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Original Article

Effects of restorative materials, colors, and surface finishing on the scanning accuracy of an intraoral scanner

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Abstract *Background/purpose:* When teeth are restored using dental materials, there is potential for these restorations to influence the accuracy of intraoral scans. Such variations in accuracy could subsequently affect the precision of the derived virtual cast, the registration of the maxillo-mandibular relationship, and the fabrication of prostheses. This study aimed to assess the effect of various restorative materials, prosthesis colors, and their surface finishes on the accuracy of intraoral scans performed with a TRIOS 4 scanner.
Materials and methods: Using a $4 \times 2 \times 2$ factorial experimental design, the research analyzed how metal-ceramic, zirconia, lithium disilicate, and milled PMMA; shades B1 and A4; and surface finishes (either polishing or glazing) influence the trueness and precision of scans. The trueness and precision were quantified using root mean square (RMS) values.
Results: Significant differences in scan accuracy were observed, contingent on material, color, and finishing, along with notable interactions between these factors. Overall, PMMA exhibited the highest trueness and zirconia demonstrated the best precision. Polished lithium disilicate and PMMA showed better trueness for the A4 shade, whereas glazed lithium disilicate and PMMA performed better for the B1 shade. Metal-ceramic restorations showed an opposite trend. Zirconia restorations showed better trueness for A4 shade than B1 shade for both polished and glazed surfaces.
Conclusion: Significant interactions between materials, colors, and surface treatments were observed. Although clinicians may not be able to modify existing restorations' materials, color, or surface treatment, they need to be mindful that the intricate interaction of these factors will affect the accuracy of intraoral scans.

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Introduction

In the field of dentistry, the selection of impression techniques and materials plays a crucial role in the success of a wide array of clinical procedures. Each impression material has its distinct advantages and drawbacks.[1–3] Nevertheless, these traditional impression techniques and materials have their limitations, including the potential for patient discomfort, especially in those prone to gagging or with dental anxiety.[4–6] Utilizing intraoral scanners (IOS), combined with digital workflows and computer-aided design and computer-aided manufacturing (CAD/CAM) prostheses, offers numerous benefits. These include enhanced communication between dental clinicians and technicians, shorter treatment durations and laboratory time, diminished storage needs for traditional impressions and casts, a reduction in both material and labor costs, and heightened patient comfort.[7–11]

According to International Organization for Standardization (ISO) 5725-1, the accuracy of a measurement consists of two essential components: trueness and precision. Trueness refers to the closeness of agreement between the arithmetic mean of measurement results and the true or accepted reference value, while precision relates to the closeness of agreement between measurement results.[12–14] It is essential to recognize that various factors can affect the accuracy of intraoral scans. These factors include device type, scanning distance, operator-related factors, patient-related factors, rescanning and post-processing scans, conditions of the preparations, and the presence of adjacent teeth.[15–19] On the other hand, patient-related factors involve various intraoral conditions such as tooth type, interdental spaces, arch width, palate characteristics, wetness, restorations, and implant-related variables.[20]

However, the effects of the presence of existing restorations on the remaining dentition have not been explored in detail. One study found no clear trend regarding how different restorative materials affect the trueness and precision of intraoral scans. However, it seems that more translucent materials, such as enamel-shade resin and lithium disilicate, negatively impact both trueness and precision. Conversely, reflective materials, such as gold, did not negatively affect scanning accuracy.[21] Furthermore, surface glazing influenced scan trueness for all definitive and interim restorative materials tested, except for zirconia. The 3D-printed polymer resin demonstrated the best precision, while milled PMMA material displayed the worst.[22] Finally, under varying surface wetness conditions, both enamel and polished zirconia specimens produced similar trueness and precision mean values.[23] When teeth are restored using interim or definitive dental materials, there is potential for these restorations to influence the accuracy of intraoral scans. Such variations in accuracy could subsequently affect the precision of the derived virtual cast, the registration of the maxillo-mandibular relationship, and the fabrication of prostheses. While current literature delves into various factors that can influence the accuracy of intraoral scans, there remains limited information specifically addressing the impact of different restorative materials, their colors, and surface finishes.

The purpose of this study is to investigate the effects of restorative material (metal-ceramic, zirconia, lithium disilicate, and milled PMMA), prosthesis color (B1 and A4), and their surface finishing (polishing or glazing) on the accuracy of the scans from an intraoral scanner using confocal technology. The null hypotheses include that there were no significant effects of restorative material, prosthesis color, and surface finishing on the scanning accuracy. In addition, there were no interaction effect among factors of restorative material, prosthesis color, and surface finishing.

Materials and methods

The flowchart diagram summarizing the study design was shown in Fig. 1. A dentoform (D85S-700-QR, Nissin Dental Product Inc, Kyoto, Japan) designed for restorative procedure simulation was utilized in the study. An index of putty silicone (Lab Putty, Coltène/Whaledent AG, Altstätten, Switzerland) was procured from the typodont to maintain the contour of the maxillary central incisor resin tooth. Subsequently, replaced with a pre-prepared abutment tooth that simulated the all-ceramic crown preparation (A21AN-700-#9 Crown, 21-AA-01, Nissin Dental Product Inc.) (Fig. 2). This dentoform was scanned using a laboratory 3D scanner (E4, 3Shape, Copenhagen, Denmark). The scanned file was exported in the Standard Tessellation Language (STL) format and imported into a dental computer-aided design and computer-aided manufacturing (CAD/CAM) software program (Dental System 2022, 3Shape) (Fig. 3).

A virtual anatomically contoured crown with a uniform 1.5 mm thickness was designed (Fig. 4A and B). The virtual crown design was saved and exported in the STL format for the fabrication of the study samples. The study groups, encompassing restorative materials, colors, and surface finishing, are delineated in Table 1. In the Metal-Ceramic group, the STL file of the virtual crown design was uniformly cut back by 0.7 mm to accommodate ample space for porcelain layering. This cut-back design was exported as an STL file and relayed to a metal 3D-printer (DMP Dental 100, 3D Systems Inc, Rock Hill, SC, USA) to additively manufacture four crown substrates using noble metal alloy (SLM Platinum Plus, Argen, San Diego, CA, USA). Upon positioning the metal crown substrate on the dentoform, the putty silicone and porcelain material (IPS InLine, Ivoclar

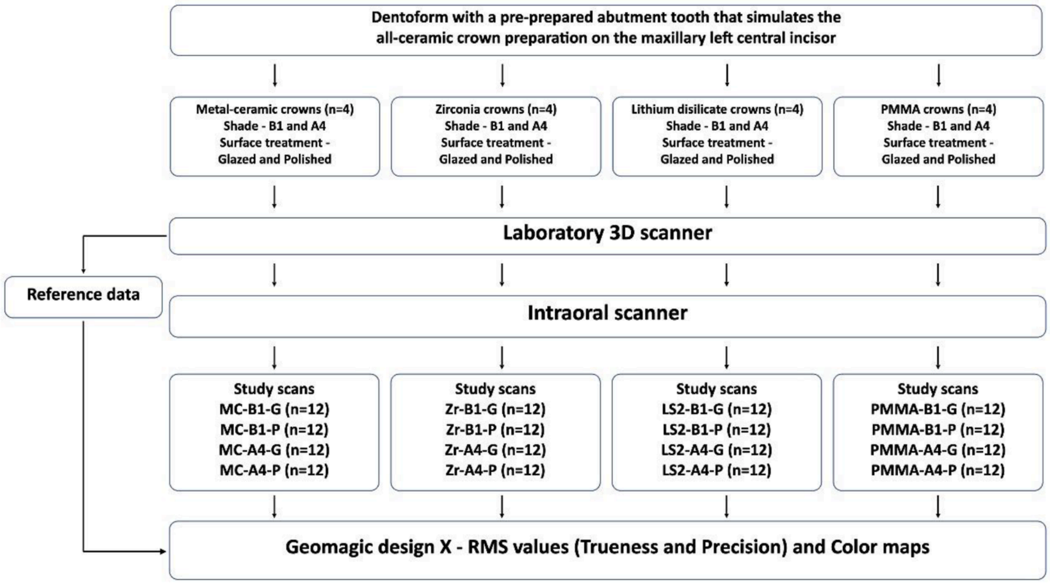

Figure 1 Study design flow diagram. PMMA stands for polymethyl methacrylate. RMS stands for root mean square.

Figure 2 Study dentoform with a pre-prepared abutment tooth simulating the all-ceramic crown preparation at the left maxillary central incisor location.

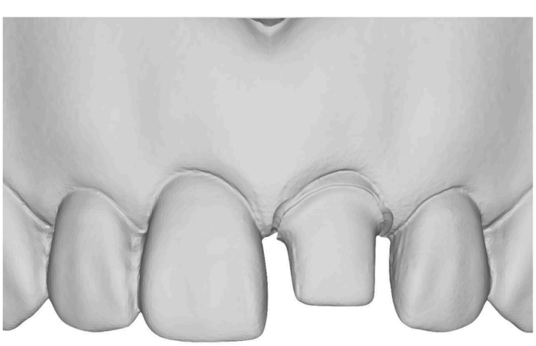

Figure 3 Digitally scanned pre-prepared abutment tooth.

Vivadent AG, Schaan, Liechtenstein) were used to fabricate a metal-ceramic crown. The two metal-ceramic crowns were made in the B1 shade and two others were made in the A4 shade. Additionally, the metal-ceramic crowns, one crown each from the B1 and A4 shade groups underwent a glazing process using a low-fusing glazing material (IPS InLine System Glaze, Ivoclar Vivadent AG). Another crown from the B1 and A4 shade groups underwent mechanical polishing procedures (Diamond Ceramic Polishing Kit - 4540A, Komet USA LLC, Rock Hill, SC, USA).

For the zirconia group, the STL file of the virtual crown design was utilized to mill four zirconia crowns using a 5-axis dental milling unit (DWX-52D Plus, Roland DGA Corp, Irvine, CA, USA) and a zirconia puck (IPS e.max ZirCAD Prime B1 and A4, Ivoclar Vivadent AG). One crown each from the B1 and A4 shade groups was glazed (MiYO Glaze Paste, Jensen Dental, North Haven, CT, USA). Conversely, another crown from both the B1 and A4 shade groups underwent mechanical polishing procedures (Dialite ZR Extraoral System, Brasseler USA, Savannah, GA, USA). The identical STL file of the virtual crown design was employed to mill four lithium disilicate crowns (IPS e.max CAD, MT, B1, and A4, Ivoclar Vivadent AG). One crown each from the B1 and A4 shade groups was randomly selected to undergo the glazing treatment (MiYO Glaze Paste). In contrast, another crown from both the B1 and A4 shade groups was subjected to mechanical polishing procedures (Dialite LD Extraoral System, Brasseler USA, Savannah). The polymethyl methacrylate (PMMA) samples were used to mill four PMMA crowns using a 5-axis dental milling unit (DWX-52D Plus, Roland DGA Corp) and a PMMA puck (Aidite PMMA Multilayer, B1 and A4, Aidite Technology Co, Whittier, CA, USA). Two crowns were milled in the B1 shade, while the remaining two were milled in the A4 shade. One crown each from the B1 and A4 shade groups was randomly selected to undergo the glazing treatment (Optiglaze, GC America Inc, Alsip, IL, USA) was added onto the crown surface and polymerized for 3 min at 30 °C using a light polymerization unit (Otoflash G171, NK Optik GmbH, Baierbrunn, Germany). Another crown from both the B1 and A4 shade groups was subjected to mechanical polishing procedures using polishing burs (Acrylic temporization system, Brasseler USA).

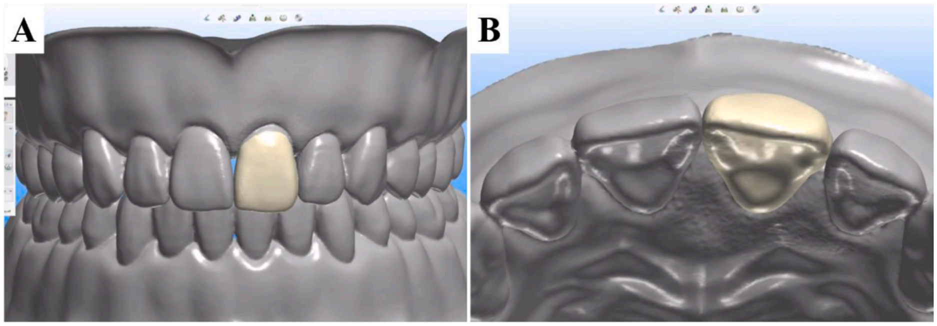

Figure 4 Virtual crown design archive. (A) Frontal view. (B) Occlusal view.

Table 1 The study groups, encompassing restorative materials, colors, and surface finishing.

Group	Restorative materials	Shade	Surface finishing
MC-B1-G	Metal - noble metal alloy (SLM Platinum plus; Argen)	B1	Glazed - (IPS InLine System Glaze)
MC-B1-P	Ceramic - (IPS InLine)	B1	Polished - (Diamond Ceramic Polishing
MC-A4-G		A4	Kit - 4540A)
MC-A4-P		A4	
Zr-B1-G	Zirconia - (IPS e.max ZirCAD Prime B1 and A4)	B1	Glazed - (MiYO Glaze Paste)
Zr-B1-P		B1	Polished - (Dialite ZR Extraoral System)
Zr-A4-G		A4	
Zr-A4-P		A4	
LS2-B1-G	Lithium disilicate - (IPS e.max CAD, MT, B1, and A4)	B1	Glazed - (MiYO Glaze Paste)
LS2-B1-P		B1	Polished - (Dialite LD Extraoral System)
LS2-A4-G		A4	
LS2-A4-P		A4	
PMMA-B1-G	PMMA - (Aidite PMMA Multilayer, B1 and A4)	B1	Glazed - (Optiglaze)
PMMA-B1-P		B1	Polished - (Acrylic temporization system)
PMMA-A4-G		A4	
PMMA-A4-P		A4	

PMMA: Polymethyl methacrylate.

Upon the completion of the 16 reference crowns, which encompassed 4 restorative materials, 2 shades, and 2 surface treatments, each crown was individually set onto the dentoform. This assembly of the crown and dentoform was digitally scanned using the laboratory 3D scanner to generate 16 reference data from all reference crowns. Following the laboratory 3D scanner's procedure, an intraoral scanner (TRIOS 4, 3Shape) was employed. Prior to each scan, the intraoral scanner was calibrated following the manufacturer's guidelines. The scanning environment was strictly controlled: all intraoral scans were taken under ambient illumination of 1000 lux on the dentoform, situated in a windowless room. Each reference crown underwent 12 consecutive digital scans ($n = 12$) using the intraoral scanner. In total, 192 digital study scans were generated using the intraoral scanner, from 16 reference crowns. This comparison aimed to compute the trueness and precision of the scans.

A CAD software program (Geomagic Design X, 3D Systems Inc) was employed for the 3D file alignment and the measurement of trueness and precision. Alignment of the data was executed through picked points, followed by global and fine alignments, using the best-fit algorithm. To evaluate the deviation between the corresponding reference data and the study scans, the root-mean-square (RMS) values were used. The RMS values were calculated with following formula, $RMS = \frac{1}{\sqrt{n}}\sqrt{\sum_{i=1}^{n}(X_{1,i} - X_{2,i})^2}$, where $X_{1,i}$ are the reference data, $X_{2,i}$ are the measurement points in the scan data, and n indicates the total number of measurement points measured in each dataset. These RMS values were used to determine the trueness and precision of the study scans.

With a sample size of 12 observations from each group, the study had 80 % power to detect an effect size of 1.210, assuming two-sided tests conducted at a 5 % significance level. Trueness (RMS means, mm) was analyzed with a fixed-effects three-way ANOVA with factors restorative material (4 levels), surface finish (2 levels), and prosthesis color (2 levels), including all two-way terms and the three-way interaction. Given that the three-way interaction was significant, the model was decomposed into simple two-way effects at each level of the third factor and, where appropriate, simple main-effects contrasts. Fisher's Protected Least Significant Differences was used for trueness following significant omnibus tests. Precision (RMS variances across repeated scans) was assessed with F-tests across groups. Analyses were performed using software (SAS version 9.4, SAS Institute Inc, Cary, NC, USA) at $\alpha = 0.05$.

Results

The descriptive statistics of RMS (mm) for subgroups categorized by restorative material, prosthesis color, and surface finishing are presented in Table 2. As can be seen in Fig. 5, the boxplot represents the RMS values of each study group. For the prosthesis color A4, the polished metal-ceramic (0.4732 ± 0.0041 mm) and glazed lithium disilicate (0.4532 ± 0.0059 mm) demonstrated the highest RMS values (lowest trueness). Similarly, for the color B1, the glazed metal-ceramic (0.4622 ± 0.0042 mm) and polished zirconia (0.4477 ± 0.0026 mm) exhibited the highest RMS values (lowest trueness).

The three-way ANOVA indicated significant differences in the trueness of scans from the intraoral scanner (TRIOS 4), as measured by RMS values (mm), across four types of restorative materials, two prosthesis colors, and two types of surface finishing (Table 3). Furthermore, the analysis revealed significant interactions between the restorative material and surface finishing ($P < 0.001$), restorative material and prosthesis color ($P < 0.001$), and surface finishing and prosthesis color ($P < 0.001$).

Table 2 Descriptive statistics of RMS values in each research group.

Group	Restorative materials	Shade	Surface finish	RMS (mean ± SD) in mm
MC-B1-G	Metal-ceramic	B1	Glazed	0.4622 ± 0.0042
MC-B1-P		B1	Polished	0.4410 ± 0.0034
MC-A4-G		A4	Glazed	0.4287 ± 0.0046
MC-A4-P		A4	Polished	0.4732 ± 0.0041
Zr-B1-G	Zirconia	B1	Glazed	0.4430 ± 0.0022
Zr-B1-P		B1	Polished	0.4477 ± 0.0026
Zr-A4-G		A4	Glazed	0.4346 ± 0.0042
Zr-A4-P		A4	Polished	0.4336 ± 0.0017
LS2-B1-G	Lithium disilicate	B1	Glazed	0.4236 ± 0.0032
LS2-B1-P		B1	Polished	0.4412 ± 0.0043
LS2-A4-G		A4	Glazed	0.4532 ± 0.0059
LS2-A4-P		A4	Polished	0.4012 ± 0.0046
PMMA-B1-G	PMMA	B1	Glazed	0.3961 ± 0.0030
PMMA-B1-P		B1	Polished	0.4305 ± 0.0033
PMMA-A4-G		A4	Glazed	0.4241 ± 0.0024
PMMA-A4-P		A4	Polished	0.4209 ± 0.0034

PMMA: Polymethyl methacrylate.
RMS: Root mean square.

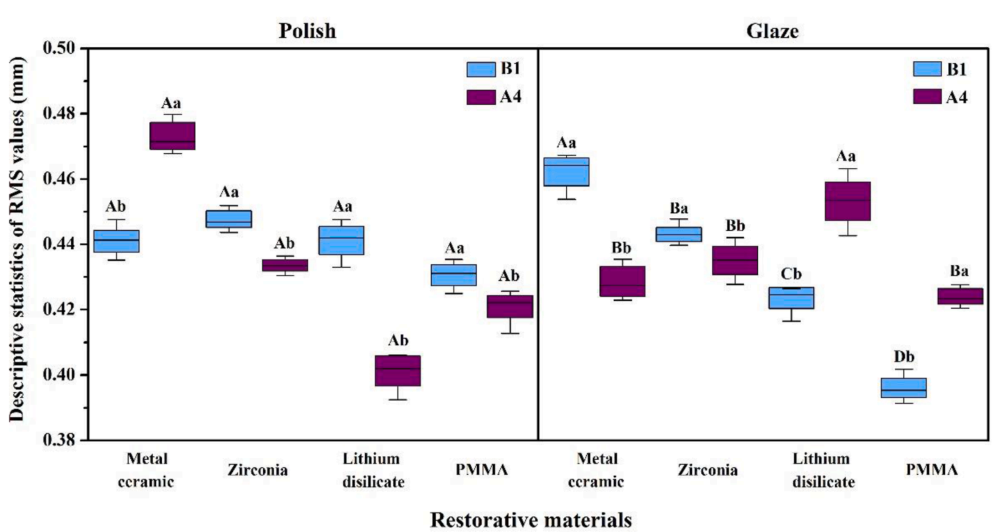

Figure 5 Boxplot showing the root mean square (RMS) values of study groups. Means with different letters were significantly different ($P < 0.001$, mean ± SD, n = 12). Different capital letters indicate differences between restorative materials. Different lowercase letters indicate differences between colors. PMMA stands for polymethyl methacrylate.

Table 3 ANOVA table comparing the means of restorative materials, colors, and surface finishes.

Effect	Num DF	Den DF	F Value	*P*-value
Material	3	176	815.1	<0.001
Finish	1	176	29.6	<0.001
Material*Finish	3	176	159.2	<0.001
Color	1	176	12.7	<0.001
Material*Color	3	176	97.4	<0.001
Finish*Color	1	176	123.9	<0.001
Material*Finish*Color	3	176	593.3	<0.001

When comparing the trueness of scans between the two prosthesis colors, the B1 color demonstrated significantly better trueness than the A4 color in cases of glazed lithium disilicate, polished metal-ceramic, and glazed PMMA ($P < 0.001$). Conversely, the A4 color exhibited significantly better trueness (smaller RMS values) compared to B1 in the scenarios of polished lithium disilicate, glazed metal-ceramic, and polished PMMA, as well as for both glazed and polished zirconia ($P < 0.001$). Regarding the precision of scans, no significant differences were observed between the two prosthesis colors across all tested conditions, except for glazed zirconia, where B1 color showed significantly greater precision than A4 ($P = 0.032$).

When comparing the trueness of scans between the two surface finishings, polished samples of lithium disilicate in color A4, metal-ceramic in color B1, and PMMA in color A4 demonstrated significantly better trueness than their glazed counterparts ($P < 0.001$). Conversely, glazed samples of lithium disilicate in color B1 and PMMA in color B1 exhibited better trueness than polished samples ($P < 0.001$). However, for zirconia, glazed samples in color B1 were significantly truer than polished samples ($P < 0.001$), while no significant difference was found between polished and glazed samples in color A4 ($P = 0.244$). In terms of precision, there was no significant difference between the two surface finishings across all restorative materials and prosthesis colors, except for zirconia in color A4, where polished samples showed significantly better precision than glazed samples ($P = 0.005$).

In comparing the trueness and precision of scans across four restorative materials under various surface finishing and prosthetic color conditions, significant differences were observed. For glazed samples in A4, lithium disilicate exhibited significantly worse trueness (higher RMS values) than all other materials ($P < 0.001$). Metal-ceramic had better trueness (lower RMS values) than zirconia ($P < 0.001$), but worse trueness compared to PMMA ($P = 0.002$). PMMA demonstrated better trueness (lower RMS values) than zirconia ($P < 0.001$). Regarding precision, PMMA showed significantly better precision (lower RMS variances) than both lithium disilicate ($P = 0.006$) and metal-ceramic ($P = 0.041$), with no significant differences noted with other materials. For glazed samples in B1, lithium disilicate had better trueness than metal-ceramic ($P < 0.001$) and zirconia ($P < 0.001$), yet it was less true than PMMA ($P < 0.001$). Metal-ceramic's trueness was significantly worse than that of both PMMA and zirconia ($P < 0.001$), while PMMA was significantly truer than zirconia ($P < 0.001$). The only notable difference in precision was that zirconia showed better precision compared to metal-ceramic ($P = 0.036$). For polished samples in A4, lithium disilicate's trueness was significantly better than the other materials ($P < 0.001$). Metal-ceramic's trueness was worse than both PMMA and zirconia ($P < 0.001$), and PMMA was truer than zirconia ($P < 0.001$). In precision, zirconia was significantly more precise than lithium disilicate ($P = 0.003$), with no other differences observed. For polished samples in B1, lithium disilicate showed worse trueness than PMMA ($P < 0.001$) but better trueness than zirconia ($P < 0.001$), with no significant difference when compared to metal-ceramic ($P = 0.895$). Metal-ceramic was less true than PMMA ($P < 0.001$) but truer than zirconia ($P < 0.001$). PMMA's trueness was significantly better than zirconia's ($P < 0.001$). Again, no significant precision differences were found among the materials.

Discussion

This study aimed to evaluate the trueness and precision of intraoral scanner scans across different prosthesis colors, restorative materials, and surface finishes. The findings highlight the complex interplay between these variables and their collective impact on the accuracy of digital dental impressions. Notably, the study found that restorative material is crucial in determining scan accuracy. PMMA (0.4179 ± 0.0134) exhibited the highest trueness, followed by lithium disilicate (0.4298 ± 0.0203), zirconia (0.4399 ± 0.0065), and metal-ceramic (0.4513 ± 0.0181). Regarding precision, zirconia led, followed by PMMA and metal-ceramic, while lithium disilicate was the least precise. These results led to the rejection of the null hypotheses.

This study reviewed relevant literature to contextualize its findings. Consistent with our results, Bocklet et al. identified significant variations in trueness and precision among four dental substrates (amalgam, composite, dentin, and enamel).[24] They found that dentin scans were significantly truer than enamel ($P = 0.0058$) and more precise than composite ($P = 0.0140$). Agustín-Panadero et al. noted better trueness in enamel and polished zirconia compared to polished nanoceramic resin, with no precision discrepancies among materials.[23] Dutton et al. reported that translucency in materials like enamel shade composite, natural enamel, and lithium disilicate adversely affects the trueness and precision of intraoral scans.[21] The flexibility of PMMA and the smoothness obtained after milling may enhance the fidelity of surface reproduction.[25] From an optical standpoint, confocal intraoral scanners (TRIOS 4; 3Shape) estimate surface depth at the focal plane from the maximal in-focus return. Subsurface scattering in highly translucent substrates and specular glare from smooth glazed or metallic surfaces can broaden or saturate this response, distorting the signal and reducing scan trueness.[14] The amorphous polymer matrix of PMMA typically yields predominantly diffuse, near-surface reflectance with limited subsurface light transport at crown thicknesses, which can account for the higher trueness observed for PMMA across shades and surface finishes. This pattern is consistent with Revilla-León et al., who reported higher trueness for conventional and milled PMMA compared with zirconia and lithium disilicate under their testing conditions.[22] Overall, existing publications, along with the findings of the current study, suggest that restorative materials indeed influence the accuracy of intraoral scans. However, the outcomes are not consistent across all studies. This inconsistency may be attributed to the influence of other factors such as translucency, prosthesis color, wetness condition during testing, the technologies used in intraoral and laboratory scanners, geometries of the study samples, and measurement software.

The impact of surface finishing on the trueness and precision of intraoral scans is significant, as indicated by current research. Except for the metal-ceramic material, shade A4 samples showed that polished restorations have better trueness than glazed ones. Conversely, for shade B1 samples, glazed restorations exhibited superior trueness compared to polished ones. Revilla-León et al. investigated the effects of restorative material and surface treatments on the accuracy of intraoral scanner readings.[22] Their study demonstrated a significant influence of both factors on scanner accuracy. The findings of this study are in partial agreement with Revilla-León et al., particularly where polished conventional and milled PMMA restorations demonstrated the highest trueness. Regarding precision, this study did not find any significant differences between finishes for all materials and shades tested, with the sole exception of zirconia in shade A4, where polished samples were significantly more precise ($P = 0.005$). This contrasts with Revilla-León et al.'s results, which indicated the lowest precision in glazed conventional PMMA.[22] A key difference between the current study and the experiment by Revilla-León et al. is the control over prosthesis color. Their study did not standardize the prosthesis color, using a range that included A1, A2, A4, B2, and B3. The findings from the present research demonstrate that prosthesis color significantly influences the accuracy of intraoral scans. These results highlight the nuanced impact of both material and surface treatment on scan accuracy and stress the importance of standardizing prosthesis color to accurately evaluate the trueness of intraoral scans.

The results of this study indicated that for the A4 shade, both polished lithium disilicate and PMMA demonstrated greater scan trueness compared to their glazed counterparts. Conversely, in the B1 shade, the glazed versions of lithium disilicate, PMMA, and zirconia exhibited better scan trueness than their polished versions. The study highlighted significant differences in trueness among prosthesis shades, with A4 and B1 showing varied accuracy profiles across different restorative materials and surface finishing techniques. Notably, the differences in precision between the A4 and B1 shades were mostly insignificant, suggesting that color selection may have a more substantial impact on trueness than precision does. Zhou et al. evaluated the effect of color and ambient lighting conditions on the accuracy of complete arch scanning using an intraoral scanner (TRIOS 3) on a zirconia restoration model with varying prosthesis shades.[26] They found that color variations significantly affected the accuracy of intraoral scans under different lighting conditions, particularly in the anterior mandibular region. However, these findings cannot be directly compared to the present study due to the considerable differences in study conditions.

The outcomes of this study are limited due to its focus solely on a single intraoral scanner. Given that each scanner's technology is specific, the results may not be generalizable to other scanners that use different imaging techniques and software algorithms, which can influence scanning accuracy. The in vitro study did not replicate environmental and clinical conditions common in live clinical settings, such as variable lighting and the presence of fluids or patient movement, limiting the applicability of the results in real-world scenarios. Additionally, the range of materials and prosthesis colors tested was limited. Considering the diversity of dental restorations patients have, a more extensive selection of materials and conditions would more accurately reflect the complexity found in routine dental practice. Future research would benefit from incorporating a variety of scanners, as well as a wider array of environmental and clinical conditions, and a broader spectrum of sample types to ensure that the findings are comprehensive and widely relevant to clinical applications.

This study investigated the effects of different restorative materials, prosthesis colors, and surface treatments on the accuracy of intraoral scanner scans. The results showed that PMMA had the highest trueness, while zirconia had the best precision. Surface finishing also influenced accuracy, with polished lithium disilicate and PMMA showing better trueness for the A4 shade, and glazed lithium disilicate, PMMA, and zirconia performing better for the B1 shade. Significant interactions between materials, colors, and surface treatments were observed. Although clinicians may not be able to modify existing restorations' materials, color, or surface treatment, they need to be mindful that the intricate interaction of these factors will affect the accuracy of intraoral scans.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

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