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Review

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# Applicability of the reverse scan body technique for the fabrication of implant-supported prostheses: a scoping review

Aplicabilidade da técnica de corpo de escaneamento reverso para a fabricação de próteses implanto-suportadas: uma revisão de escopo

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## ABSTRACT

Scanning edentulous regions rehabilitated with implants presents significant challenges and necessitates innovative solutions. The development of the reverse scan body technique (RST) has enabled scanning to be performed outside the oral environment. **Objective:** This scoping review examined the RST, critically evaluating the findings in the literature regarding its advantages and disadvantages in terms of working time and patient comfort, passive fit of prostheses on abutments, precision and accuracy of the RST. **Material and Methods:** Following the PRISMA protocol, the search was conducted until July 2025 (MEDLINE/PubMed, EMBASE, Web of Science) by two independent reviewers (RSLS,PSP) and one expert (CNCW). Objective data were analyzed without random-effects meta-analysis. **Results:** Four in vitro studies and eight technical reports were included in the analysis (kappa = 0.875). A trend has been observed favoring this technique in full arches to replicate the dimensions of the provisional prosthesis, soft tissue information, and verification jig device, with reported advantages in terms of patient comfort and working time. RST performed with the E4 RED scanner demonstrated superior measurements of trueness (65 ± 43 $\mu$m) and precision (18 ± 11 $\mu$m) compared to those of IOS. The Procrustes distance values recorded for RST intraoral (median 9.5 $\mu$m) exhibited a significant difference when compared to the Control group (median 0.3 $\mu$m). Owing to the paucity of evidence regarding the RST as the primary focus, additional research is necessary to obtain robust data. **Conclusion:** The potential applicability of the RST for the fabrication of implant-supported prostheses appears promising.

## KEYWORDS

Digital impression; Digital workflow; Implant scanning; Implant-supported prosthesis; Reverse scan body.

## RESUMO

Escanear regiões edêntulas reabilitadas com implantes apresenta desafios significativos e exige soluções inovadoras. O desenvolvimento da técnica de corpo de escaneamento reverso (RST) possibilitou que o escaneamento fosse realizado fora do ambiente oral. **Objetivo:** Esta revisão de escopo analisou a RST, avaliando criticamente os achados na literatura quanto às suas vantagens e desvantagens em relação ao tempo de trabalho e conforto do paciente, adaptação passiva das próteses sobre os pilares, precisão e exatidão da RST. **Material e Métodos:** Seguindo o protocolo PRISMA, a busca foi realizada até julho de 2025 (MEDLINE/PubMed, EMBASE, Web of Science) por dois revisores independentes (RSLS, PSP) e um especialista (CNCW). Os dados objetivos foram analisados sem meta-análise de efeitos aleatórios. **Resultados**: Quatro estudos in vitro e oito relatos técnicos foram incluídos na análise (kappa = 0,875). Observou-se uma tendência favorável a esta técnica em arcadas totais para replicar as dimensões da prótese provisória, informações de tecido mole e dispositivo de verificação, com vantagens relatadas quanto ao conforto do paciente e tempo de trabalho. A RST realizada com o scanner E4 RED demonstrou medidas superiores de veracidade (65 ± 43 $\mu$m) e precisão (18 ± 11 $\mu$m) em comparação às do IOS. Os valores de distância de Procrustes registrados para RST intraoral (mediana 9,5 $\mu$m) apresentaram diferença significativa quando comparados ao grupo Controle (mediana 0,3 $\mu$m). Devido à escassez de evidências tendo a RST como foco principal, pesquisas adicionais são necessárias para se obter dados robustos. **Conclusão:** A aplicabilidade potencial da RST para a confecção de próteses sobre implantes mostra-se promissora.

## PALAVRAS-CHAVE

Moldagem digital; Fluxo de trabalho digital; Escaneamento de implante; Prótese sobre implante; Scanbody reverso.

## INTRODUCTION

Rehabilitation of partial and complete arches using implant-supported prostheses, when established with appropriate occlusal vertical dimensions, confers various benefits to patients. These advantages include enhanced masticatory efficiency compared to removable prostheses, thereby optimizing the quality of life of individuals utilizing such prostheses [1,2].

During prosthesis fabrication, clinicians may opt for either a conventional workflow, utilizing traditional impression techniques to obtain the working cast, or a digital workflow, employing intraoral scanning to generate a digital working cast [3]. A critical aspect common to all implant rehabilitations is the requisite precision for adapting the prosthesis to the implants. Even minor discrepancies in fit can result in clinical complications, including screw fractures and issues with the underlying infrastructure [4,5].

In the conventional technique, rigid and passive splinting of the transfer copings is recommended before the impression-making procedure. This is typically accomplished using polymethyl methacrylate (PMMA) resin to ensure a stable union among the copings. This procedure necessitates a considerable amount of clinical time, which can vary based on several factors, including the practitioner's level of expertise, patient compliance, and the properties of the materials employed. To ensure the fidelity of the working cast, precision, and dimensional stability, the positions of the implants, soft tissues, and alveolar ridge must be accurately recorded. Consequently, the use of silicone is recommended for replicating these structures. However, these materials are commercially available at a high cost and may be subject to variations depending on their storage conditions. Furthermore, this technique frequently induces discomfort associated with patient anxiety. Additional factors, including meticulous handling and procurement of casts, acquisition of antagonist casts, and precise recording of the intermaxillary relationship, can also substantially influence the outcomes of dental rehabilitation [6,7].

The utilization of digital workflows for scanning and fabricating prostheses has become increasingly prevalent owing to the multiple stages and potential for errors in the process, in conjunction with advancements in computer-aided design-computer-aided manufacturing (CAD-CAM) technology [8]. This transition not only enhances communication between dental professionals and laboratory technicians but also reduces the time required for prosthesis fabrication [9-12]. The implementation of intraoral scanning technology in aesthetic and functional rehabilitation involving dentition, implants, and dental prostheses has demonstrated significant advancements over the past few decades. At present, numerous brands and models of intraoral scanners are commercially available, exhibiting notable variations in cost, accuracy, precision, image acquisition and processing speed, operational ease, and patient comfort [13-18].

Nevertheless, distortions may arise during the scanning of implants in partially or completely edentulous spaces owing to various factors. These include the presence of excessive saliva or blood, absence of reference areas for the scanner to identify (such as the occlusal surfaces of the teeth), tongue movements, substantial amounts of buccal mucosa, unsupported floor of the mouth, limited mouth opening, flaccid ridges, and narrow bands of keratinized mucosa. In such instances, a loss of reference occurs during scanning, resulting in image overlap that compromises the accuracy of the working cast [18,19].

Owing to the clinical challenges associated with intraoral scanning in edentulous regions, it is generally recommended to utilize conventional impressions followed by scanning of the gypsum cast, with the objective of implementing a mixed workflow (both conventional and digital) [20-23]. In this context, the concept of a reverse scan body has been proposed, which can be affixed to a complete denture that has already achieved proper adaptation to the mini-pillars and correct vertical occlusion dimension [24-36]. The assembly is subsequently scanned extraorally using either an intraoral or extraoral scanner, generating data regarding the positioning of the implants and references for the dental anatomy of the provisional prosthesis.

This methodology uses data from provisional prostheses employed during osseointegration to optimize the clinical duration required for the fabrication of a definitive prosthesis. This protocol can also be applied to projects involving metal or zirconia infrastructures, with reductions in the incisal, vestibular, and gingival regions for the manual application of ceramics (cut-back technique) [16].

Limited research has been conducted to evaluate the fit accuracy of infrastructure or monolithic prostheses using reverse scanning techniques. Consequently, this study aimed to conduct a critical review of the existing literature.

## METHODS

This review investigated the reverse-scanning technique in implant rehabilitation and critically evaluated the findings in the literature regarding its clinical advantages in terms of working time and patient comfort. Furthermore, it assessed objective data on the passive fit of prostheses on abutments, as well as the precision and accuracy of the reverse scans. In accordance with the PRISMA protocol, this review was registered with PROSPERO. The objective of this review was to address the following research question: "What are the applications of reverse scan body technique during the fabrication of implant-supported prostheses in a digital workflow?".

To conduct the proposed study, a research team comprising two reviewers (R. S. L. S. and P. S. P.) and one expert (C. N. C. W.) executed all phases of the article search, selection, data extraction, and analysis. Articles were selected based on their presentation of intraoral or extraoral scans of fully or partially rehabilitated arches with implants using the reverse scanning technique. The search strategy was developed using keywords and controlled vocabulary (MeSH Terms and Entry Terms) according to the Population, Concept, Context (PCC) method: P (implant-rehabilitated arches), C (reverse-scanning technique), and C (digital workflow). The aforementioned strategy was subsequently implemented in the Embase, PubMed, and Web of Science databases, followed by a systematic manual search for articles published until July 2025. The literature search encompassed publications without temporal or linguistic restrictions.

The titles and abstracts of the articles were screened using the Rayyan tool, followed by a comprehensive examination of the selected articles in accordance with the eligibility criteria [37]. The inclusion criteria encompassed study design (in vitro studies, case reports, technique reports, cross-sectional clinical studies, and randomized clinical trials) and the application of reverse-scanning for the rehabilitation of implant-supported prostheses (unitary, partial, or total). Articles that did not fulfill these criteria were excluded from the study. In both phases, the studies were independently analyzed by two reviewers (R. S. L. S. and P. S. P.), and any discrepancies between them were resolved by a third reviewer (C. N. C. W.). To assess inter-examiner agreement, the kappa coefficient was calculated using JAMOVI version 2.3.13.0.

Data collection was conducted by three authors (C. N. C. W., R. S. L. S., and P. S. P.). The extracted and tabulated data included the following: study characteristics (author, year of publication, country, study design, and sample size), type of edentulous space (single, partial, or complete), scan body characteristics, scanner characteristics, scanning strategy, CAD-CAM system characteristics, study objectives, outcomes, and conclusions. Information was compiled and presented in both qualitative and quantitative formats using textual descriptions and tabular representations. The risk of bias in the selected articles was assessed using the QUIN tool (Quality Assessment Toll For In Vitro Studies) [38].

A flowchart depicting the study selection process is shown in Figure 1.

## RESULTS

The search strategy (Figure 1) yielded 7137 articles from database searches and 10 articles through manual searching, resulting in a total of 7147 articles. Following the removal of duplicate articles, two independent reviewers (R.S.L.S and P.S.P) examined the titles and abstracts of 5922 articles, from which 19 were selected for full-text review (inter-rater kappa index = 0.719). Upon completion of the process, 12 articles were included (inter-rater kappa index = 0.875), comprising 4 in vitro studies [16,25,27,34] (Table I) and 8 technique reports [28-36] (Table II).

All eight technique reports (Table II) described cases of full-arch rehabilitation, varying in the number of implants, arch (maxilla and mandible), and scan body and scanner type. The reverse scanning techniques implemented in these studies were used to scan provisional prostheses and passivity verification devices (jigs). Liaropoulou et al. [30] elucidated a reverse digital impression technique for capturing the volumetric dimensions of the provisional

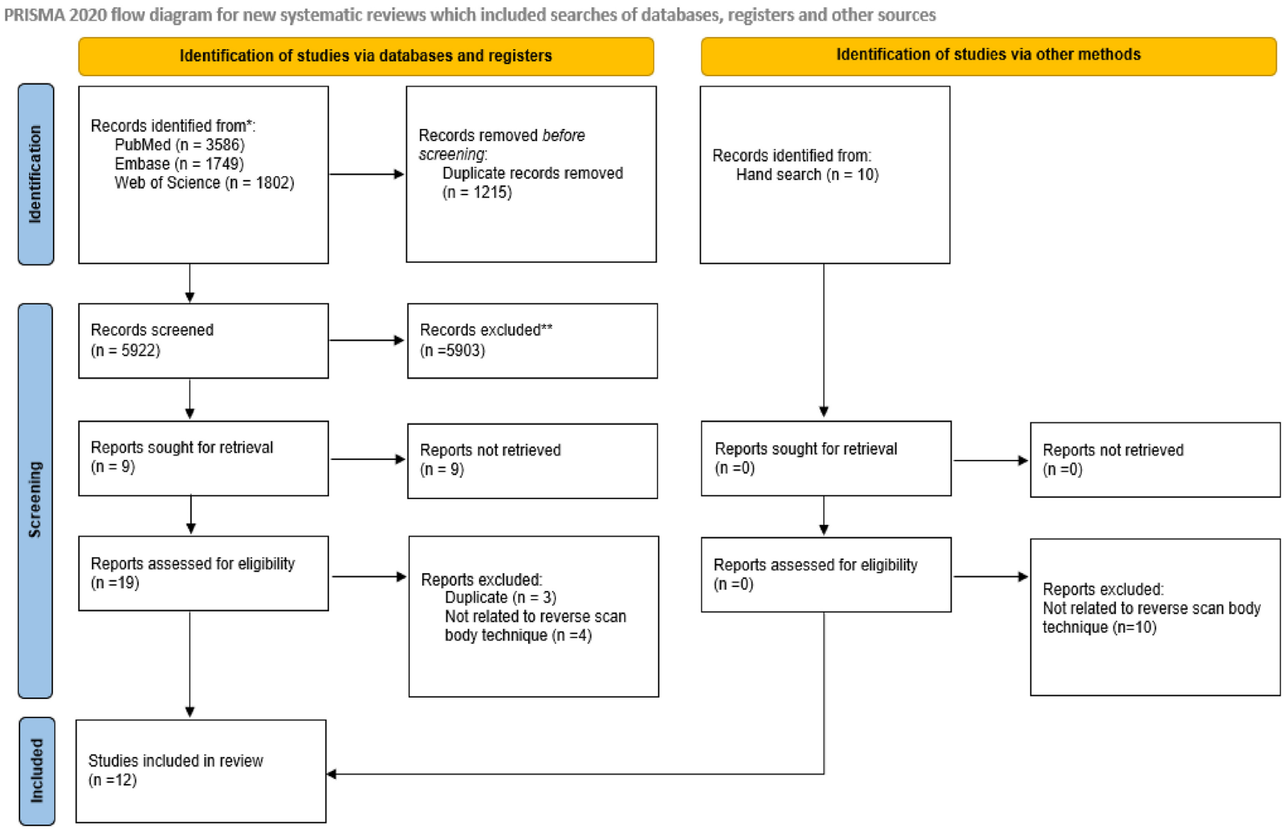


**Figure 1 -** Flowchart of the selection process.

restoration, antagonist arch, and intermaxillary relationship. Rosmaninho et al. [28,29] delineated a reverse scanning technique modified from the methodology presented by Liaropoulou et al. [30] to facilitate the acquisition of soft tissue information at the time of the definitive digital impression. Furthermore, a device was incorporated into the digital workflow to verify the prosthesis passivity. Ntovas et al. [31] demonstrated a novel methodology for superimposing the mesh with the position of the implants and the mesh of the provisional prosthesis during the fabrication of a definitive total prosthesis, through the development of a prototype virtual analog that functioned as a reference for aligning these meshes. Hyspler et al. [32] employed a combination of dual tomography techniques for implant-supported denture cases, utilizing the reverse scanning technique with scannable implant analogs. Bredrossian et al. [33] and Papaspyridakos et al. [35] introduced a reverse technique for the fabrication of a bimaxillary total prosthesis utilizing monolithic zirconia. In contrast, Nguyen et al. [36] fabricated titanium frames with a monolithic zirconia prosthesis for the maxilla and zirconia crowns with composite gingiva for the mandible.

Among the in vitro studies reviewed, two investigations concentrated on the primary outcome of assessing the passivity of the fit of prostheses on abutments [16,25] (Table I). Additionally, one study evaluated the measures of trueness and precision [27] (Table I), while another employed Procrustes distance measures [34] (Table I).

In 2023, Papaspyridakos et al. [16,25] conducted two in vitro studies utilizing the reverse scanning technique for fixed provisional prostheses with four scan bodies. In the initial study (Table I), the fit of 50 milled upper prostheses was evaluated and compared with that of 50 printed prostheses; 100% of the fittings of the former were deemed acceptable, whereas 88% of the fittings of the latter were considered acceptable, which was statistically significant ($p = 0.027$). The second study (Table I) evaluated the fit of 45 lower fixed prostheses milled on four abutments using three distinct scanning strategies (15 occlusal, 15 helix, and 15 intaglio). The prostheses fabricated using the occlusal strategy (recommended by the manufacturer) demonstrated 100% acceptance of the fittings, followed by 80% (intaglio strategy) and 53.3% (helix strategy); the difference between the groups was statistically significant ($p = 0.008$).

**Table I -** In vitro studies. Comparison of fit between milled and printed prostheses, both scanned using a reverse-scanning technique

| Author, year, country | Sample (n) | Arch type | Reverse scanbody (number, details) | Scanner | Scanning strategy | CAD/CAM details | Results |
|---|---|---|---|---|---|---|---|
| Papaspyridakos et al. (2023) [16], USA | Scans: n=50 Milled prostheses: n=50 Printed prostheses: n=50 | Complete-arch (maxilla) | n=4 (RevEX; Institute Straumann AG, Basel, Switzerland) | IOS (Trios 4, 3Shape A/S, Copenhagen, Denmark) | Recommended by the manufacturer | Software: Exocad DentalCAD (Exocad GmbH, Darmstadt, Germany) Milling unit: PrograMill PM7 (Ivoclar,Amherst, NY, USA). Polymethylmethacrylate discs: Telio CAD LT (Ivoclar Amherst, NY, USA) 3D printer: Form 3B (Formlabs, MA, USA) Resin: CB resin (Formlabs, MA, USA) | Acceptable fit n (%): Milled = 50 (100) 3D printed = 44 (88) Total = 94 Non-acceptable fit n (%): Milled = 0 (0) 3D printed = 6 (12) Total = 6 |
| **Fit assessment of prostheses fabricated using three different scanning strategies with a reverse scan body** | | | | | | | |
| **Author, year, country** | **Sample (n)** | **Arch type** | **Reverse scanbody (number, details)** | **Scanner** | **Scanning strategies** | **Results** | |
| Papaspyridakos et al. [25], (2023), USA | Scans: n = 45 Milled prototype prostheses: n=45 | Complete-arch (mandible) | n=4 (RevEX; Institute Straumann AG, Basel, Switzerland) | IOS (TRIOS 4, 3Shape A/S, Copenhagen, Denmark) | Occlusal (recommended by the manufacturer) Helical scanning Intaglio scan pattern | Fit n(%): Occlusal pattern = 15 (100%) Intaglio pattern = 12 (80%) Helix pattern = 8 (53.3%) Total = 35 (77.8%) Misfit n(%): Occlusal pattern = 0 (0%) Intaglio pattern = 3 (20%) Helix pattern = 7 (46.7%) Total = 10 (22.2%) | |
| **Comparison of trueness and precision between different types of scanners using the reverse technique** | | | | | | | |
| **Author, year, country** | **Sample (n)** | **Arch type** | **Reverse scanbody (details)** | **Scanner** | **Scanning strategy** | **Trueness** | **Precision** |
| Nuytens et al. [27] (2023), Belgium | IOS: n=80 Desktop Scanner: n=20 | Complete-arch (maxilla) | n=6 (ScAnalog; Dynamic Abutment Solutions, Lleida, Spain) | Intraoral Scanners: *TRIOS 3 (3Shape A/S, Copenhagen, Denmark) *TRIOS 5 (3Shape A/S, Copenhagen, Denmark) *i700W (Medit, Seoul, Republic of Korea *Primescan v.5.2 (Dentsply Sirona GmbH, Bensheim Deutschland) *Desktop Scanner: E4 RED (3Shape A/S, Copenhagen, Denmark) | IOS: zigzag strategy DS: Recommended by the manufacturer | Linear measurements (µm): TRIOS 3 = 118 ± 47 TRIOS 5 = 85 ± 39 Primescan v.5.2 = 106 ± 41 Medit i700W = 120 ± 49 E4 RED = 65 ± 43 Angular deviation (◦): TRIOS 3 = 0.43 ± 0.25 TRIOS 5 = 0.36 ± 0.19 Primescan v.5.2 = 0.25 ± 0.16 Medit i700W = 0.30 ± 0.21 E4 RED = y 0.26 ± 0.19 | Linear measurements (µm): TRIOS 3 = 108 ± 55 TRIOS 5 = 86 ± 55 Primescan v.5.2 = 104 ± 55 Mediti700W=90± 54 E4 RED = 18 ± 11 Angular deviation (◦): TRIOS 3 = s 0.49 ± 0.27 TRIOS 5 = 0.33 ± 0.20 Primescan v.5.2 = 0.31 ±0.18 Medit i700W = 0.36 ± 0.25 E4 RED = 0.08 ± 0.09 |
| **Comparison of the reverse scan technique with an intraoral scanner and the traditional impression technique** | | | | | | | |
| **Author, year, country** | **Sample (n)** | **Arch type** | **Reverse scanbody (number, details)** | **Scanner** | **Traditional impression technique** | **Procrustes distances** | |
| Hyspler et al. [34] (2025), Czech Republic | N=10 (control) N=10 (RST cast) N=10 (impression cast) N=10 (IOS cast) N=10(IOS intraoral) N=3 (RST intraoral) | Complete-arch (mandible) | N=6 Scannable implant analogs (LASAK; AnalogSC) | Intraoral Scanner: 3Shape (3Shape A/S, Copenhagen, Denmark) Laboratory Scanner: AG Map 300 (Amann Girrbach AG, Mäder, Austria) | Polyvinyl siloxane: Express XT (3M ESPE, St. Paul Minnesota, USA) | Control cast 0 to 0.4 µm (median 0.3 µm) RST cast 5.6 to 6.9 µm (median 6.2 µm) Impression cast 5.4 to 7.1 µm (median 6.5 µm) IOS cast group 4.5 to 41.2 µm (median 5.8 µm) RST intraoral 9.5 to 9.6 µm (median 9.5 µm) IOS intraoral 5.7 to 18.3 µm (median 10.9 µm) | |

**Table II -** Dental technique reports

| Author, year, country | Arch type | Reverse techniques aplications | Reverse scanbody (number, details) | Scanner | CAD/CAM details | Conclusions |
|---|---|---|---|---|---|---|
| Rosmaninho et al. [28] (2023), Portugal | Complete-arch (mandible) | Extraoral digitalization of the interim restoration with the wash impression of the intaglio surface. Extraoral digitalization of verification device. | N=4 (ScanAnalog for Straumann SRA; Zirkonzahn) | IOS: Primescan (Dentsply Sirona GmbH, Bensheim Deutschland). Laboratory scanner: (Not reported), verification device | Verification device manufactured trought a vat-polymerization printer (Form 3B+; FormLabs) with a resin material (Dental LT Clear Resin, V2 FormLabs). | Copy of the dimensions of the provisional prosthesis and soft tissue information at the time of scanning in the definitive phase is facilitated by this technique. Complications caused by the lack of passivity of the provisional prosthesis milled in polymethyl methacrylate are minimized by extraoral scanning of the verification device. |
| Rosmaninho et al. [29] (2023), Portugal | Complete-arch (maxilla) | Extraoral digitalization of a conventional verification jig. | N=6 (ScanAnalog for Straumann SRA; Zirkonzahn) | IOS: Primescan (Dentsply Sirona GmbH, Bensheim Deutschland). | The verification jig was designed by using the implant positions of the computer-aided implant planning surgery | The implant positions captured using the verification jig are used to obtain the virtual definitive implant cast and fabricate the definitive implant-supported prosthesis. |
| Liaropoulou et al. [30], (2023), Spain | Complete-arch (maxilla) | Extraoral scan of the intaglio surface of the interim prosthesis | N=4 (Scananalog; Dynamic Abutment Solutions | IOS: Trios 3 (3Shape A/S, Copenhagen, Denmark) | Resin prototype was screwed intraorally before fabrication of definitive prosthesis to evaluate passivity of prosthesis over multiunit abutments. | The prosthetic procedure is simplified for both clinicians and dental laboratory technicians once the 3D implant position is verified regardless of the interference of an analog step. |
| Ntovas et al. [31] (2023), Greece | Complete-arch (maxilla) | Extraoral scan of the interim prosthesis utilizing designed scan bodies attached to the copings of the implant-supported restoration | N=5 (Novel scan bodies , NR) | IOS: Trios 3 (3Shape A/S, Copenhagen, Denmark) | Novel scan bodies were hand-tightened onto the copings of the prosthesis and specially designed, by connecting the body of a regular implant scan post with a screw-retained abutment analog | Although further studies are needed to evaluate the accuracy of the presented methods, this technique can be applied even in the absence of intraoral landmarks, overcoming the limitations of using fiducial markers on soft tissues or screwed scanning pins. |
| Hyspler et al. [32] (2023), Czech Republic | Complete-arch (mandible) | Extraoral scan of the interim prosthesis | N=5 (scannable implant analog, AnalogSC; Lasak) | Laboratory scanner: AG Map 300 (Amann Girrbach AG, Mäder, Österreich, Austria) | This fully digital procedure uses a laboratory scanner and scannable implant analogs to increase accuracy. | The accuracy of implant positioning in extensive prosthetic restorations has been verified or increased using this technique. This method is economical, fast, and applicable to most indications of fixed prostheses. |
| Bedrossian et al. [33] (2023), USA | Complete-arch (maxilla and mandible) | Extraoral scan of the interim prosthesis | N=4 (RevEX; Institut Straumann AG, Basel, Switzerland) | IOS: (Not reported) | Reverse scan bodies were attached to provisional prosthesis which was scanned. A digital technique was used to mill a verification jig | This method optimizes communication between the clinician and laboratory once the implant positions are acquired. |
| Papaspyridakos et al. [35] (2024), USA | Complete-arch (maxilla and mandible) | Extraoral scan of the interim prosthesis | N=6 (RevEX; Institute Straumann AG, Basel, Switzerland) | IOS: Trios 4 (3Shape A/S, Copenhagen, Denmark) | A digital technique was used for a CAD-CAM verification jig from the IOS data, to verify that the STL file of the implant positions was accurately captured | The use of reverse scan bodies and extraoral scanning can eliminate the need to record the position of the implants with intraoral scanning |
| Nguyen et al. [36] (2025), Vietnam | Complete-arch (maxilla and mandible) | Extraoral scan of the interim prosthesis | N=4 (DIO-UFII system) | Not reported | A resin jig was used to check the passive fit of the future prosthesis in the patient's mouth. | Enhanced patient comfort, minimized chair time, and ensured the quality of the prosthetic outcome |

**Table III -** Assessment of the risk of bias in the included studies using the QUIN tool

| References | Papaspyridakos et al. [16] | Papaspyridakos et al. [25] | Nuytens et al. [27] | Hyspler et al. [34] |
|---|---|---|---|---|
| Clearly stated aims/objectives | 2 | 2 | 2 | 2 |
| Detailed explanation of sample size calculation | 0 | 2 | 2 | 0 |
| Detailed explanation of sampling technique | 2 | 2 | 2 | 2 |
| Details of comparison group | 2 | 2 | 2 | 2 |
| Detailed explanation of methodology | 2 | 2 | 2 | 2 |
| Operator details | 2 | 1 | 1 | 0 |
| Method of measurement of outcome | 2 | 2 | 2 | 2 |
| Outcome assessor details | 2 | 1 | 1 | 0 |
| Blinding | 1 | 1 | 1 | 0 |
| Statistical analysis | 2 | 2 | 2 | 2 |
| Presentation of results | 2 | 2 | 2 | 2 |
| Score | 19 | 19 | 19 | 14 |
| % | 86.36 | 86.36 | 86.36 | 63.63 |
| Risk of bias | Low | Low | Low | Medium |

In 2023, Nuytens et al. [27] evaluated the accuracy and precision of 100 images acquired using four distinct intraoral scanners and one extraoral scanner (20 images per scanner type) during the reverse scanning of a fixed total prosthesis with six scannable analogs (Table I).The E4 RED extraoral scanner demonstrated superior performance compared to the intraoral scanners, exhibiting a linear trueness and precision values of 65 ± 43 $\mu$m and 18 ± 11 $\mu$m, respectively. Among the intraoral scanners evaluated, the TRIOS 5 scanner yielded the most favorable results, with a linear trueness of 85 ± 39 $\mu$m and precision of 86 ± 55 $\mu$m.

Hyspler et al. [34] conducted a comparative analysis of the reverse scan technique (RST) and an intraoral scanner, utilizing the traditional impression technique in both in vitro and in vivo settings. Procrustes coordinates were employed to facilitate a more detailed examination of observed point-to-point (abutment-to-abutment) inconsistencies. Among the participants, the Procrustes distance values were recorded as RST intraoral ranging from 9.5 to 9.6 $\mu$m (median 9.5 $\mu$m) and IOS intraoral ranging from 5.7 to 18.3 $\mu$m (median 10.9 $\mu$m). These values represent a significant difference when compared to the Control group, which exhibited a range from 0 to 0.4 $\mu$m (median 0.3 $\mu$m).

The QUIN analysis of the in vitro studies indicated a generally low risk of bias, with the exception of one study by Hyspler et al. [34], which demonstrated methodological inconsistencies, leading to its classification as having a moderate risk of bias (Table III).

In our observations, each in vitro study assessed distinct outcomes using various comparative methodologies, including both extraoral and intraoral scanners, as well as the traditional impression technique. Additionally, different types and brands of reverse scan bodies were utilized, as detailed in the data extraction presented in Table I. Due to the heterogeneity in methodologies and outcomes, conducting a meta-analysis of in vitro studies was not feasible.

## DISCUSSION

This scoping review provides an overview of the applicability of reverse scanning techniques in implant rehabilitation. According to the articles included, this technique is predominantly utilized in full-arch cases, although it is feasible to implement this scanning method in fixed partial or single prostheses, as there may also be a provisional stage in these instances [10-12].

Among the facilities elucidated by technique report studies are the documentation of soft tissue information during the final impression process, incorporating a jig to assess the passivity of the fittings within the digital workflow [28], utilization of scannable analogs affixed to the printed abutments of the jig itself, obviating the need for implant scan bodies [29], elimination of the necessity to fabricate a device or template for prosthesis capture [30], employment of a scan body analogous to an analog, attaching it to the prosthesis [31], and the capability to verify implant positioning in extensive prosthetic restorations with enhanced precision [32]. Consequently, these solutions have established novel references for overlapping meshes with edentulous regions, potentially mitigating the risk of misalignment during laboratory procedures for definitive prosthesis fabrication [19-22].

These facilities also yield advantages such as enhanced operational efficiency (expedited consultations and reduced session frequency), decreased expenditure on component acquisition, improved visualization of prosthetic passivity, particularly in posterior regions, and increased patient comfort, especially for individuals with temporomandibular disorders, by reducing mouth opening time [10,16,17].

The comparisons between the two in vitro studies that evaluated the fit of prostheses on abutments [16,25] were consistent with the literature regarding the increased risk of settlement failures during the fabrication of printed prostheses compared to milled prostheses [15,24] and the advantage of utilizing the scanning strategy recommended by the manufacturer, as each device employs a specific image capture technology [14]. The study conducted by Nuytens et al. [27] corroborates the findings of prior research, illustrating the superior accuracy of laboratory scanners compared to intraoral scanners.[18]. In conclusion, the study conducted by Hyspler et al. [34] determined that the utilization of an IO scanner to acquire a 3D cast of an interim implant-supported prosthesis with scannable implant analogs is not advisable for clinical application. This recommendation is based on the observation that this group exhibited the most significant errors compared to the reference within the dataset examined.

Among the in vitro studies reviewed, three demonstrated a low risk of bias and employed rigorous methodologies to evaluate outcomes. These studies utilized multiple variables to assess the degree of satisfaction with the fit of prostheses on abutments. These variables included the screw resistance test, visual inspection, periapical radiographs, and inter-examiner agreement [16,25]. Nuytens et al. [27] employed Geomagic Control X (3D Systems) software to obtain values pertaining to the measurement properties of scanners that are currently available in the market. The study by Hyspler et al. [34], which was the only one identified with a medium risk of bias, utilized Procrustes analysis, despite its rare use in the assessment of digital dentistry.

Within the inherent limitations of the in vitro studies included in this review, the findings suggest that the final accuracy of the RST is within acceptable limits, though caution is advised in clinical practice. The accuracy of the chairside reverse scanbody workflow is contingent upon the IOS, as significant deviations were observed between different devices. Clinicians should exercise discernment in selecting scanning technology, favoring laboratory scanners. It is recommended to utilize a verification jig device, especially for prostheses produced through 3D printing. It is essential to ensure that the interim conversion prosthesis achieves a passive fit, while also confirming the accuracy of clinical parameters such as the appropriate vertical dimension, aesthetics, and phonetics for the patient, as well as an appropriate internal contour for hygiene. Furthermore, it is imperative to verify the torque of screw-retained abutments prior to extraoral scanning to ensure their security. Notably, the availability of reverse scan body libraries may vary among software versions and scan body manufacturers. Consequently, it is imperative to verify the compatibility between dental software and reverse scan bodies before initiating the digital workflow. It is advisable for professionals to contact software manufacturers or their representatives to obtain more comprehensive information regarding the acquisition and inclusion of available reverse scan body libraries, compatibility, and the specific features offered by each software package.

The current review did not identify any primary studies that compare the fit of prostheses on abutments fabricated using the intraoral scanning technique with those produced by the reverse technique. Furthermore, three out of the four included in vitro studies that compared the conventional impression technique with the reverse scanning technique evaluated other procedures not directly related to reverse scanning, such as milled-to-printed restorations, various scanning strategies, and different scanning devices. Owing to the paucity of evidence regarding the reverse scan technique as the primary focus, additional research is necessary to obtain robust data.

## CONCLUSION

The potential applicability of the reverse scan body technique for fabricating fixed prostheses on implants appears promising for full-arch rehabilitation. However, additional well-designed studies are necessary to corroborate these findings.

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## Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

## Author's Contributions

CNCW: Conceptualization, Data Curation, Methodology, Visualization, Writing – Original Draft Preparation. RSLS: Data Curation, Investigation, Writing – Original Draft Preparation. PSP: Data Curation, Investigation. MKM: Validation, Writing – Review & Editing. NS: Methodology, Project Administration, Supervision. EVFS: Formal Analysis, Project Administration, Supervision, Writing – Review & Editing.

## Conflict of Interest

The authors have no conflicts of interest to declare.

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## Regulatory Statement

This review protocol was registered (PROSPERO ID: CRD42024555437) and adheres to the *Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020)* guidelines, as recommended by the EQUATOR Network.

## Disclosure

The data extraction tables were exclusively populated with information sourced from the articles included in this review.

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