertaining to the influence of the geometry/material of different ISBs on the influence of implant impression accuracy. This systematic review was conducted to assess the impact of the intraoral Scan Bodies on the precision of digital impressions made for a full-coverage implant-supported prosthesis.

MATERIAL AND METHODS

Protocol and registration:

The PRISMA protocols statement was adopted when it was initiated, and the comprehensive protocol was recorded at "PROSPERO International Prospective Register of Systematic Reviews" [37] under the registration number CRD42021234179.

Focused topic and Patient, Intervention, Comparison and Outcome (PICO) Questions:

The systematic study aimed to answer the following question: Are digital impressions made for fixed implant-supported prostheses comparable in terms of accuracy with different intraoral scan bodies?

The following focused clinical question was characterized using the "population, intervention, comparisons, and outcomes" (PICO) format:

- **Population / Participants:** Digital impressions/Models/ Master models for implant prosthesis
- **Intervention:**Digital impression for implant-supported prosthesis using intraoral scan bodies.
- **Comparison:** Digital impression for implant-supported prosthesis using different intraoral scan bodies of varying geometry/material.
- **Outcome:** Three-dimensional accuracy of implant positions

Search Strategy and Selection Criteria:

Electronic databases: MEDLINE database via PubMed and Google Scholar, the register was searched for studies in English without time restrictions, reporting 3D accuracy of implant positions for use of digital impression for implant-supported prosthesis employing different intraoral scan bodies. The last search was performed in November 2021.

Inclusion criteria was all literature on dental digital impressions using intraoral scan bodies made for an implant-supported prosthesis, Systematic reviews, in-vitro studies, and RCTs pertaining to the accuracy of implant impressions made using intraoral scan bodies. Only studies published in English language upto November 2021 were included. The Exclusion criteria was Expert opinion and narrative reviews, Animal studies, Case reports and case series and articles in languages other than English

The search was carried out separately by two reviewers (V.D., A.K.). Combinations of controlled terms (MeSH), keywords, and Boolean operators were employed whenever possible. The search approach is described in great depth in **Table 1** of the document. After duplicate records were eliminated, two investigators (V.D., A.K.) independently performed the study selection by initially screening the title and abstract according to the inclusion criteria. Only with common agreement from the two parties were

articles included in the full-text analysis. Where there were disagreements, it was addressed via consensus discussion presided by a third reviewer (S.W.). In the event of several researchers from the same cohort, if the publication revealed distinct results, both investigations were included; if the same result was recorded at separate visits, all studies were included with accuracy outcome was used for quantitative analysis. After following the above two criteria, n=8 analyses have been included.
Data extraction was conducted independently with 2 reviewers (V.D., A.K.) according to the aims of a present systematic review and was reciprocally blinded to others' extraction. Disagreements between the review authors were discussed and resolved with a third review author (S.W.). The data extracted, comprises the features of the qualifying studies which were entered into the piloted data extraction sheet.
Two independent assessments for the included in-vitro analyses evaluated the risk of bias, and disagreements were settled by discussion and the necessary consultation with a third reviewer using the Joanna Briggs Institute (JBI) checklist [38-42] Based on sample size, randomization, standardization of scanners and intraoral scanning protocols, blinding, and statistical analysis, the risk assessment domains were rated as high, uncertain, or low risk. Therefore, based on the domains and criteria, the total risk for each study was rated as low, medium, or high risk. When one or more areas were determined to be unknown, the studies were given a medium-risk evaluation, with none at high risk.

RESULT

Based on the strict selection criteria, each title and abstract were reviewed. The next step was for the two reviewers to separately evaluate the whole document. The inclusion criteria for full-text reading were satisfied by a total of 8 studies throughout the last 3 decades, and all 8 were considered for further analysis. (**Figure 1**)

Study characteristics-

The studies were conducted from 2000-2021. All the studies were heterogeneous in study designs, some were clinical studies [26] [43], one was a retrospective study [44] and some were in-vitro studies [32] [45-48] (Table 2). Out of 08 studies, 06 studies [32] [44-48] were conducted on models while two studies related to patients [26] [43].
A cumulative total of 75 patients participated in the two clinical studies and both of them had a definite inclusion & exclusion criterion for choosing participants. Only those patients were included who did not suffer from any systemic illness, growth abnormality, and bone disorders. In the cross-sectional in-vitro studies, around 215 master models with varied components and specifications were incorporated. (Table 2)
Trios 3® intraoral scanner was applied in the research design of the majority of the studies [26] [43-45] [47,48] included, one study [34] used an E1 lab scanner and one study [46] used iTero Element; type of scanner. The geometry, material, and type of SB used were heterogeneous and the scans obtained were compared to their respective reference scans/models accordingly (Table 2)
The included studies assessed the influence of the SB on the implant position accuracy either by angular and/or linear displacements in the implant positions or misfits or passive fit of the prosthesis. (Table 3)
The data available was qualitative and heterogenous hence quantitative analysis of the outcome was not conducted with meta-analysis.
The bias risk was assessed by two independent reviews for in-vitro analyses included in the review using JBI review [49] and disagreements were settled by discussion and suitable consultation with a 3rd reviewer. The risk assessment categories were graded as Yes (+), No (-), or Not mentioned [50]. Therefore, based on the domains and criteria, the total risk for each study was rated as low, moderate, or high risk. The articles that reported yes in 1 to 3 items were categorized as high risk of bias, 4 to 6 as a medium, as well as 7 to 8 as low risk out of the 8 questions in the checklist. Only when all six domains were shown to be at low risk was the research evaluated to have a low overall risk; otherwise, it was determined to have a high overall risk. When one or more domains were determined to be unknown, a moderate risk evaluation was given to the research, with none at high risk.
The majority of studies reported performance and detection bias in their methodology. Studies included showed the medium risk for cross-sectional study design (Table 4).

DISCUSSION

The aim of the present systematic review was to ascertain the effect of geometry, shape, or material of ISB on the accuracy of digital impressions made for implant-supported prosthesis. ISBs are accurate components for determining the orientation and position of dental implants. They are secured to a fixture for an implant and imaged using an "intraoral scanner" right from the patient's mouth. But there is limited literature available to sort out the desirable ISB required to obtain an accurate digital implant impression.

The findings of this review indicate that there is a variation of opinion among the included studies with respect to various ISBs. The evaluation was on the basis of clinical and in-vitro studies included to try to define an evidence-based protocol regarding the use of ISBs of different shapes, geometry, or material so as to obtain an accurate digital implant impression. After a thorough screening of the databases, 8 articles including 2 clinical and 6 in-vitro studies were retrieved. Seven studies acknowledged the influence of the ISB or the scan strategy on the precision of the implant impressions and one study illustrated the span of the prosthesis which can be fabricated with acceptable clinical outcomes using a digital impression.

Clinical studies:

Of the two clinical studies involved in the systematic review, 1 study [26] described the effect of scan strategy and concluded that a continuous scan strategy i.e., the presence of an anatomical landmark between the ISBs serves as a practicable option in obtaining a precise implant impression. The other study [43] examined the ISB misfit with regard to the span of the edentulous area and concluded that digital scanning can be used as a viable option for implant-supported prostheses of up to 3 units for an edentulous saddle that is bounded.

Imburgia et al, [26] performed a retrospective clinical research among 45 individuals who had been rehabilitated with more than four implants using the continuous scan strategy and complete digital workflow. One-piece titanium SBs ("Scan Abutment AQ®") which were connected using thermoplastic resin were used and marginal adaptation as well as the passive fit were assessed at three intervals with the last evaluation at 2 years after restoration. They found 100% implant survival and 93.3% prosthetic success.

Nagata et al, [43] conducted a study on 30 individuals with up to 3 missing teeth along with teeth present on one side. Mono SB RC, RN, Straumann ®, Basel, "Switzerland" was used and the SB misfit was assessed in different clinical scenarios. He concluded that the span of the edentulous area being restored is a determinant of digital impression accuracy. However, the direct link between the span and the accuracy of intraoral scan was not established.

In-vitro studies:

All six studies included ascertained the effect of change in the material or geometry of the SB on the precision or accuracy of the implant impression. All studies had a reference model scanned either using an industrial scanner [32] [44-45] [47-48] or positions measured using a coordinate measuring machine [46]. Arcuri L et al, [44] conducted a randomized in-vitro trial comparing the effect of scan bodies of PEEK, titanium, or a combination of both. They concluded that the PEEK scan body and the PEEK-titanium SB produced the least and most linear or angular discrepancy respectively. Huang R et al, [45] conducted a study comparing the original SB and CAD-CAM scan body with and without extension to conventional impression. Based on trueness and precision, the conventional impression was the best, followed by the digital impression using the "CAD-CAM" scan body with extension and then using the CAD-CAM scan body. Kim J et al [32] performed research on scan bodies with PEEK and Titanium base assessing the vertical and horizontal displacement upon screw tightening and found out that the PEEK group (Myfit and Dentium SB) produced a remarkable vertical displacement of up to 100 microns and the Straumann group produced the least displacement in the PEEK group. Revilla Leon et al [46] comparing the angular & linear positions of implant positions found that the SB position in the Z axis was the most accurate. Nevertheless, significant variations were found in the XZ plane. This means the corono-apical position of the ISB was most accurate but the buccolingual positioning showed a variability. This suggests that the fit of the prosthesis might be hampered or it might not be passive leading to bio-mechanical complications. [51].

Mizumoto et al. [47] came to the conclusion that both the SB and the scan procedure had an impact on the correctness (precision and trueness) of whole arch digital implant scans employing ISBs. He also concluded that scan bodies have an influence on the scan time. The cylindrical type of scan body required lesser scan time as opposed to scan body with more geometrical complexities. But no conclusion regarding the effect of shape of ISB on the accuracy of the impression could be drawn. Motel C et al [48] conducted research comparing the precision of the digital impression using three different SB geometries and 2 distinct scan policies and confirmed the influence of both on the same. This might be due to the errors due to superimposing, thereby concluded about the effect of scan body and scan stratergy on the implant impression, They also deduced that the single scan protocol and 3 shape scan bodies had a potential advantage.

All these studies used Trios3; 3 shape IOS except for one study [46] which used the itero Element scanner to scan and acquire the implant position in the test group. This is to be categorized as a major limitation of this study as the effect of other commercially available IOS on the SB -determined implant position cannot be commented upon. Studies comparing the different IOS on the implant impression accuracy are necessary to probe into the effect of different IOS on the SB positions.

In comparison to the above-included studies, Schmidth A et al [52] assessed the linear distances among three commercially available scan bodies as opposed to conventional impressions and concluded that longer scanning paths led to higher deviations in implant positions. Also, the discrepancies were more toward the implants at the end of the scanning path than that at the beginning. In another study [53] it was found that the manufacturing tolerances between ISBs negatively influence the transfer precision of the implant position. Yong Do Choi [54] inferred that the level of clinical exposure to SB is inversely proportional to the accuracy of implant positioning.

This systematic review includes a small number of investigations, with significant differences across the studies in terms of the population, the comparison methods, the SB or scan strategy used, outcome assessed. Some methodological constraints with regards to the included studies rendered all the studies to be of medium risk of bias with none at low risk. All these studies were carried out in a laboratory set up and the results of the same cannot be quoted equivocally in a clinical scenario. More human-related randomized controlled trials are necessary to evaluate and address the main purpose of the systematic review. The scope for meta-analysis was constrained due to the population's diversity, the variety of comparators, and the lack of homogeneous quantitative data. Despite these constraints, this systematic review has evaluated the role of the geometry, material of the ISB, and the scan strategy, with a view that the variables pertaining to the SB has an influence on the digital impressions accuracy made for the fabrication of implant retained prosthesis.

Table 1: Study selection criteria

CRITERIA	SEARCH STRATEGY
Population	#1 ("digital impressions" [MeSH Terms]) OR "master models" [Title/Abstract]) OR ("implant supported prosthesis" [Title/Abstract]) OR ("implant prosthesis" [Title/Abstract])
Intervention	#2 ("intraoral scanners" [MeSH Terms]) OR ("digital intraoral scanners" [Title/Abstract])
Comparison	#3 ("intraoral scan bodies" [MeSH Terms]) OR ("scan bodies" [full text])
Outcome	#4 (accuracy [MeSH Terms]) OR (Precision [Title/Abstract]) or (Trueness [Title/Abstract])
Final search strategy	#1 AND #2 AND #3 AND #4 (free full texts)

TABLE 2: Demography and features of the included investigations

S. N.	The study, Year; Region	Study design	The type of scanner used	Type of ISB used (geometry)	Control/ Comparator group
1	Imburgia M et al, 2020; Italy, Europe [26]	Retrospective clinical study	Trios3®, 3Shape; Copenhagen, Denmark	One-piece titanium SBs connected to each other using thermoplastic resin	-
2	Nagata K et al, 2021; Kanagawa [43]	Clinical study	Trios 3®, 3Shape; Copenhagen, Denmark	"Mono Scanbody RC, RN, Straumann ®, Basel, Switzerland"	It was possible to compare the precision of the impressions for single, 2, & 3-unit implant prostheses with a confined edentulous space using combining the STL data from IOS with the STL data from the plaster model that was applied to create the concluding prosthesis.
3	Arcuri L et al, 2020; United Kingdom, Europe [44]	Randomized-in-vitro study	"TRIOS3; 3Shape A/S, Copenhagen, Denmark"	6 biomedical grade titanium (T), 6 polyether-etherketone (Pk), and six hybrids, (Pk body having T base) (Pkt) ("LaStruttura spa, Varese, Italy")	A structured blue light optical scanner employed in the industry was used to examine the master model with the embedded analogues (ATOS Compact Scan 5M, GOM GmbH, Braunschweig, Germany).
4	Huang R et al, 2020; China [45]	In-vitro study	TRIOS3; 3Shape	Group 1st (DO): Original SB ("Basel, Straumann, Switzerland").	parallel dental implants (Bone-level tapered RC; scanned with lab reference scanner (D2000; 3Shape

				Group 2nd (DC): CAD/CAM SB with no extensional structure. Group 3rd (DCE): Digital impression—CAD-CAM SB similar to group II SB but with extensional structure 20mm in length. Group 4th (CI): "Conventional impression"	Straumann) positioned at the positions of the canine and the 1st molar bilaterally and allocated to open-format STL) were used to create a mandibular acrylic model.
5	Kim J et al, 2020; Korea [32]	In-vitro study	E1 scanner, 3Shape, Copenhagen, Denmark	Three different forms of scan bodies with PEEK-based base areas - Myfit (PEEK), Dentium, and Straumann Group, as well as the fourth kind of SB with a titanium-based foundation—the Myfit (Metal Group)—have been developed.	The SB library was positioned on the implant's central axis to create the reference model.
6	Revilla-leon et al, 2020; Texas [46]	In-vitro study	iTero Element; Cadent	SB-I (Elos Accurate Nobel Biocare), SB-II ("NT Digital Implant Technology"), and SB-III ("Dynamic Abutment")	A coordinate measuring machine was utilized to determine the SB locations on the x, y, & z axes with a 0.5-mm stylus with a 0.1-N tactile load.
7	Mizumoto R et al, 2019; Columbus [47]	In-vitro study	TRIOS; 3Shape	NT (Nt-Trading GmbH and Co KG), AF (IO-Flo; Dentsply Sirona), DE (DESS- ***United States of America***), C3D (Core3Dcentres), and ZI ("Zimmer Biomet Dental")	Four identical ISBs from five different manufacturers were connected to each implant, resulting in five master models. Each reference model's surface was reverse-engineered after it was examined with structured "blue light" industrial. The digitized model was stored as an STL file so that it could be used as the master reference model (MRM).
8	Motel C et al, 2019; Europe [48]	In-vitro study	TRIOS®3 intraoral scanner	Group I: 3Shape A/S, Denmark- comparatively flat and cylindrical with a partially bevelled upper part; Group II: NT-Trading GmbH, Germany- had a relatively interrupted, uneven shape with indentations and bulges, which have been cylindrical within the cervical region and marginally oval within the coronal region. Group III: TeamZiereis, Germany - had an overall cylindrical form with one retraction per individual and a somewhat large coronal diameter.	A titanium master model with 3 titanium bone-level implants was positioned and welded in a linear arrangement at various distances & angulations, to guarantee a standardized investigational setup. The titanium model was examined with an industrial white light scanner, and the STL file thus obtained served as a reference scan.

TABLE 3: Result and conclusion of the studies

Sr. No.	The study, Year; Region	Outcome measured	Result	Conclusion
1	Imburgia M et al,[26]	At T0 (intraoral try-in of a "polyurethane" or metal duplicate of the concluding prosthesis) and T1 (delivery of the overall zirconia restoration), the superstructures' marginal adaptability and passive fit were examined. The secondary results, recorded at T2 (two years after the final prosthesis delivery)	At T0, 40/45 replicas exhibited flawless passive fit & adaptation. At T1, one prosthesis fractured, whereas at T2 two prostheses fractured and 1 chipped. The implant success rate was one hundred percent. The prosthesis success rate was 93.3%.	A continuous Scan Strategy seems to be a promising alternative for taking precise intraoral digital impressions for the manufacture of precision implant-aided restorations with extended service life.
2	Nagata K et al, 2021; Kanagawa [43]	The average scan-body misfit	Significant variations were found among the precisions of different clinical scenarios depending on the number of missing teeth ($P < 0.001$).	Implant-supported prosthesis with up to 3 units for a bound edentulous saddle may find clinical applications using IOS and CAD-CAM.
3	Arcuri L et al, 2020; United Kingdom, Europe [44]	Linear(DX, DY and DZ axis) and angular (DANGLE) discrepancies	When the linear discrepancy was considered, it was determined that a substantial impact of material (p less than 0.0001) and position (p=0.0009) whereas no substantial operator impact was found. When DANGLE has been taken into account, material and location had a statistically substantial impact on the predicted DANGLE (p = 0.0232 & p 0.0001), but there was no evidence of an operator influence.	The implant SB material had a large impact on the digital IOS complete-arch impression, with PEEK displaying the greatest findings on both angular and linear measures, followed by titanium, having peek-titanium displaying poor outcomes.
4	Huang R et al, 2020; China [45]	**Trueness** **Precision**	The trueness median (IQR) was 35.85 (29.80 to 49.10) µm for Group 1st (DO), 38.50 (35.35 to 52.58)µm for Group 2nd (DC), 28.45 (24.88 to 36.43) µm for Group 3rd (DCE), & 25.55 (22.98 to 28.90)µm for Group 4th (CI). CI was more precise as compared to DC(*p*=.002) & DO(*p*=.015). No substantial variations were observed between DC and DO (*p*=1.000), DCE and DO (*p*=.461), DCE and DC (*p*=.133), and DCE and CI (*p*=1.000). The median (IQR) of accuracy was 48.40 (40.80 to 57.90) µm for Group 1st (DO), 48.90 (38.70 to 85.40)µm for Group 2nd (DC), 27.30 (22.50 to 35.50)µm for Group 3rd (DCE), & 19.00 (15.70 to 22.75)µm for Group 4th (CI). CI exhibited considerably greater accuracy than DO (*p* less than .001), DC (*p* less than .001) and DCE (*p*=.007). DCE was more accurate as compared to DC (*p*	CI had a higher accuracy rate compared to DC (*p*=.002) and DO (*p*=.015). DC and DO (*p*=1.000), DO and DCE (*p*=.461), DCE and DC (*p* =.133), and CI and DCE (*p*=1.000) did not vary significantly from one another.

			less than .001) and DO (*p* less than .001).	
5	Kim J et al, 2020; Korea [32]	Vertical and horizontal displacement of implant positions	Three-dimensional, horizontal vertical, and displacements between the various SB forms differed significantly (*P* less than .001) from one another. In comparison to the Dentium and Myfit (PEEK) groups (*P* less than .05), there was a considerably smaller displacement in the "Straumann group".	There were substantial variations in three-dimensional, vertical, & horizontal displacements amongst the various forms of scan bodies (*P*<.001). The horizontal displacement for each group was below 10μm. In PEEK scan bodies, a large vertical displacement of more than 100μm happened with the hand tightening torque.
6	Revilla-leon et al, 2020; Texas [46]	Linear (x-, y-, and z-axis), angular (XZ and YZ angles), and three-dimensional differences in implant positions	Owing to its movement when palpating with the least amount of pressure feasible, the coordinate-determining machine was not able to determine the SB locations of the magnetically held SB-III group. As a result, this group was disqualified. No substantial variations have been observed in the linear differences between the SB-I & SB-II groups (P greater than .05). The z-axis was used to achieve the most precise SB location. However, Nevertheless, the SB-I group had a considerably greater XZ angular difference as compared to the SB-II group (P less than .001).	The studied systems (SB-I and SB-II groups) were capable of properly transferring linear implant locations on the x-y- & z-axes to the virtual implant working cast of a partly dentate digital scan, with the z-axis providing the most precise SB location. Nevertheless, substantial variations were found in the XZ angular implant location in the SB systems examined.
7	Mizumoto R et al, 2019; Columbus [47]	The scan bodies' distance and angular deviations.	In terms of accuracy, no statistically substantial interaction has been observed between the influences of the SB and method on the "distance deviation" (P=.246); Nevertheless, the SB (P=.031) and the method (P less than .001) each had a substantial influence independently and a substantial influence on "angular deviation" (P<.001). Screening for the homogeneity of changes revealed substantial variations in the groups' accuracy in terms of angular deviation (P≤.003) & distance deviation (P≤.013). The influences of the SB and method on the scan duration did not interact statistically significantly (P=.076), while the SB alone has been shown to have a substantial influence(P less than .001).	When employing a particular IOS system, the SB and the scan method both have an impact on the accuracy (precision) and trueness of whole arch digital implant scans with ISBs. The distance deviation was substantially lower for the ZI SB than it was for the scan bodies that had been splinted with floss. Scan methods show similar distance deviation with or without different surface modifications of ISB. The usage of various ISBs resulted in significant variations in scan times.
8	Motel C et al, 2019; Europe [48]	digital impressions accuracy.	The precision of the digital implant image with respect to the Euclidean distance was substantially impacted by strategy A w.r.t the scan bodies' shape (P=0.003). No substantial variation has been observed with approach B. Comparing the 2 scan approaches showed that approach A attained considerably greater precision overall (P=0.031).	The shape of the SB and the scan approach both seem to have an impact on the quality of digital intraoral imprints. The one-step scan approach looks advantageous for practical practice. Additionally, the 3Shape scan bodies demonstrated a possible clinical benefit.

TABLE 4- Risk of bias and Quality assessment of Included Studies based on parameters adapted from previous studies on basix research publication by Silva EJ et al, da Rosa WL et al, Sarkis-Onofre R et al, AlShwaimi E et al and Sedrez-Porto JA (38-42)

Study Id	Sample size calculation	Samples with similar dimensions	Control	Type or material of SB	Standardization of procedures	Scanning performed by a single operator	Blinding of the observer	Statistical analysis conducted	Risk of bias
Imburgia et al [26]	-	+	-	+	+	NM	-	+	Medium risk
Nagata et al [43]	-	+	+	+	+	+	-	+	Medium risk
Arcuri L et al [44]	-	+	+	+	+	-	+	+	Medium risk
Huang R et al [45]	-	+	+	+	+	+	-	+	Medium risk
Kim J et al [32]	-	+	+	+	+	NM	-	+	Medium risk
Revilla-Leon et al [46]	-	+	+	+	+	+	-	+	Medium risk
Mizumoto R et al [47]	-	+	+	+	+	+	-	+	Medium risk
Matta R et al [48]	-	+	+	+	+	NM	-	+	Medium risk

(NM: Not mentioned)

CONCLUSION

There is limited evidence with regards to the selection of a SB based on its material or geometry as most of the studies pertaining to the same are non-human based in-vitro experimental tests whose approaches and findings could not be extrapolated onto human subjects due to the ambiguity with regards to the population intervened. Thus, the findings of this systematic review must be considered carefully & well-designed human RCTs with a standardized protocol and quantitative evidence to support the same should be conducted in substantial numbers.

REFERENCES

1. "Alghamdi H, Arland PS, Anil S. (2011). Undersized implant site preparation to enhance Primary implant stability in poor bone density: a prospective clinical study. J Oral Maxillofac Surg. ;69(12):506-512.
2. Schwartz-Arad D, Herzberg R, Levin L. (2005). Evaluation of long-term implant success. J Periodontol. ;76(10):1623-8.
3. Moreira AH, Rodrigues NF, Pinho AC, Fonseca JC, Vilaça JL.(2015). Accuracy comparison of implant impression techniques: a systematic review. Clin Implant Dent Relat Res. 17:e751-64.
4. Tan KB. (1995). The clinical significance of distortion in implant prosthodontics: is there such a thing as passive fit? Ann Acad Med Singap.1;24(1):138-157.
5. Conrad HJ, Pesun IJ, DeLong R, Hodges JS. (2007). Accuracy of two impression techniques with angulated implants. J Prosthet Dent. 1;97(6):349-356.
6. Brandt J, Lauer H, Thorsten P, Brandt S. (2015). Digital process for an implant-supported fixed dental prosthesis: a clinical report. J Prosthet Dent 1;114:469-473.
7. Jemt T. (1991). Failures and complications in 391 consecutively inserted fixed prostheses supported by Brånemark implants in edentulous jaws: a study of treatment from the time of prosthesis placement to the first annual checkup. Int J Oral Maxillofac Implants. 1;6(3).90-98
8. Masri R, Driscoll CF, editors. (2015). Clinical applications of digital dental technology. New York, NY: John Wiley & Sons; 27;27-41
9. Seelbach P, Brueckel C, Wöstmann B. (2013). Accuracy of digital and conventional impression techniques and workflow. Clin Oral Investig. 17(7):1759-64.
10. Lee SJ, Gallucci GO. (2013). Digital vs. conventional implant impressions: efficiency outcomes. Clin Oral Implants Res. ;24(1):111-5.

11. Yuzbasioglu E, Kurt H, Turunc R, Bilir H. (2014). Comparison of digital and conventional impression techniques: evaluation of patient's perception, treatment comfort, effectiveness, and clinical outcomes. BMC oral health. ;14(1):1-7.
12. Christensen GJ. (2009). Impressions are changing: deciding on conventional, digital, or digital plus in-office milling. J Am Dent Assoc, ;40:1301-4.
13. Rudolph H, Salmen H, Moldan M, Kuhn K, Sichwardt V, Wöstmann B, et al. (2016). Accuracy of intraoral and extraoral digital data acquisition for dental restorations. J Appl Oral Sci,;24:85-94.
14. BIPM, IEC, IFCC, ISO, IUPAC, IUPAP, OIML (1993) International vocabulary of basic and general terms in metrology (VIM). 2nd edition, ISO, Geneva 7.
15. ISO (1993) ISO 3534-1 Statistics–Vocabulary and symbols. Probability and general statistical terms.
16. ISO, Geneva 8. ISO 5725-1 (1998) Accuracy (trueness and precision) of measurement methods and results–Part 1: General principles and definitions. ISO, Geneva
17. ISO 5725-1.(1994). Accuracy (trueness and precision) of measuring methods and results. Part-I: General principles and definitions. Berlin: Beuth Verlag GmbH; pp 2-24.
18. Ender A, Mehl A: (2013). Accuracy of complete-arch dental impressions: a new method of measuring trueness and precision. J Prosthet Dent 1;109:121-8.
19. Gan N, Xiong Y, Jiao T: (2016). Accuracy of intraoral digital impressions for whole upper jaws, including full dentitions and palatal soft tissues. PLoS One 11:e0158800.
20. Lie A, Jemt T. (1994). Photogrammetric measurements of implant positions. Description of a technique to determine the fit between implants and superstructures. Clin Oral Implants Res; 5:30-6
21. Wilk BL. (2015). Intraoral digital impressioning for dental implant restorations versus traditional implant impression techniques. Commend Contin Educ Dent; 36:529-30, 532-3.
22. Del Corso M, Abà G, Vazquez L, Dargaud J, Dohan Ehrenfest DM. (2009). Optical three-dimensional scanning acquisition of the position of osseointegrated implants: an in vitro study to determine method accuracy and operational feasibility. Clin Implant Dent Relat Res;;11:214-21.
23. Stimmelmayr M, Güth JF, Erdelt K, Edelhoff D, Beuer F. (2012). Digital evaluation of the reproducibility of implant scan body fit, an in vitro study. Clin Oral Investig,;16:851-6.
24. Mizumoto RM, Yilmaz B.(2018). Intraoral scan bodies in implant dentistry: A systematic review. J Prosthet Dent ;120(3):343-52
25. Jeong B, Lee Y, Hong SJ, Paek J, Noh K, Pae A, Kim HS, Kwon KR. (2021). Accuracy of implant digital scans with different intraoral scan body shapes and library merging according to different oral exposure heights. J Korean Acad Prosthodont. 59(1):27-35.
26. Imburgia M, Kois J, Marini E, Lerner H, Mangano FG. (2020). Continuous scan strategy (CSS): a novel technique to improve the accuracy of intraoral digital impressions. Eur J Prosthodont Restor Dent. 28:1-4.
27. Logozzo S, Zanetti EM, Franceschini G, Kilpelä A, Mäkynen A. (2014). Recent advances in dental optics - Part I: 3D intraoral scanners for restorative dentistry. Opt Lasers Eng ;54:203-21.
28. Pan Y, Tsoi JK, Lam WY, Chen Z, Pow EH. (2021). Does the geometry of scan bodies affect the alignment accuracy of computer-aided design in implant digital workflow: an in vitro study? Clin Oral Implants Res.33(3);313-321.
29. Moslemion M, Payaminia L, Jalali H, Alikhasi M. (2020). Do type and shape of scan bodies affect accuracy and time of digital implant impressions? Eur J Prosthodont Restor Dent. 28(1):18-27.
30. Braian M, De Bruyn H, Fransson H, Christersson C, Wennerberg A. (2014). Tolerance measurements on internal- and external-hexagon implants. Int J Oral Maxillofac Implants.;29(4). 10-15
31. Lerner H, Nagy K, Luongo F, Luongo G, Admakin O, Mangano FG. (2021). Tolerances in the production of six different implant scan bodies: a comparative study. Int J Prosthodont. 34(5):591-9.
32. Kim J, Son K, Lee KB. (2020). Displacement of scan body during screw tightening: A comparative in vitro study. J Adv Prosthodont. 12(5):307.
33. Tan JZ, Tan MY, Toh YL, Wong KY, Tan KB. (2021). The three-dimensional positional accuracy of intraoral and laboratory implant scan bodies. J Prosthet Dent. 20:89-96.
34. Kim RJ, Benic GI, Park JM. (2020). Trueness of ten intraoral scanners in determining the positions of simulated implant scan bodies. Sci Rep. 28;11(1):1-9.
35. Amornvit P, Rokaya D, Sanohkan S. (2021). Comparison of the accuracy of current ten intraoral scanners. BioMed Res Int. 13;2021.
36. Oh KC, Park JM, Moon HS. (2020). Effects of scanning strategy and scanner type on the accuracy of intraoral scans: a new approach for assessing the accuracy of scanned data. J Prosthodont.29(6):518-23.
37. Shamseer L, Moher D, Clarke M, Ghersi D, Liberati A, Petticrew M, Shekelle P, Stewart LA. (2015). Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: elaboration and explanation. Br Med J. 2:349.
38. Silva EJ, Canabarro A, Andrade MR, Cavalcante DM, Von Stetten O, da Silva Fidalgo TK, De-Deus G. (2019). Dislodgment Resistance of Bioceramic and Epoxy Sealers: A Systematic Review and Meta-analysis. J Evid Based Dent Pract. 1;19(3):221-35.
39. da Rosa WL, Piva E, da Silva AF. (2015). Bond strength of universal adhesives: A systematic review and meta-analysis. J Dent. ;43(7):765-76.

40. Sarkis-Onofre R, Skupien JA, Cenci MS, Moraes RR, Pereira-Cenci T. (2014). The role of resin cement on bond strength of glass-fiber posts luted into root canals: a systematic review and meta-analysis of in vitro studies. Operative dentistry.39(1):E31-44.
41. AlShwaimi E, Bogari D, Ajaj R, Al-Shahrani S, Almas K, Majeed A. (2016). In vitro antimicrobial effectiveness of root canal sealers against enterococcus faecalis: A Systematic Review. J Endod. 1;42(11):1588-97.
42. Sedrez-Porto JA, da Rosa WL, Da Silva AF, Münchow EA, Pereira-Cenci T. (2016). Endocrown restorations: A systematic review and meta-analysis. J Dent. 52:8-14.
43. Nagata K, Fuchigami K, Okuhama Y, Wakamori K, Tsuruoka H, Nakashizu T, Hoshi N, Atsumi M, Kimoto K, Kawana H. (2021). Comparison of digital and silicone impressions for single-tooth implants and two-and three-unit implants for a free-end edentulous saddle. BMC Oral Health.21(1):1-8.
44. Arcuri L, Pozzi A, Lio F, Rompen E, Zechner W, Nardi A. (2020). Influence of implant scan body material, position and operator on the accuracy of digital impression for complete-arch: a randomized in vitro trial. J Prosthodont Res. 64(2):128-36.
45. Huang R, Liu Y, Huang B, Zhang C, Chen Z, Li Z.(2020). Improved scanning accuracy with newly designed scan bodies: An in vitro study comparing digital versus conventional impression techniques for complete-arch implant rehabilitation. Clin Oral Implants Res. 31(7):625-33.
46. Revilla-León M, Smith Z, Methani MM, Zandinejad A, Özcan M. (2021). Influence of scan body design on accuracy of the implant position as transferred to a virtual definitive implant cast. J Prosthet Dent. 1;125(6):918-23.
47. Mizumoto RM, Yilmaz B, McGlumphy Jr EA, Seidt J, Johnston WM. (2020). Accuracy of different digital scanning techniques and scan bodies for complete-arch implant-supported prostheses. J Prosthet Dent. 123(1):96-104.
48. Motel C, Kirchner E, Adler W, Wichmann M, Matta RE. (2020). Impact of different scan bodies and scan strategies on the accuracy of digital implant impressions assessed with an intraoral scanner: an in vitro study. J Prosthodont. 29(4):309-14.
49. Tran L, Tam DN, Elshafay A, Dang T, Hirayama K, Huy NT. (2021). Quality assessment tools used in systematic reviews of in vitro studies: A systematic review. BMC Med Res Methodol.;21(1):1-3.
50. Moola SZ, Munn Z, Tufanaru C, Aromataris E, Sears K, Sfetcu R, Currie M, Qureshi R, Mattis P, Lisy K, Mu PF. (2017). Chapter 7: Systematic reviews of etiology and risk. Joanna briggs institute reviewer's manual. The Joanna Briggs Institute. 17;5.
51. Mukhopadhyay P, Khalikar A, Wankhade S, Deogade S, Shende R. (2021). The Passive Fit Concept-A Review of Methods to Achieve and Evaluate in Multiple Unit Implant Supported Screw Retained Prosthesis. J Dent Oral Sci. ;3(2):1-7.
52. Schmidt A, Billig JW, Schlenz MA, Wöstmann B. (2021). The influence of using different types of scan bodies on the transfer accuracy of implant position: an in vitro study. Int. J. Prosthodont.;34:254-60.
53. Schmidt A, Billig JW, Schlenz MA, Rehmann P, Wöstmann B. (2019). Influence of the accuracy of intraoral scan bodies on implant position: differences in manufacturing tolerances. Int J Prosthodont.;32(5):430-2.
54. Choi YD, Lee KE, Mai HN, Lee DH. (2020). Effects of scan body exposure and operator on the accuracy of image matching of implant impressions with scan bodies. The Journal of prosthetic dentistry. 124(3):379-e1".

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