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Digital Surveying of Removable Partial Dentures Using Digitally Developed Analyzing Tips: A Case Report

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CASE REPORT

ABSTRACT

Surveying is an essential step in the planning of removable partial dentures (RPDs), as it allows the identification of guiding planes, retentive areas, and the path of insertion. Although digital workflows are increasingly being used in prosthodontics, digital surveying often relies on proprietary software, which may limit its use in clinical and educational settings. This study describes the development and application of digitally designed surveyor tips for performing digital surveying in an open-source software environment and presents a qualitative comparison with conventional analog surveying.A 68-year-old female patient was rehabilitated with maxillary and mandibular removable partial dentures. The surveyor tips were digitally designed using CAD software and applied to a scanned dental model within an open-source environment to perform digital surveying. Subsequently, conventional analog surveying was performed using the same analytical criteria, allowing a qualitative comparison between both approaches.Digital surveying enabled the identification of guiding planes, retentive areas calibrated at 0.25 mm, and topographic interferences. The qualitative comparison demonstrated agreement between digital and conventional surveying regarding the identified areas and the overall prosthetic planning approach. After the surveying stage, the RPDs were completed using a conventional analog workflow, reestablishing dental elements within the function and esthetics of the stomatognathic system.The digitally developed surveyor tips used in an open-source environment allowed digital surveying of this clinical case, with results comparable to conventional mechanical surveying, suggesting a viable alternative for digital or hybrid workflows in removable partial denture fabrication.

Keywords: removable partial denture, digital dentistry, computer-aided design, computer-aided manufacturing, software.

Delineamento Digital de Prótese Parcial Removível Utilizando Pontas Analisadoras Desenvolvidas Digitalmente: Relato de Caso

RESUMO

O delineamento é uma etapa essencial no planejamento de próteses parciais removíveis (PPR), pois permite identificar planos guias, áreas retentivas e o caminho de inserção. Embora os fluxos de trabalho digitais estejam sendo cada vez mais utilizados na prótese dentária, o delineamento digital frequentemente depende de softwares proprietários, o que pode limitar seu uso em ambientes clínicos e educacionais. Este estudo descreve o desenvolvimento e a aplicação de pontas analisadoras projetadas digitalmente para a realização do delineamento digital em um ambiente de software livre e apresenta uma comparação qualitativa com o delineamento analógico convencional. Uma paciente do sexo feminino, de 68 anos, foi reabilitada com próteses parciais removíveis superior e inferior. As pontas analisadoras foram projetadas digitalmente utilizando software CAD e aplicadas a um modelo dental escaneado em um ambiente de software livre para realizar o delineamento digital. Em seguida, o delineamento analógico convencional foi realizado utilizando os mesmos critérios analíticos, permitindo comparação qualitativa. O delineamento digital possibilitou a identificação de planos guias, áreas retentivas calibradas de 0,25 mm e interferências topográficas. A comparação qualitativa demonstrou concordância entre o delineamento digital e o convencional nas áreas identificadas e na abordagem geral do planejamento protético. Apos a etapa de delineamento, a PPR foi finalizada utilizando o fluxo convencional analógico, reintegrando os elementos dentais à função e estética do sistema estomatognático. As pontas analisadoras desenvolvidas digitalmente e utilizadas em ambiente de software livre permitiram a realização do delineamento digital do presente caso clínico, com resultados comparáveis ao delineamento mecânico convencional, sugerindo uma alternativa viável para fluxos de trabalho digitais ou híbridos em PPR.

Palavras-chave: prótese parcial removível, odontologia digital, desenho assistido por computador, manufatura assistida por computador, software.

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INTRODUCTION

The fabrication of removable partial dentures (RPDs) involves sequential manual procedures, including surveying, planning on gypsum casts, and laboratory fabrication of the metal framework. Although well established, these procedures are subject to variations in accuracy, standardization, and reproducibility of outcomes (SILVA; OLIVEIRA; SOUZA, 2024). Proper surveying of dental casts is essential for preserving supporting tissues and ensuring patient comfort, as it allows the identification of retentive areas, interferences, and structural characteristics necessary for the development of a functional, aesthetic, and biomechanically balanced prosthetic design (REIS; REIS, 1995). These factors are directly associated with the longevity of both the remaining teeth and the prosthetic treatment.

In recent years, the incorporation of digital technologies has transformed dentistry by introducing workflows that include intraoral scanning, CAD (Computer-Aided Design) software, and CAM (Computer-Aided Manufacturing) processes, such as milling and 3D printing. These advances contribute to greater predictability in surveying, improved adaptation of metal frameworks, and enhanced standardization in the fabrication process of RPDs (TAKAICHI et al., 2022; TAKAHASHI et al., 2023; ELGAMAL et al., 2025).

Recent evidence indicates that digitally fabricated RPDs show promising results regarding framework adaptation, patient satisfaction (TAKAHASHI et al., 2023), reduction in clinical adjustments, and improved communication between clinician and laboratory, in addition to reduced overall clinical time (SILVA; OLIVEIRA; SOUZA, 2024; KUMAR et al., 2024). However, technical challenges still remain, including issues related to the bonding between metal framework and acrylic base, material durability, and dimensional accuracy, which are essential factors for long-term clinical success (TAKAICHI et al., 2022; ELGAMAL et al., 2025).

Furthermore, concerns remain regarding the accessibility, standardization, and academic applicability of digital surveying, which is still not widely disseminated in many clinical and educational environments. A recent review highlighted the absence of reports employing digitally developed accessories created in open-source software

environments, eliminating the dependence on expensive commercial solutions (BIASI, 2019).

In this context, free software platforms designed for drawing, analysis, and manipulation of STL (Standard Tessellation Language) files have been investigated as viable and safe alternatives for digital RPD planning (REVILLA-LEÓN; ÖZCAN, 2020; CURINGA et al., 2025). These resources allow virtual simulation of the functions traditionally performed by conventional dental surveyors, enabling prosthetic design development without the need for paid platforms and favoring the democratization of digital workflows (REVILLA-LEÓN; ÖZCAN, 2020). Specific commercial software programs offer features such as insertion path suggestion (Guiding Planes Tool), survey line definition (Draw Survey Line), colorimetric undercut mapping (Undercut Display), and interference detection (Blockout Undercuts), although requiring paid licenses (LONEY et al., 2017). However, these programs still present limitations, such as the absence of tools for selective tooth reduction or creation of retentive areas, while also maintaining dependence on manual determination of the insertion path. Therefore, despite offering facilitating resources, they remain highly dependent on operator skill (BEZZON et al., 1997).

The tools proposed in the present study demonstrate that these same functions may be performed effectively and efficiently using intuitive free software platforms. In light of this technological transition, reporting clinical cases that illustrate the practical application of these resources becomes relevant, contributing to a better understanding of their advantages, limitations, and clinical potential (FREITAS et al., 2022). Therefore, the aim of this case report is to describe the use of digitally developed analyzing tips created by the authors through the design of characteristic and precise digital replicas of conventional surveying components for digital surveying of an RPD, as well as to demonstrate its comparison with conventional analog surveying.

CASE REPORT

A 68-year-old female patient sought dental care reporting masticatory difficulty and aesthetic dissatisfaction with a provisional removable partial denture. During anamnesis, no relevant systemic comorbidities were identified; the patient was undergoing follow-up treatment for temporomandibular disorder at a hospital service. Clinical examination revealed the absence of teeth 14, 12, 11, 21, 22, 23, 25, 34, 36, 37,

44, 45, 46, and 47. According to Kennedy's classification, the maxillary arch was classified as Class III, modification 2, and the mandibular arch as Class I, modification 1. The remaining teeth presented satisfactory periodontal support and were considered suitable as abutment teeth. Rehabilitation with maxillary and mandibular removable partial dentures with metal frameworks was indicated, preceded by oral environment conditioning, including periodontal therapy, replacement of unsatisfactory restorations, and incisal recontouring.

Digital analyzing tips were developed using CAD software (Fusion 360, Autodesk, version 2022.1), faithfully reproducing the dimensions of the instruments used in conventional surveying, obtained using a digital caliper. The following components were modeled: vertical analyzing tip, horizontal blade, cylindrical analyzing tip, graphite marker, and retention gauges with different diameters. The digital analyzing tip models were exported as mesh files and saved in STL format for subsequent use in the digital analysis environment (FIGURE 1).

Intraoral scanning of the mandibular arch was performed using a Trios 3Shape® scanner (3Shape, Copenhagen, Denmark), generating a digital model exported in STL format and imported into Meshmixer software (Autodesk Inc., San Rafael, CA, USA). The virtual model was oriented to define the path of insertion while maintaining parallelism with the horizontal plane. Guiding plane analysis was performed using the digital analyzing tip, whereas retentive areas were identified using the 0.25-mm digital gauge. When ideal guiding planes could not be established, conventional surveying principles were applied, including anteroposterior and lateral movements of the analyzing tip to identify retentive zones and determine the path of insertion. Topographic interferences and aesthetic aspects were also considered during digital surveying.

After completion of the surveying process, the model was stabilized at the selected angulation and used as a reference for the digital design of a zirconia crown for tooth 35, incorporating rest seats and planned surfaces for support and retention. The crown was fabricated through a CAD/CAM workflow using Ceramill Mind/Cockpit® software (Amann Girrbach, Koblach, Austria), subsequently milled in zirconia and cemented with dual-cure resin cement.

Following crown cementation, an impression was taken using condensation silicone in a stock tray, followed by pouring of a type IV gypsum cast. Conventional surveying was performed using a mechanical dental surveyor, reproducing the same protocol applied in the digital environment: model orientation parallel to the horizontal plane, guiding plane analysis using a vertical analyzing tip (FIGURE 2), identification of 0.25-mm calibrated retentive areas (FIGURE 3), and evaluation of interferences and aesthetic parameters. The comparison between digital and conventional surveying was qualitative, considering the correspondence of the identified areas and the overall prosthetic planning rationale.

After these procedures, the case proceeded through the conventional clinical and laboratory workflow for removable partial denture fabrication, including oral preparation guided by the planning, definitive impressions, metal framework try-in, altered cast technique, maxillomandibular records, shade selection, tooth arrangement, functional and aesthetic try-ins, acrylic processing, and prosthesis delivery. The patient authorized the anonymized use of her clinical data for scientific purposes.

RESULTS AND DISCUSSION

The digital workflow in fixed prosthodontics presents numerous advantages over the analog approach, such as the acquisition of a digital model in a single step through intraoral scanning, with high accuracy and precision described in the literature (ENDER; MEHL, 2013). In addition, the technique for obtaining digital models is more comfortable for patients and eliminates the need for physical storage of casts, making it a more environmentally sustainable approach (REVILLA-LEÓN; ÖZCAN, 2019). However, its use in removable partial dentures is still under development (PIAO et al., 2022). In this context, digital surveying represents a relevant technological advancement, especially when performed entirely using open-source software (GAN et al., 2025). This approach provides greater accessibility and reproducibility across different academic and clinical settings while reducing dependence on costly proprietary tools (BIASI, 2019).

Although specific commercial software allows simplified modification of the path of insertion and automatic blocking of retentive areas, thereby reducing laboratory time

and the potential for human error associated with these procedures (TAKAICHI et al., 2022), the digital surveying method using the analyzer tips proposed in this study demonstrated the potential to perform similar functions in an accessible and license-free manner.

The main distinguishing feature of the proposed methodology consists of transforming the instruments traditionally used in the mechanical dental surveyor into parametrized and reproducible digital equivalents. Thus, the developed digital analyzer tips function as three-dimensional virtual replicas of conventional instruments, enabling the digital reproduction of analyses commonly performed during conventional surveying procedures. This digital standardization may improve process predictability and reproducibility among different operators and computational environments.

The use of CAD (Computer-Aided Design) technology enabled the digital fabrication of analyzer tips with a high level of detail, ensuring geometric precision and supporting future stages of prototyping and additive or subtractive manufacturing (BÓSIO; DEL SANTO; JACOB, 2017). In this regard, the combined use of Fusion 360 and open-source software was established as an innovative strategy for developing digital replicas of the instruments employed in conventional surveying. The use of these digital tools allows clinicians to reproduce analog surveying procedures in a simplified manner through three-dimensional manipulation of digital models and instruments at different angulations while maintaining consistency with the biomechanical principles of prosthetic planning.

In the present case report, all functions traditionally performed with a conventional dental surveyor were successfully reproduced digitally. A qualitative agreement was observed between digital and conventional surveying regarding the analyzed areas and the rationale of prosthetic planning. Although this technology is still in an early stage of validation, the digital surveying workflow demonstrated promising results, since the procedures performed virtually showed clinical correspondence with those reproduced using the conventional method. Furthermore, the digital approach makes the process potentially faster and less dependent on specific equipment, such as mechanical surveyors or complex laboratory systems, thereby expanding its clinical and academic

applicability.

This approach not only promotes the creation of an open-access digital repository but also increases its educational applicability by allowing students to interact with three-dimensional digital resources capable of facilitating the understanding of the surveying technique (REIS; REIS, 1995). Moreover, the proposed method demonstrates potential clinical impact, since the use of digital models may contribute to greater standardization of the surveying process, reduction of operational errors, and integration into digital workflows for removable partial dentures (BIASI, 2019; BÓSIO; DEL SANTO; JACOB, 2017). Its reproducibility and low operational cost may contribute to democratizing access to more precise technological resources, aligning with contemporary trends in digital dentistry.

These conditions also support a relevant educational alternative for introducing students to the digital environment, including situations in which a complete digital workflow is not available. Therefore, the incorporation of these accessible tools may facilitate the transition between analog and digital methods, establishing a hybrid workflow applicable to different clinical and educational realities.

This case report demonstrated the application of these tools in the digital surveying of a bimaxillary removable partial denture case. However, additional clinical studies are required to expand the scientific evidence regarding the applicability, reproducibility, and clinical performance of the proposed tools, contributing to greater dissemination and consolidation of digital workflows in removable partial dentures.

FINAL CONSIDERATIONS

Therefore, the digital development of analyzer tips for surveying using accessible and precise software represents a scientifically promising, economically viable, and pedagogically enriching alternative. In addition to enabling the parametrized digital reproduction of instruments conventionally used in mechanical surveying, this approach may contribute both to academic training and clinical practice, establishing a bridge between traditional methods and contemporary innovations in digital dentistry.

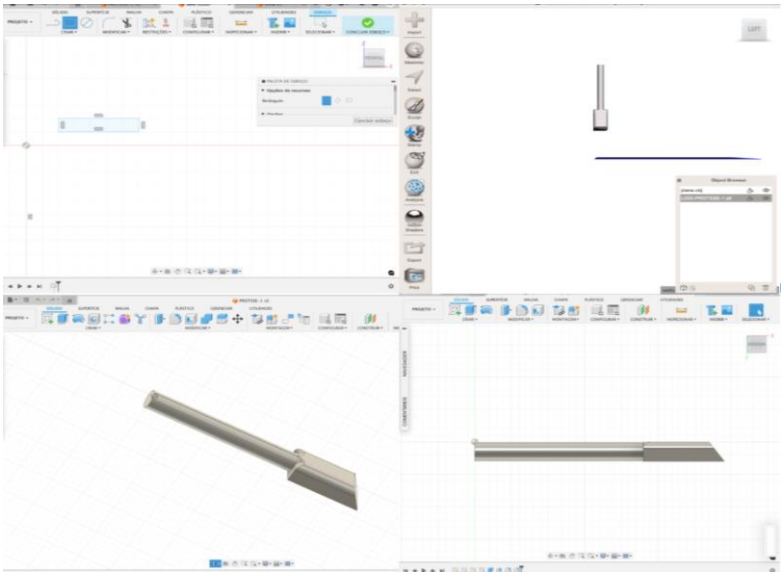

FIGURE 01-Design of digital custom analyzing tips

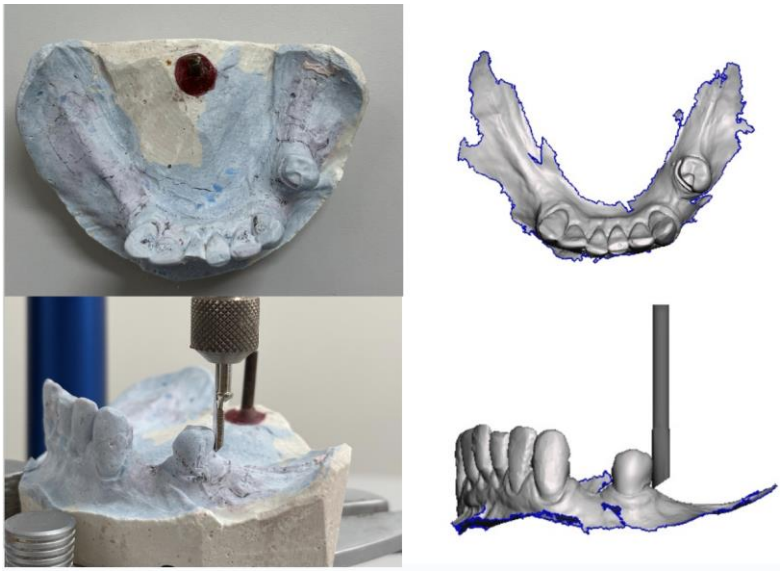

FIGURE 02 – Comparison between digital and conventional surveying: vertical analyzer tip for guide plane definition.

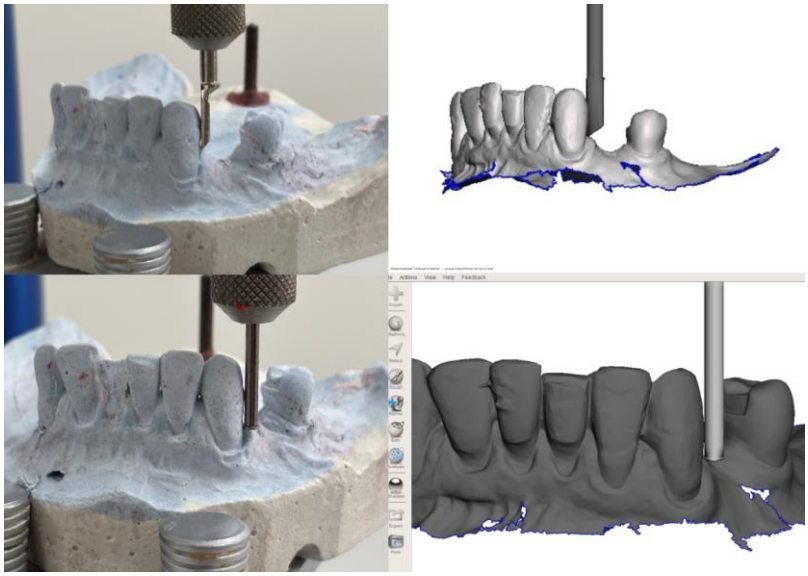

FIGURE 03 – Comparison between digital and conventional surveying.

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