The journal of
PROSTHETIC
AND IMPLANT
DENTISTRY
Official Publication of Indian Prosthodontic Society
Kerala State Branch

ACCURACY OF DIGITAL IMPRESSION WITH DIFFERENT GEOMETRY AND MATERIAL OF SCAN BODIES FOR FULLY EDENTULOUS ARCHES – A SYSTEMATIC REVIEW AND META-ANALYSIS

*Naisargi Shah, **Suprabha Krishnakumar, ***Anuradha Govardhane,
****Adithi Prabhu, **** Sailee Bhogwekar, ****Priya Pungle

*Head of the Department, **PG Student, ***Reader, ****Lecturer, Department of Prosthodontics and Crown and Bridge. Terna Dental College and Hospital, Navi Mumbai. Corresponding Author: Dr. Suprabha Krishnakumar, Email: suprabha.kk97@gmail.com

https://doi.org/10.55231/jpid.2025.v08.i02.02

Abstract

Aim: *To evaluate the accuracy of digital impression by using scan bodies of different geometry and materials for full arch implant prosthesis.*

Settings and Design: *This was a systematic review and meta-analysis following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.*

Methods and Material: *An electronic search of PubMed (including MEDLINE), EBSCO host databases, Cochrane library and Google Scholar search engine for articles published from January 2011 to May 2023 was conducted. The literature search intended to retrieve all relevant clinical and in vitro studies about the effect of scan bodies on the accuracy of digital impression in fully edentulous arches for full arch implant prosthesis.*

Statistical analysis used: *Meta-analysis was conducted in from the reported quantitative data*

Results: *A total of 1166 articles were obtained via electronic search; 8 studies met the inclusion criteria and were included in this systematic review and were all in vitro studies. Among the different parameters described, the scan body material and geometry were evaluated. Accuracy was measured by evaluating the linear and angular discrepancies. Among the 8 included studies in this systematic review, only 3 studies were selected for meta-analysis as they were relatively homogenous in their study design and outcome variables. Linear discrepancies along X, Y and Z axis showed a statistically significant difference between PEEK and Titanium scan bodies (P < 0.05, pooled mean difference ranging from 0.00 to 0.07)*

Conclusions: *There is an overall increase in dimensional accuracy of digital impression recorded by scan bodies of cylindrical and simpler geometry. In terms of materials, PEEK scan bodies reported least discrepancies, thereby deeming to be more accurate than Titanium scan bodies.*

Keywords: ***Accuracy, edentulous, scan bodies, digital impression***

Introduction:

Tooth loss results in impairment of masticatory function, speech, aesthetics, and also affects the psychology of the patient. Implant-supported prosthesis, to replace naturally missing teeth, is one of the most common treatment modalities.[1] An accurate implant impression is an essential pre-requisite for implant restorations, as inaccurate transfer of the implant position can lead to an ill-fitting prosthesis, which may induce unnecessary strain on several prosthetic components and may result in various complications. Moreover, there is no intervening periodontal ligament at the implant-bone interface to compensate for any inaccuracies. The different factors that influence the implant impression accuracy include the impression techniques, materials used, and the number of implants present.[2]

There are two main conventional implant supported impression techniques: the direct/ pick-up technique that uses an open-tray; and the indirect/ transfer technique that uses a closed-tray. The open tray technique is chiefly indicated when the implants are not oriented parallel to each other, and can further be subdivided into splinted and non-splinted techniques. The closed tray technique is mainly indicated in case of restricted mouth opening, limited access areas (posterior region) or in patients with strong gag reflex.[3]

Nowadays, digital impressions are widespread and have revolutionized the field of implantology. Compared to traditional implant impression techniques, digital impressions eliminate several procedures such as dispensing and setting of impression materials, disinfection, and stone cast pouring. Also, the simplified workflows not only improve time efficiency, but also reduces the possibilities of deformation.[4]

Digital impressions can be achieved with the help of scan bodies. In the field of implantology, standardized scan bodies that are inserted onto the implant instead of impression copings, have been developed and well established. This enables computer-aided determination of the actual implant position using data from the digital scanner.[5] Implant Scan bodies are precision attachments that are screwed onto the coronal portion of the implant and reproduces its position in the digital model. They also assist on the digital transfer of 3-dimensional position of dental implants from the patient's mouth to computer-aided design (CAD) softwares.[6]

Implant scan body (ISB) characteristics such as connection type, geometry, dimensions, material and reusability can play a significant role in the overall accuracy of the intraoral digital impression.[7] Currently, there are different types of scan bodies of respective implant system that are available in the market. These scan bodies are manufactured as monolithic components or by a combination of different materials, as titanium alloy, polyetheretherketone (PEEK), aluminum alloy, and various resins. Scan bodies from different manufacturers also differ in their characteristic geometries as well, such as Flag shaped, Cylindrical, Tapered, Straight with/ without bevel.[7]

However, there is limited literature on the effects of ISB material and geometry on the accuracy of digital impressions made in fully edentulous arches. Hence, there is a need of more detailed investigations on these parameters of scan body which would be helpful for more accurate reproduction of the full mouth implant supported prosthesis. Therefore, the purpose of this systematic review is to evaluate the accuracy of digital impression by using scan bodies of different geometry and material for full arch implant prosthesis.

The journal of
PROSTHETIC
AND IMPLANT
DENTISTRY
Official Publication of Indian Prosthodontic Society
Kerala State Branch

Table 1: PICO concept table

PICO	POPULATION	INTERVENTION	COMPARISON	OUTCOME
KEY CRITERIA	Fully Edentulous arches for full arch implant prostheses	Digital impressions	All types of scan bodies	Accuracy of digital impression
CONTROLLED VOCABULARY TERMS (MeSH TERMS)	Jaws, edentulous Mouth¸ Edentulous Dental Prosthesis, Implant-supported	Dental Impression technique		Dimensional measurement accuracy Data accuracy
FREE TEXT **TERMS/ TEXT** **WORDS/ TiAb**	• Fully edentulous arch • Fully edentulous arches • Arches, Fully edentulous • Completely edentulous arch • Completely edentulous arches • Arches, completely edentulous • Edentulous Jaw • Edentulous Jaws • Jaws, Edentulous • Edentulous Mouth • Edentulous Mouths • Mouths, Edentulous • Mouth, Toothless • Toothless Mouth • Edentulous Patient • Edentulous Patients • Patients, Edentulous • Full arch implant prosthesis • Full arch implant prostheses • Implant prostheses, Full arch • Complete arch implant prosthesis • Complete arch implant prostheses • Implant prostheses, Complete arch • Implant Crowns • Crowns, Implant • Dental Prosthesis, Implant Supported • Implant-Supported Dental Prosthesis • Dental Prostheses, Implant-Supported • Implant Supported Dental Prosthesis • Implant-Supported Dental Prostheses • Prostheses, Implant-Supported Dental • Prosthesis, Implant-Supported Dental • Denture, Implant-Supported • Denture, Implant Supported • Implant-Supported Denture • Dentures, Implant-Supported • Implant Supported Denture • Implant-Supported Dentures • Prosthesis Dental, Implant-Supported • Dental, Implant-Supported Prosthesis • Dentals, Implant-Supported Prosthesis • Implant-Supported Prosthesis Dental • Implant-Supported Prosthesis Dentals • Prosthesis Dental, Implant Supported • Prosthesis Dentals, Implant-Supported	• Full arch impression • Full arch impressions • Impressions, full arch • Full mouth implant impression • Full mouth implant impressions • Implant impressions, full mouth • Complete arch impression • Complete arch impressions • Impressions, complete arch • Optical digital impression • Optical digital impressions • Digital impression, Optical • Dental digital impression • Dental digital impressions • Digital impressions, Dental • Digital impression • Digital impressions • Virtual impression • Virtual impressions	• Dental scan body • Dental scan bodies • Scan bodies, Dental • Digital scan body • Digital scan bodies • Scan bodies, Digital • Digital impression post • Digital impression posts • Impression posts, Digital • Dental impression post • Dental impression posts • Impression posts, • Dental • Scan post • Scan posts • Posts, Scan	• Digital impression precision • Precision of digital impression • Accuracies, Dimensional Measurement • Accuracy, Dimensional Measurement • Dimensional Measurement Accuracies • Measurement Accuracies, Dimensional • Measurement Accuracy, Dimensional • Accuracies, Data • Accuracy, Data • Data Accuracies • Data Quality • Data Qualities • Qualities, Data • Quality, Data • Discrepancies • Linear Discrepancies • Angular Discrepancies

Material and Methods:

This systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines8 with prior registration in PROSPERO (Registration number CRD42023433845). The focused question was "Will different geometry and material of scan bodies have an effect on the accuracy of digital impression for fully edentulous arches for full arch implant prostheses?" The PICO i.e., the Population, Intervention, Comparison, and Outcome format was used (Table 1). The inclusion criteria were studies that evaluated the effect of Scan bodies in fully edentulous arches for full arch prosthesis, studies on accuracy of digital implant impression by using scan bodies and articles appearing in the English dental literature, published after year 2011 till 31st May 2023. The exclusion criteria were studies wherein the use of scan bodies was limited to partially edentulous arches. Review articles, case series and case reports were also excluded.

Electronic search of PubMed (including MEDLINE), Cochrane Central, EBSCO host

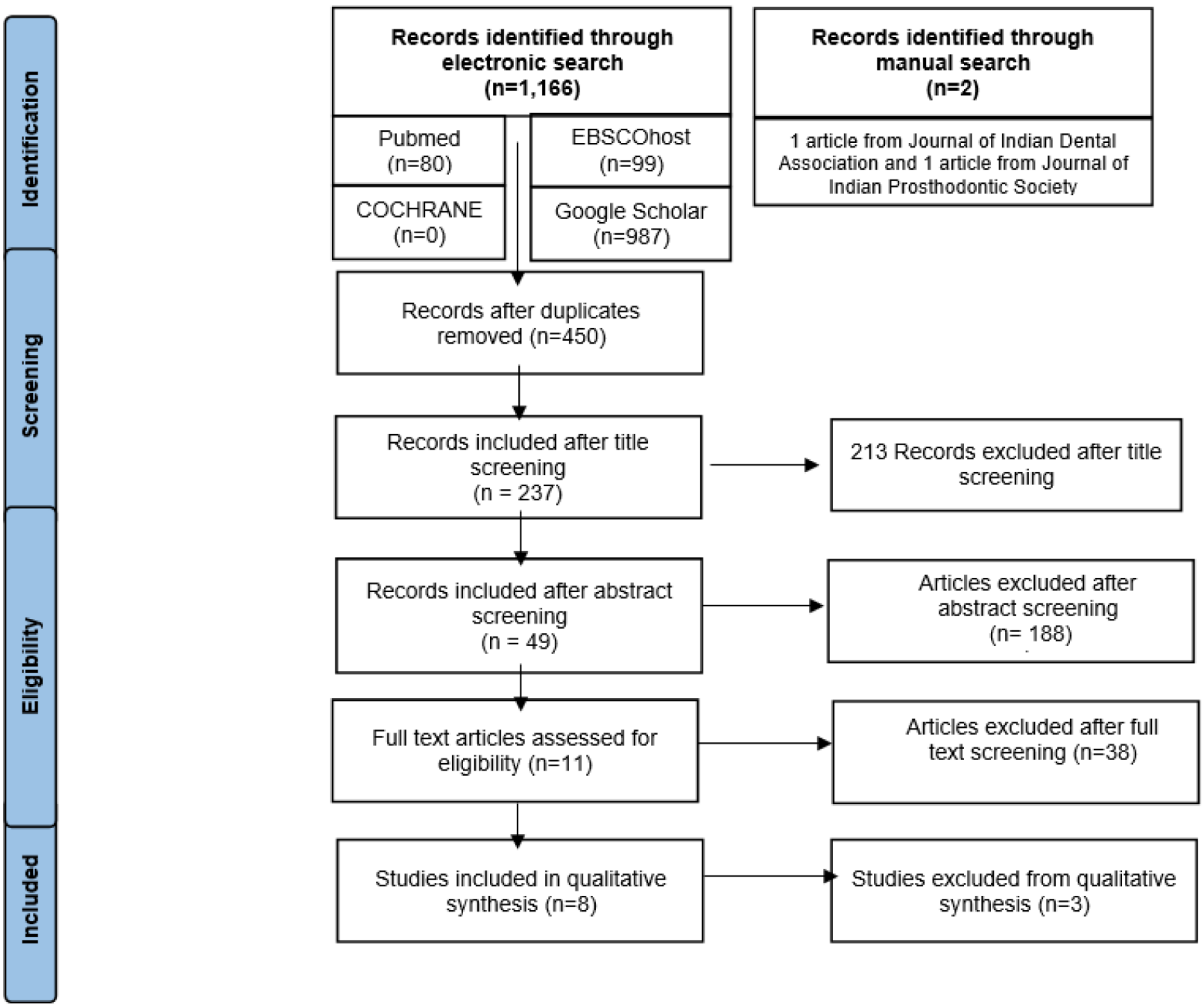

Fig. 1: PRISMA 2009 Flow Diagram

The journal of
PROSTHETIC
AND IMPLANT
DENTISTRY
Official Publication of Indian Prosthodontic Society
Kerala State Branch

databases and Google Scholar search engine for articles published from 1st January 2011 to 31st May 2023 was conducted. The controlled vocabulary terms (i.e., MeSH terms) and free text terms were obtained by searching key concepts in the MeSH database and a thorough evaluation of related articles, thesaurus, dictionaries, and entry terms. The terms such as edentulous jaws, edentulous mouth, edentulous patients, fully edentulous arches, completely edentulous arches, full mouth implant impressions, digital impressions, dental digital impressions, complete arch impressions, virtual impressions, dental scan bodies, digital scan bodies, dimensional measurement accuracy, data accuracies were combined using suitable Boolean operators (AND, OR, NOT) (Table 2).

An electronic search was conducted independently by two reviewers (S.K., A.P.) A total of 1166 articles were obtained via electronic search. The articles thus obtained were evaluated for duplicates. A detailed summary of data selection has been put forth in the PRISMA 2009 Flow Diagram[8] (Figure 1). The study characteristics of each systematic review were extracted including study details, search details, analysis and results/findings by two independent reviewers (S.K., A.P.) A third reviewer (N.P.S.) was called in for a final decision if any disagreement persisted between the two calibrated reviewers.

Results:

The 1166 articles that were obtained through the electronic searches were compared meticulously with respect to the author's name, year of publication, title, abstract as well as the journal name, issue and volume number. The articles thus obtained after the electronic and manual searches, were evaluated for duplicates using the Mendeley Desktop software (v1.19.6). The 2 articles obtained through the manual search were added manually using the 'add entry manually' feature of Mendeley Desktop software (v1.19.6). Duplicates were identified and removed using the software's "Check for Duplicates" feature. 716 duplicate articles were identified and subsequently eliminated leaving behind 450 articles. Two calibrated reviewers (S.K., A.P.) independently screened the relevant titles of the studies found through the electronic search. Out of 450 articles, 213 articles were excluded after screening of the title. The articles thus eliminated were either literature reviews, scoping reviews, case reports, case series, or articles on utilization of scan bodies on partially edentulous arches. Thus, 237 articles were selected after title screening.

Two calibrated reviewers (S.K., A.P.) now independently screened the abstracts of the studies found relevant during the screening of the titles and a total of 188 articles were further excluded after abstract screening. The articles eliminated through abstract screening were mainly involving different impression materials and comparing different brands of scan bodies. 49 articles were included after abstract screening. Hence, 8 articles were selected after abstract screening and thus were included in this systematic review. All the 8 included articles were in-vitro studies (Supplementary Table 1 and 2).

A third reviewer (N.P.S.) was called in for a final decision, if any disagreement over article selection persisted between the two calibrated reviewers. Inter-reviewer reliability was checked via Cohen's kappa coefficient.[9] The Cohen's kappa coefficient values obtained for title, abstract and full text screening was 0.65, 0.72 and 0.68 respectively, indicating moderate inter-reviewer agreement for title, abstract and full text screening. The data was subsequently extracted from the 8 included studies and recorded in 2 excel data extraction sheets as mentioned in the

Table 2: Characteristic Data extraction table of included studies

AUTHOR (YEAR)	STUDY DESIGN	MODEL	NO OF SB	MATERIAL / GEOMETRY USED	TYPE OF SCANNER	MEASUREMENT VARIABLES	TEST OF ANALYSIS	OUTCOME	ADDITIONAL OUTCOMES
Arcuri et al.[12] (2019)	In vitro	Pmma Milled Model With 6 Implant Analogues	18	-Peek -Titanium -Peek With Titanium Base	Intra-Oral Scanner	Linear And Angular Discrepancies	Analysis Of Variance (Anova)	Peek Sb Is Most Accurate, Followed By Titanium, Peek With Titanium Base	Implant Angulation Affected Linear Deviations, Implant Position The Angular Deviations.
Motel et al.[13] (2019)	In vitro	Titanium Model With 3 Implant Analogue	9	- Flat And Cylindrical With Partially Bevelled Upper Part - Cylindrical Cervically, Oval Coronally With Uneven Surface - Overall Cylindrical	Intra-Oral Scanner	Linear And Angular Discrepancies	Box-Whisker-Plots Of Deviance	Sb With Relatively Flat And Cylindrical With A Partially Bevelled Upper Part Is More Accurate	One Step Scan Strategy Is More Accurate Than Two Step
Mizumoto et al.[1] (2019)	In vitro	Poly Urethane Edentulous Maxillary Models	20	-Overall Cylindrical With Upper Bevel, -Tapered -Straight	Structured Blue Light Industrial Scanner, Intra-Oral Scanner	Linear And Angular Discrepancies	2-Way Anova Test, Bonferroni-Corrected Student T Tests.	Sb With Overall Cylindrica With A Partially Bevelled Upper Part Is More Accurate	Novel Scan Body Splinting Technique, Caused Max. Linear And Angular Discrepances
Kim et al.[14] (2020)	In vitro	Resin Cad Reference Model (Crm)	30	-Peek -Titanium	Laboratory Scanner.	Linear Discrepancies	One-Way Analysis Of Variance And Tukey's Hsd Post Hoc Test	Titanium Sb More Accurate. Vertical Displacement Occurred More In Peek Scan Bodies	Tightening Torque Of 5 Ncm Produces Least Displacement
Karthik et al.[15] (2022)	In vitro	Completely Edentulous Mandibular Model With 4 Dental Implants	8	Sb-1 Group (Peek/Flag Shaped) Sb-2 Group (Titanium/ Cylindrical Shape)	Laboratory Scanner And Intra-Oral Scanner	Linear And Angular Discrepancies	Mann–Whitney U-Test	Sb-1 Group Achieved Higher Accuracy	Sb-1 Also Exhibited Lower Scan Time.
Lawand et al.[16] (2022)	In vitro	Completely Edentulous Maxillary Cast With 2 Anterior Parallel And Two 17° Posteriorly Tilted Implant Analogs	4	- Non-Modified (Nm Group) -Subtract Ively Modified (Sm Group) -Additive Ly Modified (Am Group)	Intra-Oral Scanner	3d Surface, Linear, And Angular Position Discrepancies	One-Way Anova, And Univariate Analysis And Bonferroni Multiple Comparison Tests	- Sm Group Obtained Lowest Mean Linear And Angular Discrepancies, -Am Group Showed Highest 3d Surface And Angular Discrepancies.	Isb Geometric Modifications Did Not Affect Scanning Time

The journal of
PROSTHETIC AND IMPLANT DENTISTRY
Official Publication of Indian Prosthodontic Society Kerala State Branch

summary table (Table 2)

1. DIFFERENT SCAN BODY MATERIALS

Titanium
PEEK
PEEK with Titanium base

2. DIFFERENT SCAN BODY GEOMETRIES

Cylindrical
Cylindrical with bevel
Flag shaped
One/ Two-piece SB with milled/pyramidal side
Tapered

The data extracted was entered under the following headings: Author and Year of publication, Study design, Study model, Number of ISB used, Number of scans, Material/ Geometry of Scan body, Type of digital scanner used, Measurement variables, Test of Analysis, Outcome and Additional Outcomes

Risk of bias assessment of the included studies was done using the QUIN tool scale10 by two independent reviewers (S.K., A.P.) This scale is primarily used to assess the risk of bias of in-vitro studies. Since all the 8 included studies were in-vitro studies, this scale was considered apt for the risk of bias evaluation in this systematic review. The changes made to the scale were validated by the third reviewer (N.P.S.) In this scale, the items are scored 0 if not specified, 1 if inadequately specified or 2 if adequately specified. The results were then summed to obtain an overall score for a given in vitro study. The scores thus obtained were used to grade the in vitro study as high, medium, or low risk (>70%=low risk of bias, 50% to 70%=medium risk of bias, and <50%= high risk of bias) by using the following formula :

$$\text{Final score} = \frac{(\text{Total score} \times 100)}{(2 \text{ x number of criteria applicable})}$$

The risk of bias of all the 8 included studies ranged from 79% to 91%, which falls under the category of low risk of bias.

Gomez-Polo et al.[17] (2022)	In vitro	Two Definitive Casts With 4 Implant Analogs Placed Parallel Or Angulated Up To 30□	20	Sb Geometry Bevel Position: Facial, Mesial, Distal, Lingual, Or Random	Laboratory Scanner And Intra-Oral Scanner	Linear And Angular Discrepancies	Three- Way Anova And Tukey Tests (□ = .05).	Lingual Orientation Of Isb Geometry Bevel Computed Highest Trueness And Precision Value	Parallel Implant Analog Positions Obtained Better Accuracy Than The Angulated Positions
Alvarez et al.[7] (2022)	In vitro	Poly Amide Plaster Model With 6 Implant Analogs	24	- 1 Piece Screw In Placement Sb With Milled Angulated Side, -2 Piece Clip In System With Milled Pyramidal Side - 1 Piece Scew In Placement With 12 Milled Sides - 2 Piece Magnetic Placement With Milled Side	Intra-Oral Scanner	Distance Errors	Anova Test And Student´S T-Test	More Accurate: -1 Piece Scew In Placement With 12 Milled Sides - 2 Piece Magnetic Placement With Milled Side	Sb With A Flatter And Simpler Structure Are Linked With Smaller Deviations

The journal of
PROSTHETIC AND IMPLANT DENTISTRY
Official Publication of Indian Prosthodontic Society
Kerala State Branch

Meta Analysis

Eight studies evaluating the accuracy of digital impression with different geometry and material of scan bodies for fully edentulous arches were included in the systematic review. Five studies which evaluated the effect of different geometry of scan bodies on accuracy *(Mizumoto et al.,*2019; *Motel et al.,* 2019; *Alvarez et al.,* 2022; *Lawand et al.,*2022; *Gomez-Polo et al.,* 2022*)*[1,13,7,16,17] were excluded from meta-analysis due to lack of uniformity in the comparison groups. Three studies which evaluated the effect of PEEK vs Titanium material scan body on the accuracy of digital impression (*Arcuri et al.,* 2019; *Kim et al.,* 2020; *Karthhik et al.,* 2022)[12,14,15] were included for meta-analysis.

Supplementary Table 1: Included Studies = 8

STUDY ID	AUTHOR	YEAR	TITLE
1.	Arcuri et al.[12]	2019	Influence of implant scan body material, position and operator on the accuracy of digital impression for complete-arch
2.	Motel et al.[13]	2019	Impact of Different Scan Bodies and Scan Strategies on the Accuracy of Digital Implant Impressions Assessed with an Intraoral Scanner
3.	Mizumoto et al.[1]	2019	Accuracy of different digital scanning techniques and scan bodies for complete-arch implant-supported prostheses
4.	Kim et al.[14]	2020	Displacement of scan body during screw tightening: A comparative in vitro study
5.	Karthhik et al.[15]	2022	Role of scan body material and shape on the accuracy of complete arch implant digitalization
6.	Lawand et al.[16]	2022	Effect of implant scan body geometric modifications on the trueness, scanning time of complete arch intraoral implant digital scans
7.	Gomez-Polo et al.[17]	2022	Influence of the implant scan body bevel location, implant angulation and position on intraoral scanning accuracy
8.	Alvarez et al.[7]	2022	How the geometry of the scan body affects the accuracy of digital impressions in implant supported prosthesis.

The Review Manager software (Version 5.4.1) was used to perform meta-analysis. Mean values and standard deviations for linear discrepancies were included for the analysis. The linear discrepancies were measured along three axis- X, Y and Z axis. The primary outcome measures the accuracy of digital impression, and was evaluated by measuring the linear deviations along X, Y and Z axis. More the linear deviations present, lesser is the accuracy. The data was tabulated under the headings of study name, group, and effect size. The effect size was calculated on the continuous raw data entered for mean, standard deviation and sample size. 95% confidence interval for each effect size was also computed. The heterogeneity of effects was assessed by the Higgin's I^2 test.[11]

A statistically significant difference was observed between the two materials of scan body along X axis ($P < 0.05$, pooled mean difference = 0.00 CI = 95%), along Y axis ($P < 0.05$, pooled

Supplementary Table 2: Excluded Studies = 3

SR. NO.	AUTHOR	YEAR	TITLE	REASON FOR EXCLUSION
1.	Stimmelmayr et al.[5]	2011	Digital evaluation of the reproducibility of implant scan body fit—an in vitro study	Only fit of the scan bodies evaluated
2.	Mizumoto et al.[18]	2018	Intraoral scan bodies in implant dentistry: A systematic review	Systematic review article
3.	Huang et al.[19]	2021	Improved accuracy of digital implant impressions with newly designed scan bodies	In vivo animal study

mean difference = 0.07 CI = 95%), and along Z axis ($P < 0.05$, pooled mean difference = 0.03 CI = 95%) as stated in the forest plot. The results of the meta-analysis for linear marginal discrepancy showed minimum discrepancy in PEEK and maximum discrepancy in Titanium scan body along X, Y and Z axis (Figures 2, 3, 4 respectively)

Discussion:

This systematic review analyzed the effect of the various characteristics of ISBs on the accuracy of implant impression, and is chiefly based on in vitro studies. Among the parameters assessed in this study were the scan body material and geometry.

The ISB material is a crucial factor that has to be scrutinized, as it can have a significant impact on the biocompatibility and scanning accuracy which depends on surface reflections and in turn can influence the number of stitching points in order to attain the desired results.[12] Different materials which are used include polymers such as polyetheretherketone (PEEK), titanium alloys, aluminum alloys, and resin materials. PEEK and Titanium are the most commonly used for ISB fabrication. PEEK is high-performance thermoplastic polymer with excellent physical

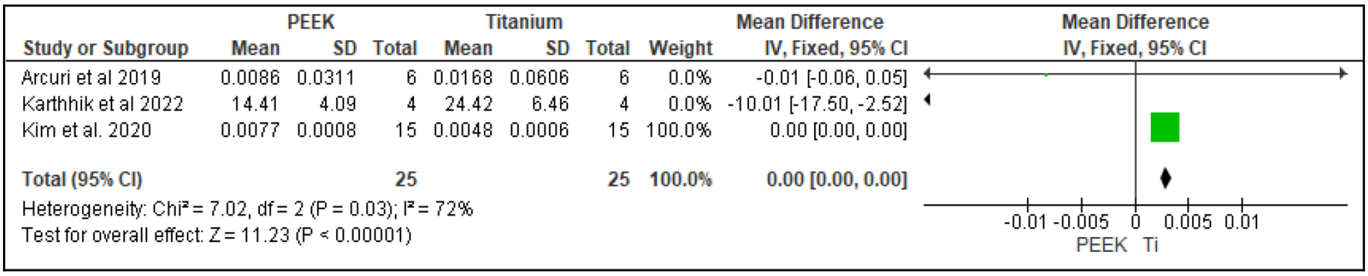

Fig. 2: Forest plot of results for linear deviations (mm) measured in PEEK and Titanium scan bodies along X axis

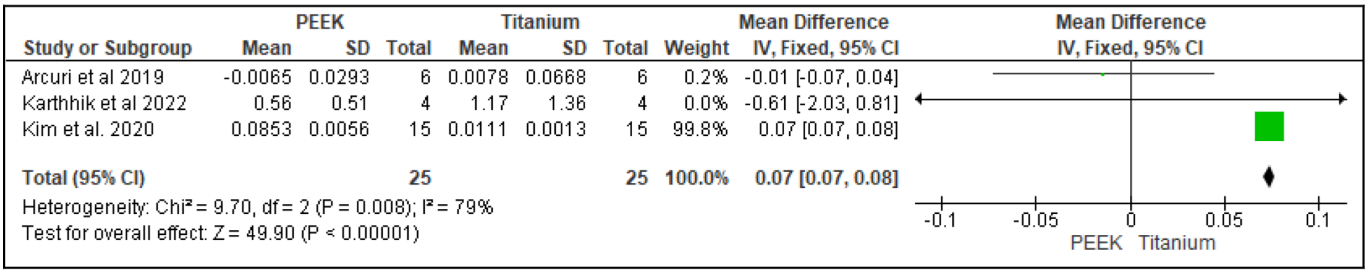

Fig. 3: Forest plot of results for linear deviations (mm) measured in PEEK and Titanium scan bodies along Y axis

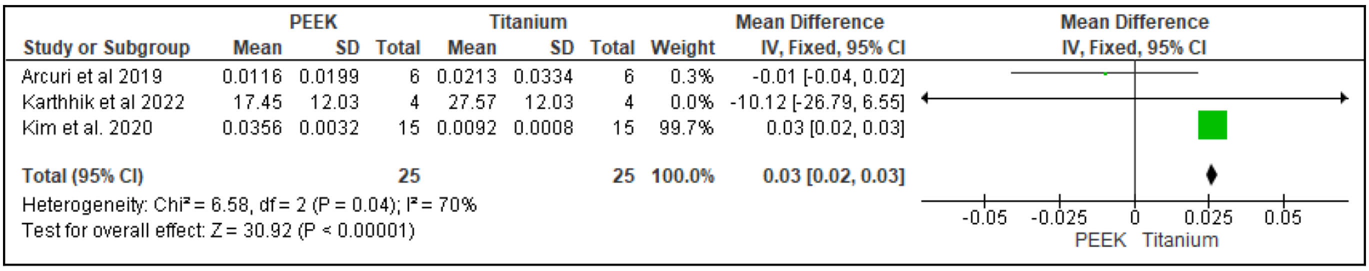

Fig. 4: Forest plot of results for linear deviations (mm) measured in PEEK and Titanium scan bodies along Z axis

and mechanical properties, chemical stability and low weight. It is often used in ISBs because it can easily be scanned compared to other materials and it does not cause any surface reflections which could cause hinderance in intraoral scanning.[12]

However, the selection of polymeric materials has recently come into question, as repeated sterilization, clamping forces, and even chewing forces can deform and abrade the polymeric materials. This is the reason why PEEK ISBs are suggested only for single usage. Ti-alloy components are also commonly selected for the fabrication of ISB. It represents excellent biocompatibility and is resistant to deformation on repeated sterilization.[13] Hashemi et al evaluated the effect of repeated use of PEEK and Titanium Scan Bodies on the transfer accuracy of implant position and demonstrated that the inter-implant distance variations were more in titanium as compared to PEEK scan bodies. The results further indicated that titanium scan bodies had lesser dimensional changes as compared to PEEK scan bodies after repeated use.[19]

Nevertheless, there were inconsistencies between the different studies about which is the preferable material for ISB. In a study given by Arcuri et al, PEEK ISBs showed optimal results on both linear and angular measurements, which was followed by Titanium. PEEK with titanium base showed least accuracy because of its bi-component configuration.[12] In a study given by Karthhik et al, PEEK SB material showed more scanning accuracy as it reduced the problem of light reflectance that can occur in the metal alloy.[15] PEEK showed optimal results on both the studies however this was in disagreement with another study by Kim et al, which presented better trueness and stability of the Ti-ISB compared to PEEK ISBs.[14]

Another characteristic feature that was assessed in the included studies was the ISB geometry. A relatively flat, more simply constructed scan body resulted in significantly smaller deviations within the digital impression. In two studies ISB with overall cylindrical geometry with a partially beveled upper part showed better scanning trueness in distance deviation.[1,6] The current study found out that worst results were seen in scan bodies which had a very complex anatomy with irregular surface. This finding agrees with the study published by Kurz et al, which shows that more intricate the scan body surface, as in sharp edges, more are the errors registered.[20] The ISB geometry bevel also has a significant effect on the scanning accuracy and the lingual placement of the bevels is proposed for best results.[17] An interesting finding is that the scanning trueness of ISBs was improved by subtractive modifications in design, whereas it was reduced by additive alterations.[18] Surfaces which are more challenging to scan include steep, sharp, deep undercuts, angled or overcrowded surfaces.

The position and location of implant and ISB has impact on the scanning trueness in distance deviations. If the most distal implant was tilted mesially, there would be better trueness in scanning accuracy. The extent of edentulism is another important factor; Free-end partial edentulism (Kennedy I, II) results in higher deviations compared to Kennedy III, IV. This is can be possibly attributed to inter-implant space which is limited in Kennedy I and II cases.[21] In this systematic review, majority of studies had linear and angular discrepancies as measurement variables. In terms of material, PEEK showed least discrepancies, followed by Titanium followed by PEEK with Titanium base. Considering the geometrical aspect of ISB, Scan bodies with cylindrical and simple configuration showed least discrepancies.

The QUIN Tool has been used here based on the in-vitro study design of the included studies to identify the risk of bias of the individual studies.[10] Three out of 8 included studies seemed to be relatively homogenous in their study design and outcome variables. Hence, a quantitative analysis by means of a meta-analysis was planned. Meta-analysis is a systematic procedure that is used for assessing and combining statistical information based on results of available independent studies regarding the same topic. The results of the quantitative analysis have been provided in the form of forest plots for easy visualization. The heterogeneity of the primary studies has been evaluated using the Higgins's I^2 test.[11] Heterogeneity refers to differences in results between primary studies that are greater than expected by chance alone. The results of the meta-analysis for linear marginal discrepancy showed minimum discrepancy in PEEK and maximum discrepancy in Titanium scan body along all three planes.

After evaluating different studies in the current systematic review, PEEK biomaterial scan bodies do show a promising outcome for better accuracy for full arch implant supported prosthesis as compared to that of Titanium scan bodies. Also, when it comes to the geometry of scan bodies, it can be said that scan bodies with least complex geometry will show minimal errors during scanning, especially in full arch cases. Hence, clinicians will have a better understanding in selection of scan bodies when it comes to scanning of fully edentulous arches.

Limitations of this systematic review were that all the included articles were in vitro in their study design, as there were nearly no clinical studies in the available literature. The search for this study was also limited to articles published in the English language only. Other ISB parameters like location of ISB, wear, inclination of dental implants and ISB dimensions were not included in this systematic review as it would contribute more to the heterogeneity of the current systematic review. Hence, the results of this systematic review should be applied with caution to the clinical scenario and more in vivo randomized controlled trials should be carried out to support the current evidence.

Conclusion:

Although intraoral scan bodies and their characteristics vary widely, they significantly influence implant impression accuracy. The majority of studies agree that, among the various characteristics, the material, and the geometrical design affect the impression accuracy significantly.

1. In terms of materials, PEEK scan bodies reported least discrepancies, thereby deeming to be more accurate than Titanium scan bodies.

2. There is an overall increase in dimensional accuracy of digital impression recorded by scan bodies of cylindrical and simpler geometry.

These conclusions enable the clinician in proper decision making to choose the PEEK scan bodies with simple geometry whenever possible for digital impressions of their full arch implant cases. However, more clinical studies are necessary for safer conclusions, since the available scientific evidence is not yet conclusive about the optimal Intraoral Scan Body.

References:

1. Mizumoto RM, Yilmaz B, McGlumphy EA, Seidt J, Johnston WM. Accuracy of different digital scanning techniques and scan bodies for complete-arch implant-supported prostheses. J Prosthet Dent 2020 Jan;123(1):96-104.
2. Osman MS, Ziada HM, Abubakr NH, Suliman AM. Implant impression accuracy of parallel and non-parallel implants: a comparative in-vitro analysis of open and closed tray techniques. Int J Implant Dent 2019 Dec;5(1):24-29.
3. Kalpana D, Sharan DS, Chandra PK, Brunda K, Jabeen SN. A review on dental implant impressions. Int J Appl Dent Sci 2019 Jan;5(1):33-36.

The journal of
PROSTHETIC AND IMPLANT DENTISTRY
Official Publication of Indian Prosthodontic Society Kerala State Branch

4. Arieli A, Adawi M, Masri M, Weinberg E, Beitlitum I, Pilo R, et al. The Accuracy of Open-Tray vs. Snap on Impression Techniques in A 6-Implant Model: An In Vitro 3D Study. Materials 2022 Mar 12;15(6):2103.
5. Stimmelmayr M, Güth J, Erdelt K, Edelhoff D, Beuer F. Digital evaluation of the reproducibility of implant scanbody fit—an in vitro study. Clin Oral Invest 2012 Jun;16(3):851-6.
6. Motel C, Kirchner E, Adler W, Wichmann M, Matta RE. 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 2020 Apr;29(4):309-14.
7. Alvarez C, Domínguez P, Jiménez-Castellanos E, Arroyo G, Orozco A. How the geometry of the scan body affects the accuracy of digital impressions in implant supported prosthesis. In vitro study. J Clin Exp Dent 2022;57(1):160-68.
8. Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gøtzsche PC, Ioannidis JP, Clarke M, Devereaux PJ, Kleijnen J, Moher D. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. Jour Clin Epidem 2009 Oct 1;62(10):1-34.
9. Cohen J. A Coefficient of Agreement for Nominal Scales. Educ Psychol Meas 1960;20:37–46.
10. Sheth VH, Shah NP, Jain R, Bhanushali N, Bhatnagar V. Development and validation of a risk-of-bias tool for assessing in vitro studies conducted in dentistry: The QUIN. J Prosthet Dent 2022 Jun;1-5.
11. Higgins JP, Thompson SG. Quantifying heterogeneity in a meta analysis. Statistics in medicine. 2002 Jun 15;21(11):1539-58.
12. Arcuri L, Pozzi A, Lio F, Rompen E, Zechner W, Nardi A. Influence of implant scanbody material, position and operator on the accuracy of digital impression for complete-arch: A randomized in vitro trial. J. Prosthodont Res. 2019 Apr;64(2):128-36.
13. Motel C, Kirchner E, Adler W, Wichmann M, Matta RE. 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 2019 Apr;29(4):309-14.
14. Kim J, Son K, Lee KB. Displacement of scan body during screw tightening: A comparative in vitro study. J Adv Prosthodont 2020 Oct;12(5):307-11.
15. Karthhik R, Raj B, Karthikeyan BV. Role of scan body material and shape on the accuracy of complete arch implant digitalization. J. Oral Res. 2022 Jul 1;14(2):114-20.
16. Lawand G, Ismail Y, Revilla-León M, Tohme H. Effect of implant scan body geometric modifications on the trueness and scanning time of complete arch intraoral implant digital scans: An in vitro study. J. Prosthet. Dent 2022 Jul.12(6):233-37.
17. Gómez-Polo M, Álvarez F, Ortega R, Gómez-Polo C, Barmak AB, Kois JC, et al. Influence of the implant scan body bevel location, implant angulation and position on intraoral scanning accuracy: An in vitro study. J Dent. 2022 Jun;121-24.
18. Mizumoto RM, Yilmaz B. Intraoral scan bodies in implant dentistry: a systematic review. J Prosthet Dent 2018;120(3):343-52.
19. Hashemi AM, Hasanzadeh M, Payaminia L, Alikhasi M. Effect of Repeated Use of Different Types of Scan Bodies on Transfer Accuracy of Implant Position. J Dent. 2023 Dec;24(4):410.
20. Kurz M, Attin T, Mehl A. Influence of material surface on the scan ning error of a powder-free 3D measuring system. Clin Oral Investig. 2015;19:2035-43.
21. Pachiou A, Zervou E, Tsirogiannis P, Sykaras N, Tortopidis D, Kourtis S. Characteristics of intraoral scan bodies and their influence on impression accuracy: A systematic review. J Esthet Restor Dent. 2023 Dec;35(8):1205-17.
22. Huang R, Liu Y, Huang B, Zhang C, Chen Z, Li Z. 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. 2020;31(7): 625-33.
23. Park SW, Choi YD, Lee DH. The effect of the improperly scanned scan body images on the accuracy of virtual implant positioning in computer-aided design software. J Adv Prosthodont 2020;12(3): 107-13.
24. Moslemion M, Payaminia L, Jalali H, Alikhasi M. Do type and shape of scan bodies affect accuracy and time of digital implant impressions? Eur J Prosthodont Restor Dent 2020;28(1):18-27.
25. Jahn D. NT-trading GmbH, assignee. Scan body for determination of positioning and orientation of a dental implant. US Patent 14 011 936. 2014.
26. Gimenez-Gonzalez B, Hassan B, Özcan M, Pradíes G. An in vitro study of factors influencing the performance of digital intraoral impressions operating on active Wavefront sampling technology with multiple implants in the edentulous maxilla. J Prosthodont 2017;26(8): 650-55.
27. Revilla-Leon M, Smith Z, Methani MM, Zandinejad A, Özcan M. Influence of scan body design on accuracy of the implant position as transferred to a virtual definitive implant cast. J Prosthet Dent 2021; 125(6):918-23.
28. Shi X, Liu X, Liu S, Wang M, Liu F. Vertical deviation caused by tightening torque on implant scan body: an In vitro study. Int J Prosthodont 2022;35(5):653-59.

List of Abbreviations:

Abbreviation	Definition
ISB : Intraoral Scan body	**DIGITAL SCAN:** capturing the optical image directly of the patient's anatomy or indirectly of a definitive cast of the anatomy.
	DIGITAL SCANNER: a device for the 3D acquisition of the surfaces of an object by mechanical contact, laser, or photographic image.
	SCAN BODY: an intraoral implant-positioning-transfer device which is utilized in the digital implant restoration workflow