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Comparative Analysis of Analogue Vs. Digital Surveying in Removable Partial Dentures: An Original Research

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ABSTRACT

Aim: *This study aimed to compare and evaluate the accuracy of conventional analogue surveying using a mechanical dental surveyor with digital surveying performed through specialised software.*

Materials and Methods: *Fifteen participants diagnosed with Kennedy Class II partial edentulism requiring removable partial dentures were selected based on predetermined inclusion and exclusion criteria. Preliminary impressions were taken using irreversible hydrocolloid for analogue processing, and intraoral digital scans were obtained using a 3D scanner. Analogue casts were surveyed using the Wills mechanical surveyor (BEGO Paraflex), while digital scans were analysed with dedicated dental CAD software (AiDental). Key parameters, including survey lines and undercut measurements, were recorded for both techniques. Comparative data were analysed using SPSS software with Paired t-test, ANOVA, and Chi-Square tests; a p-value <0.05 was considered statistically significant.*

Results: *No statistically significant differences were observed between the analogue and digital techniques across all surveyed parameters ($p>0.05$). Both techniques demonstrated high consistency in identifying undercuts and guiding planes.*

Conclusion: *Digital surveying demonstrated accuracy comparable to conventional analogue methods. Owing to its efficiency, reproducibility, and integration with digital workflows, it presents a viable alternative in prosthodontic diagnostics, particularly for Kennedy Class II removable partial denture cases.*

Keywords: *Prosthodontics, Denture, Partial, Removable*

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INTRODUCTION:

Surveying is a fundamental step in RPD design that involves analysing a cast of the patient's arch to define the optimal path of insertion and locate heights of contour and undercuts on abutment teeth. A dental surveyor – a parallelometer instrument with a tilting cast table and a movable arm – is traditionally used for this purpose[1]. By systematically moving the stylus around each tooth, the clinician identifies the greatest circumference (height of contour) and maps retentive versus non-retentive undercut areas. In effect, surveying determines how the RPD framework will engage the teeth: it guides the design of clasps, guiding planes, and occlusal rests so that the prosthesis can be inserted and removed along a predetermined, repeatable path[1]. As McCracken's textbook notes, surveying "identifies the modifications of oral structures…

necessary to fabricate a removable partial denture that will have a successful prognosis," facilitating stable, comfortable RPDs[2]. In practice, accurate surveying ensures that clasp retentive undercuts are optimally used and that unwanted interferences are avoided, which is critical for retention and long-term function.

Traditionally, surveying is performed on gypsum (stone) casts using a mechanical surveyor. The cast is mounted on the surveyor's table, and the desired path of insertion is established by tilting the cast until multiple abutment teeth present their guiding planes (parallel proximal surfaces) and undercuts are favourably aligned[3]. Common surveyor designs include the Ney (with a fixed horizontal arm) and the Jelenko surveyor (with a swiveling arm), each allowing the cast to be indexed at various tilts. Once an acceptable path is found, the cast is tripoded – three non-collinear points are marked on the cast base – to record its exact orientation on the surveyor[3]. This enables the same tilt to be reproduced later on the master cast after mouth preparations.
Accurate surveying is directly linked to the clinical success of an RPD. A properly surveyed and planned design ensures that the prosthesis seats fully along the chosen path, fully engaging rests and clasps without interference[5]. This translates into optimal retention, support, and stability. For instance, guide planes that are parallel to the path of insertion help distribute lateral forces and prevent torque on abutment teeth, while clasps placed in measured undercut produce the needed frictional retention[6]. McKraken emphasises that using a surveyor to plan tooth modifications is "vitally important in helping to provide stable and comfortable removable prostheses". In contrast, poor surveying can lead to ill-fitting dentures, sore spots, and premature failure of clasps or tooth structure[2].

Recent advances in digital dentistry have introduced virtual surveying tools that replicate these steps on digital models. In a fully digital workflow, an intraoral scanner or desktop scanner creates a 3D model of the partially edentulous arch (often in STL format)[7]. Software tools can then "survey" this model: automatically detecting heights of contour, displaying undercut depth maps, and allowing the user to rotate the model to select the optimal path of insertion[8]. For example, CAD/CAM programs can colour-code areas of retentive undercut and non-undercut on a virtual cast, and some systems enable "drag-and-drop" placement of clasp and connector components[9].

Compared to conventional surveying, digital methods offer several advantages. CAD-based analysis can be much faster and more reproducible: one study notes that drawing survey lines and calculating undercuts in software takes seconds, whereas manual surveying is far more time-intensive and variable[10]. Digital surveying also reduces human error and facilitates easy storage and sharing of designs. Modern software often includes libraries of clasp designs and other RPD components, which can be applied to the model automatically once undercuts are identified. These tools eliminate the need for physical markers or block-out on gypsum casts and allow the entire framework to be designed in a virtual environment before any lab work begins[11].

Innovations such as the AiDENTAL RPD Surveyor (a browser-based 3D surveyor and design application) aim to bridge the gap between traditional planning and digital workflows. Mahrous et al. (2025) note that fully digital RPD workflows have been slow to emerge due to a lack of accessible surveying/design software and highlight new solutions that streamline digital analysis of RPDs[12]. In general, CAD/CAM fabrication of RPD frameworks (including subtractive milling or additive 3D printing) has been shown to produce highly accurate and reproducible metal frameworks, with reduced fitting adjustments compared to conventional casting. Digital methods also simplify patient records: a digital cast and design file can be archived indefinitely, facilitating rapid remake if teeth or tissue change[11].

The null hypothesis would be that there would be no significant differences between the analogue and digital methods in terms of undercut determination and height of the survey line

MATERIALS AND METHODS:
This was a cross-sectional study, which meticulously selected fifteen participants based on strict inclusion and exclusion criteria at Narsinhbhai Patel Dental College and Hospital, Visnagar. The inclusion criterion mandated that all participants be classified under Class II of Kennedy's classification system for partial

edentulism, indicating specific patterns of missing teeth[13]. The abutment teeth must exhibit good periodontal health, be free from restorations or caries, and necessitate additional treatment. Conversely, the exclusion criteria were comprehensive, aiming to eliminate confounding factors. These included individuals classified under Classes I, III, IV, V, or VI of Kennedy's classification, those deemed uncooperative, patients with recent dental extractions that could affect the alveolar ridge, individuals suffering from acute illnesses that might influence oral health, those with existing Temporomandibular Joint (TMJ) issues potentially impacting jaw movements and occlusion, patients with a history of alcohol or drug abuse known to affect oral hygiene and treatment compliance, and individuals who had undergone radiotherapy, which can significantly alter oral tissues and healing capabilities. Participants were selected based on predetermined clinical screening, using the inclusion and exclusion criteria above, and consecutive sampling was done to reduce bias.

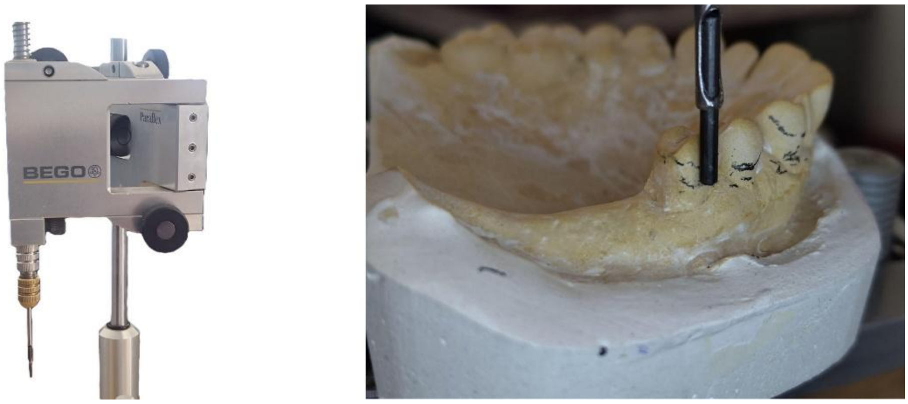
The primary outcomes measured included undercut depth at various line angles (mesiobuccal, distobuccal, mesiolingual, distolingual) and survey line classification (high, medium, low). The main exposure was the type of surveying method used—either conventional analogue surveying with a mechanical device or digital surveying using specialized CAD software. Predictors of these outcomes included the surveying technique itself, the type and location of the abutment tooth, and the specific line angles measured.

Two distinct impression techniques were employed to accurately represent the participants' dental arches. First, irreversible hydrocolloid material (Tropicalgin, Zhermack Inc.) was used to create conventional impressions. This material is known for accurately recording oral tissues, although it is susceptible to distortion if not handled properly. Simultaneously, intraoral scans were performed on all fifteen patients utilising the Intraoral Scanner (NH100, Irific Pvt Limited), a digital method for capturing precise three-dimensional data of the oral cavity. This dual approach allowed for a direct comparison between traditional and digital methods of data acquisition.

Following the conventional impression-taking procedure, the impressions were immediately poured in dental stone (Gyprock) to create positive replicas of the dental arches. Subsequently, a base was formed using Plaster (Kalabhai) to provide stability and a standardised platform for the ensuing surveying process. Surveying, a critical step in removable partial denture design, was then conducted using a Wills Surveyor (Paraflex, BEGO) (Figure 1A). This mechanical device allowed for the identification and marking of the height of contour on the abutment teeth (Figure 1B), which is the greatest circumference of the tooth at a selected horizontal plane. Furthermore, undercuts, areas below the height of contour that can be engaged by the retentive components of a partial denture, were meticulously measured using an undercut gauge to ensure adequate retention. The study involved specific abutment teeth in different quadrants of the dental arches: the upper right first premolar, upper left first premolar, lower left first premolar, and lower right first premolar. The distribution of these abutment teeth among the fifteen participants revealed that 20% involved the upper right first premolar, 13.3% the upper left first premolar, 20% the lower left first premolar, and a higher proportion, 46.7%, involved the lower right first premolar. This variation in the location of abutment teeth allowed for an assessment of the surveying methods across different tooth morphologies and positions within the dental arch, with all cases falling under Kennedy's Class II classification.

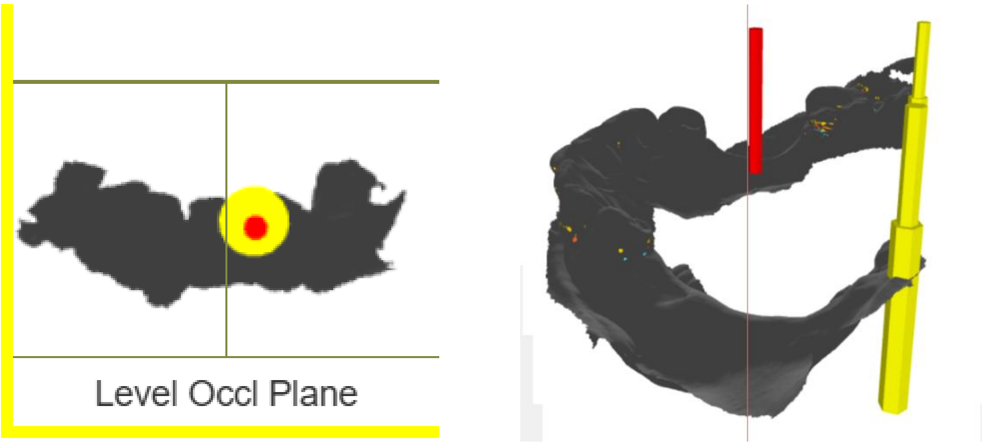
In the digital methodology, the identical abutment teeth identified in the conventional method were targeted for surveying, ensuring a direct comparison. However, the entire workflow was executed digitally. The intraoral scans acquired earlier were used to generate Standard Tessellation Language (STL) files, a common file format for 3D surface geometry. These digital models were then securely uploaded to the AiDental app portal, a software platform designed for dental analysis and treatment planning.

The digital surveying process within the AiDental app involved a structured sequence of steps. Initially, the orientation of the digital model was determined and digitally stored within the software, establishing a consistent frame of reference. The subsequent step involved the levelling of the occlusal plane (Figure 2A),



A B

Figure 1: (A) Surveyor (B) Surveying on cast



A B

Figure 2: (A) Digital Occlusal Plane (B) Digital Surveying completed with survey points

ensuring that the digital model was oriented in a manner that accurately represented the patient's bite. Following these preparatory steps, the digital surveying process commenced. The software's initial analysis determined whether the scanned model represented a maxillary (upper) or mandibular (lower) arch. Through subsequent automated runs utilising pre-determined algorithms, the digital surveying process was completed (Figure 2B). The time required for each scan to be surveyed ranged from approximately 30 seconds to a full minute, highlighting the efficiency of the digital approach. Upon completion of the digital surveying, various markings were visually displayed on the digital model. Two perspectives were offered: a ribbon view for a general overview and a point view for greater accuracy. A yellow mark indicated the height of the survey line, representing the maximum convexity of the abutment teeth at the determined plane. A red mark denoted the presence of a 0.01-inch undercut, a commonly used value for retentive clasp arms in removable partial dentures. Similarly, a turquoise line indicated the presence of a 0.02-inch undercut, which might be utilised for other prosthetic components or in different clinical situations. Notably, the software incorporated algorithms that automatically adjusted the tripoding, a process of selecting three non-interfering points on the model to define its orientation during surveying, ensuring a consistent and reproducible survey path. The occlusal plane established in the software was meticulously compared to the occlusal plane determined using the analogue surveyor, confirming the accuracy and consistency between the two methods.

For each abutment tooth selected, undercuts were measured at four distinct locations to provide a comprehensive assessment of retentive potential: the mesiobuccal, distobuccal, mesiolingual, and distolingual aspects. These specific locations are clinically significant for the placement and function of clasp assemblies. While different teeth were analysed based on the specific Kennedy’s Class II configuration of each participant, the focus remained consistently on teeth adjacent to the edentulous areas requiring prosthetic replacement. Once all the undercut measurements and the height of contour were determined using both the analogue and digital methods, all the collected data were carefully recorded and compiled. Subsequently, statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 20.0 software. The specific statistical tests employed included the paired t-test, which is appropriate for comparing the means of two related groups; repeated measures ANOVA, and the Chi-square test. These statistical analyses were crucial for determining the degree of agreement and any significant differences between the conventional analogue surveying method and the digital surveying workflow using the AiDental app.

RESULTS

1. Type of Tooth Distribution: The highest proportion of teeth analysed was the lower right first premolars (46.7%), followed by equal distributions (20%) of upper right and lower left first premolars.
2. Comparison of Line Angles Between Analogue and Digital Surveying (Table 1):

There were no statistically significant differences in measurements at any line angle between analogue and digital methods (p = 1.000 for all). This indicates that both methods provide nearly identical outcomes in evaluating undercut depths at all key survey angles.

Table 1*: Comparison of line angles between analogue and digital surveying

Line angle	Type of surveying	Number	Mean value			P Value
			Mean	SD	Difference	
MB	Analogue	15	0.012	0.007	0	1.000**
	Digital	15	0.012	0.007		
DB	Analogue	15	0.015	0.006	0	1.000**
	Digital	15	0.015	0.006		
ML	Analogue	15	0.012	0.007	0	1.000**
	Digital	15	0.012	0.007		
DL	Analogue	15	0.013	0.007	0	1.000**
	Digital	15	0.013	0.008		

*Level of Significance P ≤ 0.05, * Significant, ** Non-Significant

3. Comparison Among Line Angles Within Each Technique (Table 2):

For both analogue and digital groups, repeated measures ANOVA revealed the following p-values:

Analogue: p = 0.625

Digital: p = 0.685

There was no significant difference among the MB, DB, ML, and DL angles within either group. This suggests internal consistency within each surveying method across various line angles.

Table 2: Comparison among Line Angles

Type of	Line angle	Number	Mean value	P Value

surveying			Mean	SD	
Analogue	MB	15	0.012	0.007	0.625**
	DB	15	0.015	0.006	
	ML	15	0.012	0.007	
	DL	15	0.013	0.007	
Digital	MB	15	0.012	0.007	0.685**
	DB	15	0.015	0.006	
	ML	15	0.012	0.007	
	DL	15	0.013	0.008	

4. Survey Line type comparison (Table 3):

Table 3: Survey Line type comparison

Parameter	Survey line	Analogue		Digital		P Value
		n	%	n	%	
Type of survey line	High	4	26.7%	4	26.7%	1.000**
	Medium	7	46.7%	7	46.7%	
	Low	4	26.8%	4	26.8%	

The chi-square test again showed no statistically significant difference between analogue and digital techniques regarding survey line type. Both methods classified the same percentage of casts into high, medium, and low survey lines

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DISCUSSION:

The findings of this study align with the growing body of literature supporting the clinical reliability of digital tools in prosthodontic diagnostics. Despite perceived technological differences, the digital technique offered equivalent outcomes to traditional analogue surveying across all tested parameters. Hence, the null hypothesis in this case was accepted.

A key finding resonating through current research is the comparable accuracy of digital surveying. This parity is largely attributed to the implementation of standardised scanning protocols and the enhanced accuracy inherent in digital surface mapping. Intraoral and laboratory scanners can capture intricate details of dental and soft tissue anatomy with high fidelity, translating them into precise 3D virtual models. This allows for meticulous analysis and planning in a digital environment, minimising some of the manual variabilities associated with traditional techniques. Studies have shown that for many applications, digital impressions exhibit accuracy similar to conventional methods without statistically significant differences, particularly for smaller-span restorations.

Despite the advancements in digital technology, traditional analogue surveying continues to be a valid and dependable approach in routine prosthodontic practice. For decades, dental surveyors have been instrumental in determining the path of insertion for removable partial dentures, identifying undercuts, and establishing guiding planes. The tactile feedback and direct visualisation offered by analogue surveyors are well-understood and trusted by many practitioners[14]. Its continued relevance is supported by its established protocols, cost-effectiveness in certain settings, and the comfort level many clinicians have with these long-standing techniques.

The choice between digital and analogue surveying in prosthodontics is, therefore, a nuanced one. It hinges on a practice's resources, the clinician's expertise and preference, and the specific demands of the clinical case, all underpinned by the reassuring evidence that both pathways can lead to clinically reliable and accurate diagnostic outcomes. As digital technologies continue to evolve and become more accessible, their integration into routine practice is likely to expand, potentially leading to a synergistic approach that leverages the best of both worlds.

Limitations of the study:

The study was limited to just 15 patients, and those were limited to Kennedy's Class II cases. This severely limits Class III, IV and Class I cases with modifications significantly increasing the number of abutments required, and can change the result. Hence, more studies are required that can reaffirm the claim that digital and analogue surveying have comparable accuracy.

CONCLUSION:

Both analogue and digital surveying methods demonstrate comparable accuracy in evaluating undercuts for removable partial dentures in Kennedy's Class II cases. Digital surveying can be preferred due to its speed and efficiency, as it relies entirely on digital scans. However, further studies are needed to confirm these findings across different Kennedy's Classifications and with a larger patient pool.

REFERENCES:

1) DeRisi MC. Surveying for removable partial denture prosthesis. The Journal of the American Dental Association. 1961 Nov 1;63(5):603-10.
2) Carr AB, Brown DT. McCracken's removable partial prosthodontics-e-book. Elsevier Health Sciences; 2010 Jun 22.
3) Phoenix RD, Cagna DR, DeFreest CF. Stewart's clinical removable partial prosthodontics.
4) Curtis DA, Curtis TA, Wagnild GW, Finzen FC. Incidence of various classes of removable partial dentures. The Journal of prosthetic dentistry. 1992 May 1;67(5):664-7.
5) Bezzon OL, Mattos MD, Ribero RF. Surveying removable partial dentures: the importance of guiding planes and path of insertion for stability. The Journal of prosthetic dentistry. 1997 Oct 1;78(4):412-8.
6) Wöstmann B, Budtz-Jørgensen E, Jepson N, Mushimoto E, Palmqvist S, Sofou A, Öwal B. Indications for removable partial dentures: a literature review. International Journal of Prosthodontics. 2005 Mar 1;18(2).
7) Lima JMC, Anami LC, Araujo RM, Pavanelli CA. Removable partial dentures: use of rapid prototyping. J Prosthodont 2014;23:588-91
8) Ye H, Ning J, Li M, Niu L, Yang J, Sun Y, et al. Preliminary clinical application of removable partial denture frameworks fabricated using computer-aided design and rapid prototyping techniques. Int J Prosthodont 2017;30:348-53.
9) Campbell SD, Cooper L, Craddock H, Hyde TP, Nattress B, Pavitt SH, Seymour DW. Removable partial dentures: The clinical need for innovation. The Journal of prosthetic dentistry. 2017 Sep 1;118(3):273-80.
10) Tregerman I, Renne W, Kelly A, Wilson D. Evaluation of removable partial denture frameworks fabricated using 3 different techniques. The Journal of prosthetic dentistry. 2019 Oct 1;122(4):390-5.
11) Mohamed HA. Mini review: Role of digital technology and recent martials in removable partial denture fabrication. ERU Research Journal. 2024 Jul 29.
12) Mahrous A, Botsko DL, El-Gendy T, Elgreatly A. Enhancing digital workflows for removable partial dentures: A novel diagnostic surveyor and designer. Journal of Prosthodontics. 2025 Apr 22.
13) Bharathi M, Babu KR, Reddy G, Gupta N, Misuriya A, Vinod V. Partial Edentulism based on Kennedy's classification: an epidemiological study. The journal of contemporary dental practice. 2014 Mar 1;15(2):229-31.
14) Bohnenkamp DM. Removable partial dentures: clinical concepts. Dental Clinics. 2014 Jan 1;58(1):69-89.