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Dimensional Accuracy of Implant Surgical Guides Fabricated Using Direct Light Processing and 5-AXIS CAD–CAM Milling: A Comparative Analysis

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Abstract

Introduction: The accuracy of implant surgical guides is critical for the precise transfer of virtual implant planning to the clinical setting. Dimensional inaccuracies may result in deviations during implant placement, compromising prosthetic outcomes and patient safety. Surgical guides can be fabricated using additive manufacturing techniques such as Direct Light Processing (DLP) or subtractive methods such as 5-axis CAD–CAM milling; however, evidence directly comparing their dimensional accuracy remains limited.

Aim: To compare the dimensional accuracy (trueness and precision) of the intaglio surface of implant surgical guides fabricated using Direct Light Processing (DLP) 3-D printing and 5-axis CAD–CAM milling in terms of trueness and precision.

Objectives:

- To evaluate the trueness of Direct Light Processing and Milled guides.

- To evaluate the precision of Direct Light Processing and Milled guides
- To statistically compare the deviations between groups.

Materials and Methods

Twelve surgical guides were fabricated (n = 6 per group). Group A guides were produced using DLP (Direct Light Processing) 3-D printing, and Group B using 5-axis CAD–CAM milling. A power analysis was established by G*power, version 3.0.1(Franz Faul universitat, Kiel, Germany). A sample size of 12 (6 per group) would yield 80% power to detect significant differences, with assuming the effect size of 1.8 and significance level at 0.05. The intaglio surfaces were digitized and superimposed on the reference CAD design using Geomagic control X software. Trueness was evaluated by root mean square (RMS) deviation between the test and reference models. Precision was calculated from pairwise superimposition within each group. Independent Student's t-tests were used for statistical comparison ($\alpha = 0.05$).

Results: Mean RMS trueness was significantly lower for DLP (0.1009 ± 0.0171 mm) than for milling (0.1629 ± 0.0189 mm) ($p < 0.001$). Mean RMS precision was also lower for DLP (0.0664 ± 0.0184 mm) compared to milling (0.0963 ± 0.0338 mm) ($p = 0.005$). Lower RMS trueness and precision values observed for DLP indicate significantly higher dimensional accuracy and reproducibility compared to milling.

Conclusion: DLP-printed surgical guides demonstrated significantly superior trueness and precision compared with 5-axis CAD–CAM milled guides.

Keywords: 3D printing, edentulous surgical guide, precision, guided implant surgery, trueness, direct light processing CAD-CAM milling.

Introduction

Dental implant therapy has become a cornerstone in the management of partially and completely edentulous patients because it offers superior functional, aesthetic, and psychological benefits compared with conventional removable prostheses. The growing elderly population has further increased the demand for implant-supported prosthetic solutions.[1] While conventional complete dentures remain an option, they are frequently associated with inadequate retention and compromised chewing efficiency. Consequently, full-arch implant-supported prostheses have gained widespread acceptance as a more stable and functional alternative. Although implant survival rates are high, treatment success is strongly influenced by the accuracy of diagnosis, careful prosthetic planning, and precise surgical execution. However, conventional freehand implant placement relies heavily on the operator's experience and typically requires flap elevation, which increases surgical trauma. Even minimal deviations from the planned implant position can adversely affect prosthetic fit, biomechanical stability, and the protection of adjacent anatomical structures.[2]

These clinical requirements led to the evolution of prosthetically driven computer-assisted implant surgery (CAIS), surgical guides have become essential tools for accurately transferring virtual implant plans to the clinical setting. These guides help protect critical anatomical structures and contribute to improved long-term stability of dental implants. To accurately transfer this virtual plan to the surgical field, implant surgical guides are used. Surgical guides facilitate the virtual implant plan to be transferred to the patient resulting in more accurate placement, reduced surgical invasiveness, and improved long-term outcomes thereby improving the predictability and safety of implant surgery.[2]

The overall accuracy of guided implant surgery is influenced by several interconnected steps, including radiographic imaging, digital scanning, data fusion, virtual planning, and guide fabrication.[2]

Surgical guides are currently fabricated using either additive manufacturing or subtractive manufacturing methods. Additive techniques such as stereolithography (SLA), digital light processing (DLP), and material jetting (PolyJet) build guides layer by layer using photopolymer resins. SLA employs a focused laser to cure resin point by point, whereas DLP projects an entire layer simultaneously, which may improve efficiency and geometric fidelity. PolyJet technology deposits droplets of photopolymer resin using inkjet print heads. However, studies have reported inconsistent findings regarding the relative accuracy of these printing methods. Alternatively, 5-axis CAD–CAM milling produces guides by removing material from solid polymer blocks. angular deviations, which may become clinically significant in anatomically complex implant cases.[2]

According to ISO 5725-1, dimensional accuracy consists of two components: trueness, which reflects how closely a fabricated guide matches its digital design, and precision, which represents the consistency or reproducibility of the manufacturing process. Both parameters are essential because a guide that is true but inconsistent may still lead to unpredictable implant positioning.[2]

Surgical guides can be produced using either subtractive methods, such as milling, or additive methods, such as three-dimensional printing. The type of fabrication and the materials employed may influence the final properties and performance of the guides. However, limited evidence is currently available regarding how different manufacturing techniques affect the accuracy of implant placement in static computer-assisted implant surgery.

Despite the widespread use of both DLP-based 3-D printing and 5-axis CAD–CAM milling, there remains limited direct evidence comparing their dimensional accuracy using trueness and precision.

Therefore, the aim of this in-vitro study was to compare the dimensional accuracy (trueness and precision) of the intaglio surface of implant surgical guides fabricated by Direct Light Processing and 5-axis CAD–CAM milling.

The null hypothesis was that no significant difference would be observed between the two fabrication methods.

Materials and Methods

A total of 12 surgical guides were produced and divided into two groups (n = 6 per group).

Master Model and Digital Data Acquisition

A standardized edentulous maxillary cast was used as the reference. The model was digitized using a high-resolution laboratory scanner to obtain a three-dimensional surface model. The scan file was imported into implant planning software for virtual implant planning (EXOPLAN).

Virtual Planning and Surgical Guide Design

Six implant sites were virtually planned in the maxillary arch in a prosthetically driven manner. In addition, three fixation pin positions were incorporated to enhance guide stability during surgery. A sleeveless surgical guide was designed over the planned implants using CAD software. The guide was designed with a uniform thickness of 2.5 mm and exported in standard tessellation language (STL) format, which served as the reference design for fabrication and accuracy analysis.

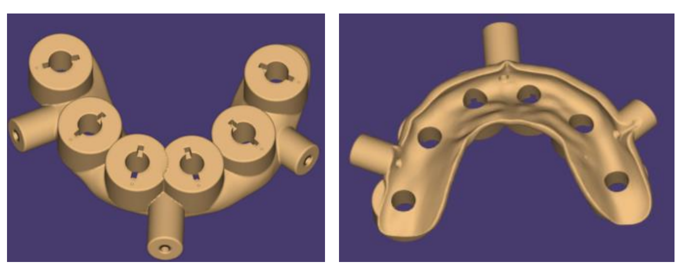


Figure 1: CAD Design of Surgical Guide

Fabrication of Surgical Guides

The STL files were used to fabricate surgical guides by two different manufacturing techniques.

Group A – DLP 3-D Printing

Six guides were fabricated using a digital light processing (DLP) 3-D printer. The guides were printed with a layer thickness of 50 µm using a photopolymer resin. After printing, the guides were cleaned according to the manufacturer's protocol and post-cured for 5 minutes to ensure complete polymerization.

Figure 2: Resin Dots on The Cameo Surface of Guide

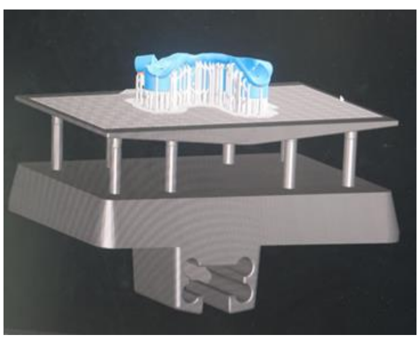


Figure 3: Supporting Structures Attached To The Platform

Group B – 5-AXIS CAD–CAM Milling

Six guides were fabricated using a 5-axis computer numerical control (CNC) milling machine. The guides were milled from polymethyl methacrylate (PMMA) blocks using a dry-milling protocol. Following milling, the guides were manually finished and polished.

Figure 4: Polymethylmethacrylate Disc for Milling

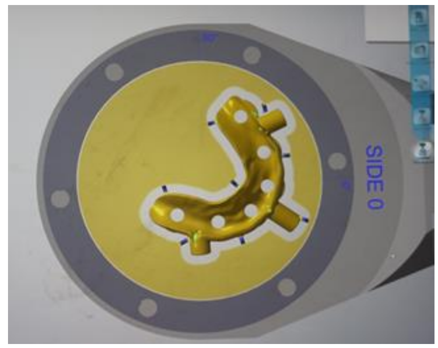


Figure 5: Orientation of PMMA Disc in Blank Holder

Figure 6: Cortec 350i Imes Icore 5 Axis Milling Machine

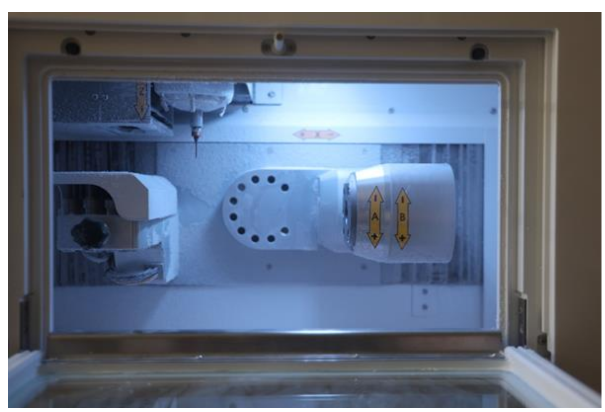


Figure 7: Cortec 350i Imes Icore 5 Axis Milling

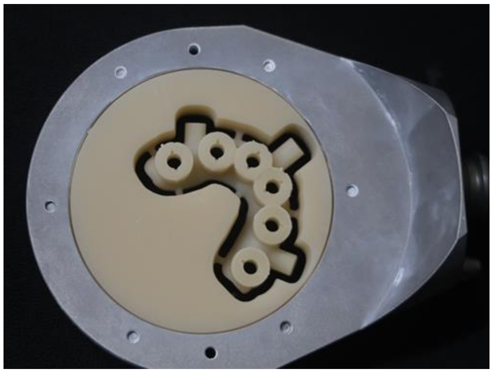


Figure 8: The Surgical Guide After Milling

Milled Surgical Guide

DLP Surgical Guide

Figure 9: Surgical Guides On Cast

Digitization of Fabricated Guides

All fabricated guides were scanned using a laboratory scanner and exported in Standard tessellation language (STL) format. To improve scanning accuracy, a uniform, thin layer of scanning spray was applied to the intaglio surface of each surgical guide. Each guide was secured to the scanner platform using a reusable adhesive putty (BLU-TACK) with the intaglio surface oriented upward.

All scans were performed using the high-resolution scanning (SHINING 3D AUTOSCAN DS EX PRO) and the specimens were scanned in a randomized sequence. The resulting digital files were exported in standard tessellation language (STL) format.

The intaglio surface of each STL file was then isolated and segmented using dental CAD software. The original digital design file of the surgical guide was used as the reference model for subsequent accuracy analysis.

Figure 10: Shining 3d Autoscan Ds Ex Pro Laboratory Scanner

Scanning of the DLP Surgical Guide

Scanning of The Milled Surgical Guide

Dimensional Accuracy Analysis

All fabricated surgical guides were digitized using a high-resolution laboratory scanner (SHINING 3D EX PRO). The scanned datasets were exported in STL format and imported into 3-dimensional inspection software (Geomagic Control X; 3D Systems, South Carolina, USA) for qualitative and quantitative evaluation.

The intaglio surface of each experimental guide was isolated and aligned to the corresponding reference STL file using the best-fit alignment algorithm. Following alignment, color-coded deviation maps were generated automatically by the software, where positive deviations were represented in red and negative deviations in blue, allowing visual assessment of surface deformation.

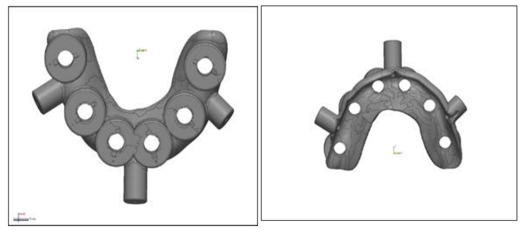
For quantitative analysis, the root mean square (RMS) deviation was calculated using the built-in 3D comparison function. RMS values were computed based on a large number of randomly distributed measurement points across the intaglio surface, using the formula:

RMS = $\sqrt{\sum(X\,reference - Xtest)2/n}$

where *n* represents the number of measurement points. A lower RMS value indicates closer agreement between the fabricated guide and the reference model, reflecting greater dimensional accuracy.

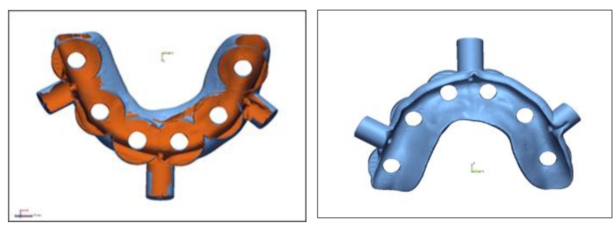
According to ISO 5725-1, dimensional accuracy consists of two components: trueness and precision. In the present study, trueness was defined as the degree of conformity between each fabricated guide and the original digital design and was expressed as the mean RMS deviation. Precision represented the reproducibility of the manufacturing process and was evaluated by comparing all guides within each group through pairwise superimposition to determine intra-group consistency.

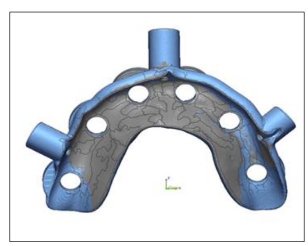
Truness Analysis



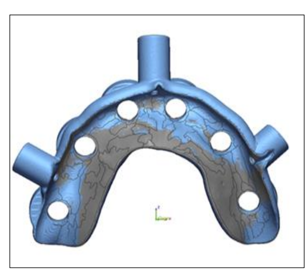
Cameo and Intaglio Surface of the Reference Data in Geomagic Control X Software

Cameo and Intaglio Surface of the Measured Data (DLP PRINTED) Surgical Guide in Geomagic Control X Software

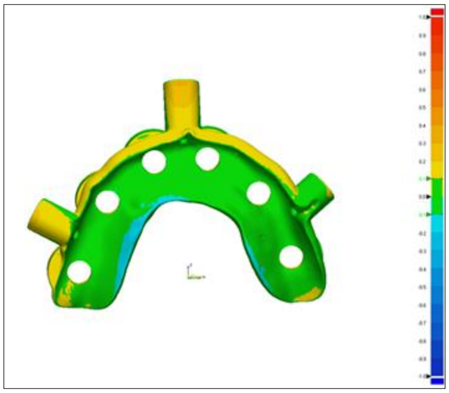




Intial Alignment in Geomagic Control X Software

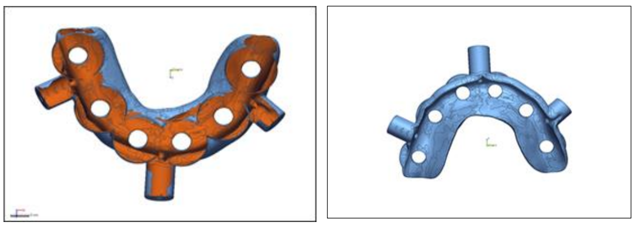


Best Fit Alingnment in Geomagic Control X Software



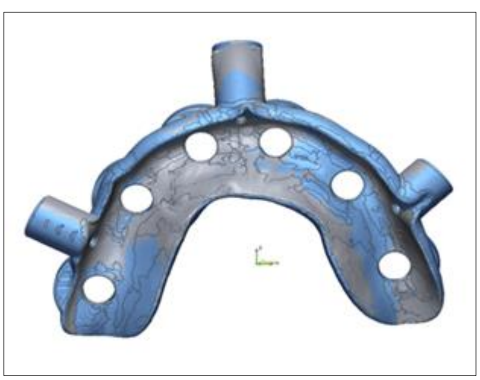
3D Color Deviations Maps After Superimposistion

Precision Analysis



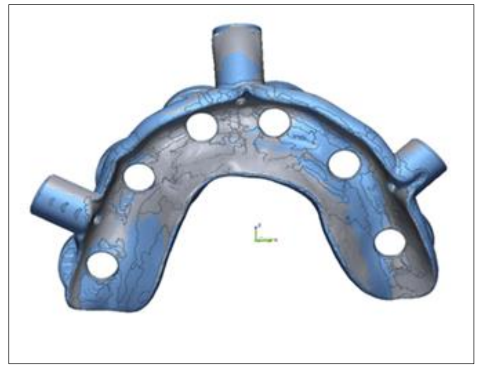
Cameo and Intaglio Surface of the Reference Data (DLP PRINTED - D1) In Geomagic Control X Software

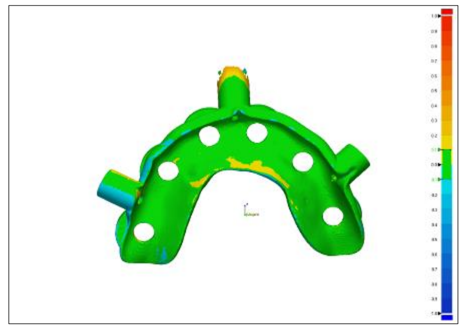
Cameo and Intaglio Surface of the Measured Data (DLP PRINTED - D2) Surgical Guide in Geomagic



Intial Alignment (D1 AND D2) IN Geomagic Control X Software

Best Fit Alingnment in Geomagic Control X Software





3D Color Deviations Maps After Superimposistion

Statistical Analysis

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) for Windows, version 22.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize the data, and results were expressed as mean values with corresponding standard deviations (mean ± SD) for both trueness and precision parameters.

For inferential analysis, an independent Student's t-test was employed to compare the root mean square (RMS) deviation values between the two fabrication methods—Direct Light Processing (DLP) 3-D printing and 5-axis CAD–CAM milling—for both trueness and precision. The level of statistical significance was set at $p < 0.05$.

Results

Table 1: Comparison of Mean Rms Values for Trueness Between 2 Groups Using Independent Student T Test

Parameter	Groups	N	Mean	SD	Mean Diff	95% CI		t	p-value
						Lower	Upper		
Trueness	Group A	6	0.1009	0.0171	-0.0620	-0.0852	-0.0389	-5.959	<0.001*
	Group B	6	0.1629	0.0189					

* Statistically Significant

Note: Group A: Direct Light Processing (3D Printing) & **Group B:** 5-Axis CAD–CAM Milling.

Trueness

The mean RMS value for trueness was 0.1009 ± 0.0171 mm for the DLP group (Group A; n = 6) and 0.1629 ± 0.0189 mm for the 5-axis milling group (Group B; n = 6). The mean difference between the two groups was −0.0620 mm, with a 95% confidence interval ranging from −0.0852 to −0.0389.

This difference was statistically significant ($t = -5.959$, $p < 0.001$), indicating that surgical guides fabricated using DLP exhibited significantly greater trueness compared with those produced by 5-axis CAD–CAM milling.

Table 2: Comparison of Mean Rms Values for Precision Between 2 Groups Using Independent Student T Test

Parameter	Groups	N	Mean	SD	Mean Diff	95% CI		t	p-value
						Lower	Upper		
Precision	Group A	15	0.0664	0.0184	-0.0300	-0.0503	-0.0010	-3.013	0.005*
	Group B	15	0.0963	0.0338					

* Statistically Significant

Precision

The mean root mean square (RMS) value for precision in the Direct Light Processing (DLP) group was 0.0664 ± 0.0184 mm (n = 15), whereas the 5-axis CAD–CAM milling group demonstrated a higher mean RMS value of 0.0963 ± 0.0338 mm (n = 15). The mean difference between the two groups was −0.0300 mm, with a 95% confidence interval ranging from −0.0503 to −0.0010, and this difference was statistically significant ($p = 0.005$). These findings indicate that surgical guides fabricated using DLP exhibited significantly greater reproducibility and consistency than those produced by 5-axis CAD–CAM milling.

Precision was evaluated using pairwise comparisons among all guides within each fabrication group. Although six surgical guides were fabricated per group, each guide was compared with every other guide within the same group, resulting in 15 unique pairwise measurements per group. This methodology enabled a more robust assessment of intra-group variability and provided a comprehensive estimation of manufacturing consistency.

Figure 1:

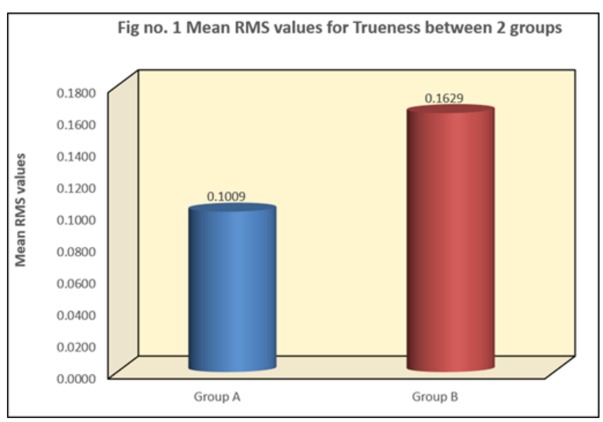
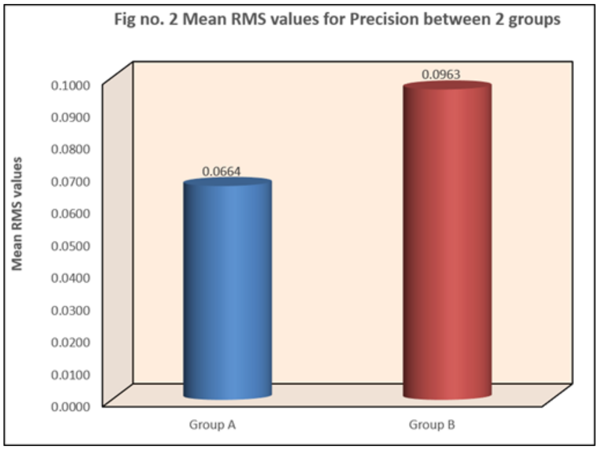


Figure 2:



Group A- Direct Light Processed Surgical Guide

Group B – Milled Surgical Guide

Discussion

The clinical implications of the present study are highly relevant to contemporary implant dentistry, where the accuracy of surgical guides plays a pivotal role in determining the precision of implant placement. Dimensional inaccuracies in surgical guides can lead to deviations in implant positioning, potentially resulting in biomechanical complications, prosthetic misalignment, or damage to adjacent anatomical structures.[2]

The present in-vitro study evaluated the influence of Direct Light Processing (DLP) additive manufacturing and 5 Axis milling which is a subtractive manufacturing on the dimensional accuracy of edentulous implant surgical guides, with particular emphasis on trueness and precision. The findings demonstrated that DLP-fabricated surgical guides exhibited the better accuracy, confirming the capability of this technology to reproduce digital designs with high fidelity and reproducibility, which are critical for achieving predictable implant placement outcomes.

The superior trueness and precision of DLP-fabricated guides can be attributed to the inherent characteristics of the technology. Direct Light Processing (DLP) technology employs a digital light source that projects an entire layer as a single image onto the build platform simultaneously, thereby significantly reducing printing time which reduces cumulative scanning and voxel alignment errors commonly associated with point-by-point curing techniques. This rapid, uniform layer polymerization may limit initial polymerization shrinkage, resulting in improved dimensional accuracy after manufacturing. [2]

The higher trueness observed in DLP-fabricated guides indicates a closer correspondence between the manufactured guide and the original digital design, while improved precision reflects greater consistency across repeated fabrications. Together, these attributes contribute to reduced surgical deviation and improved control during implant placement. Clinically, this increased accuracy may translate into improved long-term stability of implants, better prosthetic fit, and reduced need for corrective interventions. Consequently, clinicians may consider adopting DLP-based fabrication methods, particularly in anatomically demanding cases or situations where prosthetically driven implant positioning is critical.[2]

The findings in this invitro study imply that DLP technology may offer enhanced dimensional accuracy and consistency relative to milling. A plausible explanation is that subtractive milling is susceptible to cumulative errors related to bur diameter limitations, tool wear, and machine tolerances, whereas DLP fabrication relies on layer-by-layer photopolymerization, minimizing mechanical tool-induced deviations. Previous investigations of milled guides have reported acceptable but measurable deviations at sleeve positions, highlighting the influence of machining and data transfer errors in milled surgical guide. [3]

One study stated that implant positioning accuracy in fully static computer-assisted surgery is significantly influenced by metal sleeves and guide fabrication methods (additive vs. subtractive manufacturing).[4]

Sleeve-free guides outperformed metal-sleeved ones across 3D, crestal, apical, lateral (X-axis), and angular deviations. Metal sleeves add interfaces that increase play, while sleeve-free designs optimize drill-guide contact. [4]

Printed sleeve-free (PNS) and milled sleeve-free (MNS) guides showed comparable overall accuracy, but PNS excelled in angular deviation—offering superior implant angulation control. This advantage likely stems from additive manufacturing's precision in creating smoother, more adaptive guide channels with tighter drill conformity, enhanced rigidity, and better surface finish compared to milling. Printed guides also benefit from higher resolution in modern 3D printers, reducing tolerances in sleeveless designs where direct drill-guide interaction is critical. Prior studies on manufacturing methods report inconsistencies—some favour milling for rigidity, others printing for detail—due to variations in printer resolution, materials, post-processing, and experimental setups. [4]

The superior accuracy of DLP-manufactured surgical guides observed in the present study is consistent with previous reports on the precision and trueness of DLP-based additive manufacturing. Kim et al. demonstrated significantly lower RMS deviations for DLP (Direct light processing) compared with SLA (Stereolithography) and FFF (Fused Filament Fabrication) techniques, indicating enhanced precision and reproducibility. As RMS values reflect deviation magnitude, lower values correspond to improved trueness and precision. The improved performance of DLP may be attributed to its layer-by-layer photopolymerization process, which minimizes errors associated with mechanical machining. Clinically, enhanced accuracy may facilitate more precise transfer of the virtual implant plan and reduce intraoperative adjustments. Similar findings have been reported in studies evaluating DLP-fabricated dental models and guides.[5]

Unlike subtractive milling, which is influenced by bur diameter, tool wear, milling direction, and machine vibration, DLP printing eliminates many mechanical variables that can compromise dimensional fidelity. Kim et al. reported that techniques relying on sequential tool movement or scanning paths were more susceptible to inaccuracies, particularly in complex geometries and larger measurement dimensions. These limitations are clinically relevant for implant surgical guides, where inaccuracies in sleeve positioning or guide geometry may translate into angular or linear deviations during implant placement.[5]

Furthermore, the higher precision associated with DLP fabrication indicates greater consistency across repeated prints, an essential requirement for predictable guided implant surgery. Kim et al. emphasized the importance of evaluating both trueness and precision, noting that high trueness alone does not guarantee reproducibility. The present study similarly highlights that DLP technology offers advantages in both parameters, supporting its reliability for clinical application.[5]

The superior accuracy of DLP-manufactured surgical guides observed in this study is in agreement with Garcia-Montagut et al., who reported higher dimensional accuracy for vat photopolymerization techniques compared with other additive manufacturing technologies. The reduced deviations associated with photopolymerization-based fabrication support the improved trueness and precision noted for DLP guides. This enhanced performance may be attributed to the layer-by-layer photopolymerization process, which enables precise reproduction of complex geometries.

Clinically, improved accuracy may facilitate more reliable transfer of the virtual implant plan and reduce intraoperative adjustments.[6]

The findings of the present study highlight the practical advantages of DLP-based 3D printing in surgical guide fabrication. Beyer et al. reported that although SLA demonstrated slightly higher dimensional accuracy and lower material consumption, DLP achieved markedly shorter printing times (25–75 min vs. 90–200 min for SLA), supporting its suitability for time-efficient, high-throughput workflows. The substantially reduced production time associated with DLP is clinically relevant, particularly in scenarios requiring rapid turnaround, such as immediate or same-day guided procedures. These observations support the use of DLP technology when workflow speed and productivity are prioritized.[7]

From a clinical perspective, improved guide accuracy directly enhances the predictability of implant positioning, minimizes the risk of deviation from the planned trajectory, and supports prosthetically driven implant placement. In anatomically sensitive regions, even minimal inaccuracies may result in adverse outcomes. Therefore, the superior performance of DLP-fabricated guides observed in this study supports the growing preference for additive manufacturing workflows in implant dentistry.

Overall, when interpreted in conjunction with existing literature, the findings of the present study reinforce the role of DLP technology as a highly accurate and reproducible fabrication method for surgical guides. Future clinical studies correlating guide accuracy with intraoperative implant deviation and long-term prosthetic outcomes are recommended to further substantiate these advantages.

Despite the valuable insights provided by this investigation, certain limitations must be acknowledged. First, the study was conducted under controlled in vitro conditions, which may not fully replicate the clinical environment where factors such as patient movement, soft tissue resilience, and intraoperative handling can influence surgical guide performance. Additionally, well-designed clinical trials evaluating surgical accuracy and patient-center`ed outcomes are warranted to further substantiate the clinical advantages of DLP-fabricated surgical guides. Second, the sample size was limited, and only a single DLP printing system and 5-axis milling system were evaluated.

Variations in machine calibration, software algorithms, and manufacturing protocols across different systems may affect accuracy outcomes. Third, the study assessed dimensional accuracy in terms of trueness and precision but did not evaluate the mechanical properties, wear resistance, or long-term dimensional stability of the fabricated guides, which are clinically relevant considerations. Additionally, the use of a single material for each fabrication technique restricts the generalizability of the findings, as different resins and milling blanks may exhibit varying polymerization behaviour or machining characteristics.

Clinical Implication

The dimensional accuracy of surgical guides is critical for precise implant placement. In this study, Direct Light Processing (DLP)–fabricated guides demonstrated superior trueness and precision compared with 5-axis CAD–CAM milled guides. This increased accuracy supports more predictable implant positioning, reduces the risk of surgical deviation, and contributes to improved prosthetic alignment and long-term stability. Clinicians may therefore consider DLP as a preferred fabrication method for surgical guides, particularly in cases where high accuracy is essential to avoid anatomical complications and optimize prosthetic outcomes.

Conclusion

Within the limitations of this invitro study it was concluded that:

- The dimensional accuracy of implant surgical guides is a critical determinant of the precision and predictability of guided implant surgery.
- In the present in-vitro study, both Direct Light Processing (DLP) 3-D printing and 5-axis CAD–CAM milling was capable of producing clinically acceptable implant surgical guides; however, significant differences were observed between the two fabrication techniques.
- Surgical guides fabricated using Direct Light Processing demonstrated significantly superior trueness, indicating closer conformity to the original digital design when compared with guides fabricated using 5-axis CAD–CAM milling.
- DLP-fabricated guides also exhibited significantly higher precision, reflecting greater reproducibility and consistency of the manufacturing process.
- The enhanced dimensional accuracy observed with DLP fabrication may be attributed to its layer-by-layer additive manufacturing process with uniform light projection, which reduces cumulative fabrication errors and minimizes mechanical limitations associated with subtractive milling.
- Improved trueness and precision of DLP-fabricated surgical guides may contribute to more accurate transfer of virtual implant planning to the clinical environment, thereby reducing the risk of implant positioning errors.
- From a clinical perspective, the superior dimensional accuracy of DLP-fabricated guides may support improved prosthetic fit, enhanced biomechanical stability, and reduced risk to adjacent anatomical structures.
- In addition to accuracy, DLP fabrication offers practical advantages such as reduced material wastage, as material is added only where required, in contrast to the substantial material loss associated with subtractive milling processes.
- DLP-based manufacturing is also associated with shorter fabrication time due to simultaneous layer curing and simplified post-processing steps, making it more efficient for clinical and laboratory workflows.
- The absence of cutting tools and reduced need for extensive finishing procedures in DLP fabrication may further contribute to lower equipment wear and operational costs when compared with 5-axis CAD–CAM milling.
- Further well-designed clinical studies are recommended to correlate the dimensional accuracy of surgical guides with actual implant placement accuracy and long-term clinical outcomes.

References

1. Kusum CK, Varshney N, Trivedi A. Implant guides: A literature review. SRM Journal of Research in Dental Sciences. 2022 Apr 1;13(2):64-7.
2. Gu Y, Yang S, Wang S, Yue L, Yuan Q. Influence of the printing technologies, storage conditions, and storage time on the intaglio surface accuracy of additively manufactured edentulous surgical guides: An in vitro study. Journal of Prosthodontics. 2025 Aug 20.
3. Liu X, Liu J, Feng H, Pan S. Accuracy of a milled digital implant surgical guide: An in vitro study. The Journal of Prosthetic Dentistry. 2022 Mar 1;127(3):453-61.

4. Ballesteros J, Vásquez S, Revilla-León M, Gómez-Polo M. A Comparative Study on the Accuracy of Implant Placement Using 3D-Printed and Milled Guides Without Metal Sleeves. Clinical Implant Dentistry and Related Research. 2025 Aug;27(4): e70072.
5. Kim SY, Shin YS, Jung HD, Hwang CJ, Baik HS, Cha JY. Precision and trueness of dental models manufactured with different 3-dimensional printing techniques. American Journal of Orthodontics and Dentofacial Orthopedics. 2018 Jan 1;153(1):144-53.
6. García Montagut J, González A, Paz R, Suárez L, Bordón P, Ortega Z, Antoniac I, Cacciotti I, Ileana A, Monzón M. Additive Manufacturing in Dentistry: A Comparative Study of Polymeric Surgical Guide Fabrication. Polymers. 2025 Oct 15;17(20):2764.
7. Stino MS, Morsy TS, Samhaan TM. Comparing Accuracy Of Surgical Guides Fabricated By Additive Method (3D Printing) Versus Subtractive Method (Milling by CAD/CAM) for Prosthetically Driven Implant Placement "An In-Vitro Study". Journal of Fundamental and Clinical Research. 2024 Jun 1;4(1):30-41.