Comparative Assessment of Precision of Prepared Single Tooth using Shining 3D Intraoral Scanner and Conventional Impressions Made using Polyvinyl Siloxane and Polyether Impression Material – An *In vitro* Study

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Abstract

Introduction: Making an accurate dental impression is one of the most crucial and timeconsuming procedures in dental practice. During this procedure, it is pivotal to ensure the restriction of the intraoral condition as exactly as possible, as inexactness or inexactitudes could have farreaching effects on the quality of restoration. The aim of the study was to estimate and compare correctness of conventional and digital impressions in terms of precision and trueness. **Materials and Methods:** Forty samples were divided into four groups having 10 samples each. API Typhodent mandibular first molar model was taken as master model. Metal-ceramic tooth preparation was done according to the clinical preparation principles. Four points, namely, Point A, Point B, Point C, and Point D were marked as reference points. The mean of buccolingual (Point A-Point B) and mesiodistal (Point C-Point D) width, respectively, was measured. **Results:** The findings of the present study revealed that digital intraoral scanners Shining 3D were more accurate in recording the tooth surface as compared to the conventional impression materials polyvinyl siloxane and polyether.

Keywords: Precision, Prepared Single Tooth, Polyvinyl Siloxane, Polyether Impression.

Introduction

Impression making to reproduce oral condition and tooth morphology is dynamic part of prosthetic dentistry.[1] According to the 8th edition of the Glossary of Prosthodontics Terms, “impression” is defined as “a negative likeness or copy in reverse of the surface of an object; an imprint of the teeth and adjacent structures for use in dentistry.[2]” The characteristic problems and shortfalls of orthodox elastomeric impressions with stock trays include improper tray selection, requirement for sanitization of the impression, parting of impression material from impression tray, alteration of conventional impressions before pouring, and storage of the impressions for impending remaking of the casts and dies.[3] Although these problems can be abridged by adjustment of work sequence, they cannot be utterly abolished.

The introduction of computer-aided design/computer-aided manufacturing (CAD/CAM) technology in dentistry gave rise to a more exact manufacturing of prosthetic frameworks, and greater accurateness of dental restorations, and the technology has improved since the 1980s.[4] Duret first set forth the concept of CAD/CAM in dentistry. Since then, the application of CAD/CAM has amplified ominously. Digital impressions offer speed, efficacy, capability of storing captured information endlessly, and transmitting digital images among the dental office and the laboratory.[5] The benefits of the digital impressions and scanning systems are successful patient

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acceptance, plummeting the alteration of impression materials, 3D pre-visualization of tooth preparations, and probable cost- and time-effectiveness.[6]

A number of intraoral scanning systems are available today in the market like CEREC AC with Bluecam (Germany), iTero (USA), Lava C.O.S. (Germany), TRIOS (Denmark), etc. Digital impression is projected to be a substitute to traditional impression practices.[7,8] Intraoral scanners are basically of two types: Photographic technology scanners and video technology scanners. Photographic technology captures individual images of the area and amalgamates to form the digital 3D model while, on the other hand, video technology scanners work in a very parallel way to a video camera.

In this *in vitro* study, we used Shinning 3D intraoral scanner, which uses OptimScan 3D Scanner Software and two impression materials, namely, polyvinyl siloxane and polyether to assess and compare the precision of a prepared single tooth.

Materials And Methods

In this study, API Typhodent mandibular model was taken as master model. Mandibular left first molar Typhodont tooth was considered for the study. Metal-ceramic tooth preparation of mandibular first left molar was done according to the clinical preparation principles with 1.5 mm occlusal reduction using diamond burs EX-11 and 1.0 mm width chamfer margin using diamond burs SO-21 [Figure 1]. Four points, namely, A, B, C, and D were marked as reference points on bucco-occlusal, linguo-occlusal, mesio-occlusal, and disto-occlusal line angles, respectively, with the help of diamond bur BR-40 [Figure 2].

Impressions made with both the impression materials with smooth and even surface, accurately recorded reference points were included. Non-porous smooth casts accurately duplicating the reference points were include in this study. Impressions having rough uneven surface, distorted impressions, as well as rough or porous casts were not included in the study. In case of digital impressions, if the area was not scanned accurately following the standardized technique or reference points were not scanned accurately, then such impressions were discarded and not included in the study.

Figure 1: Tooth preparation of mandibular first left molar

For control group, the prepared Typhodont tooth on the master model was scanned with the help of reference scanner Sirona inEos X5 using scanning protocol and the obtained data were transferred in Standard Tesselation Language (STL) format for further calculation. The mean of buccolingual (point A-point B) and mesiodistal (point C-point D) width, respectively, was measured with the data collected from STL format (n=10) [Figure 3]. The scan data of this reference scan were then compared with all other test groups.

In case of digital impression technique, the prepared Typhodont tooth on the master model was scanned from the occlusal surface of the second molar tooth, going on toward the second premolar. SHINNING 3D intraoral scanner was used to scan every tooth from buccal and lingual side inclining the scanner at 45° to the long axis of tooth.

In case of conventional impression technique, impression of the prepared Typhodont tooth on master model was made with putty and light body polyvinyl siloxane impression material [Figure 4] as well as soft polyether impression material [Figure 5] under the manufacturer's recommendations using stock impression trays and all the casts were poured with die stone class IV after 24 h [Figure 6]. Then, cast was scanned with the help of reference scanner Sirona inEos X5 using scanning protocol and the data collected were exported in STL format for further calculation. The mean of buccolingual (point A-point B) and mesiodistal (point C-point D) width was measured with the data collected from STL format (n = 10) [Figures 7 and 8].

Figure 2: Prepared tooth with four reference points

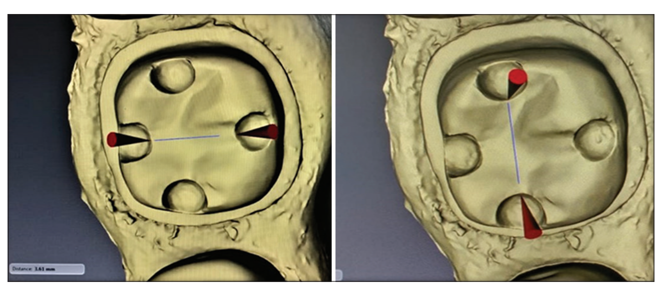

Figure 3: Buccolingual and mesiodistal width of mandibular prepared molar scanned with reference scanner Sirona inEos X5

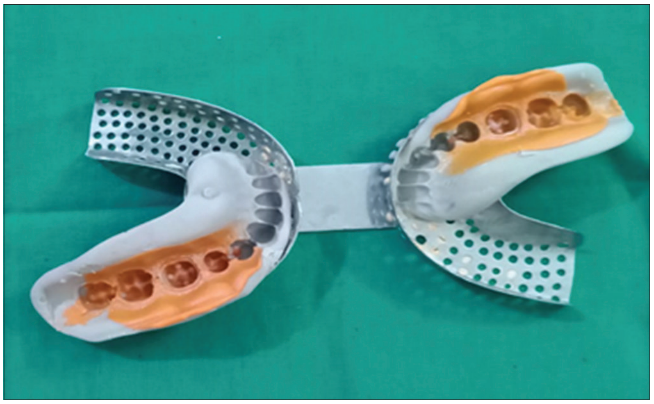

Figure 4: Polyvinyl siloxane impression

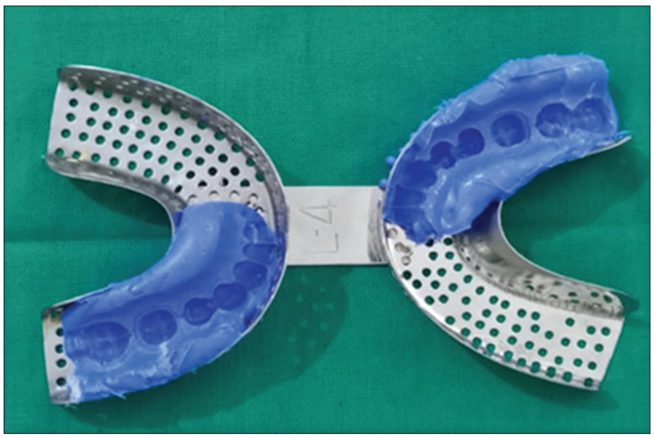

Figure 5: Polyether impression

Figure 6: Die stone casts made from polyvinyl siloxane and polyether impressions

Results

The data collected were subjected to statistical analysis using SPSS software version 26.0 for Windows. The level of significance was fixed at 5% and $P \leq 0.05$ was considered statistically significant. One-way analysis of variance (ANOVA) and *post hoc* Scheffé analysis were performed for quantitative variables.

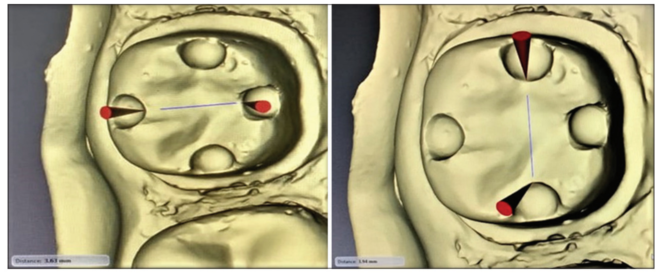

Figure 7: Buccolingual width and mesiodistal width of polyvinyl siloxane cast scanned with reference scanner Sirona inEos X5

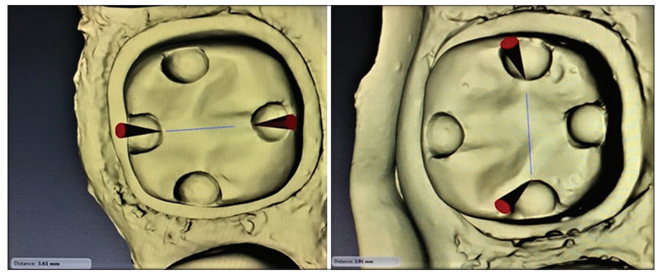

Figure 8: Buccolingual width and mesiodistal width of polyether cast scanned with reference scanner Sirona inEos X5

Precision

Maximum, minimum, median, and interquartile range deviations for each group are listed in Table 1 for buccolingual measurements and in Table 2 for mesiodistal measurements. The median value for Shining 3D was found to be closest to the median value of control group suggestive of better precision compared to both impression materials for both buccolingual and mesiodistal measurements.

Trueness

Mean and standard deviation for each group is listed in Table 3 for buccolingual measurements and in Table 4 for mesiodistal measurements.

On comparing the mean and standard deviations of all three impression techniques for buccolingual measurements, it was found that Shining 3D intraoral scanner (3.515 ± 0.048) was the most accurate among all three techniques, followed by polyether (3.445 ± 0.083) and polyvinyl siloxane (3.410 ± 0.104) when compared to the control group (3.562 ± 0.053). On comparing the mean and standard deviations of all three impression techniques for mesiodistal measurements, it was found that Shining 3D intraoral scanner (3.827 ± 0.027) was the most accurate among all three techniques, followed by polyether (3.823 ± 0.061) and polyvinyl siloxane (3.879 ± 0.103) when compared to the control group (3.834 ± 0.021).

Different groups were compared based on the buccolingual measurements using the one-way ANOVA test (95% confidence interval with $P \leq 0.05$ being statistically significant) with *post hoc* Scheffe test. Statistically significant correlations were exhibited between all groups under study with $P < 0.05$ and between Shinning 3D intraoral scanner and polyether

Table 1: Analysis of precision for each measurement method (buccolingual width in mm)

Method	Maximum	Minimum	Median	Interquartile range
Control	3.658	3.497	3.546	0.096
Shining 3D intraoral scanner	3.613	3.478	3.496	0.027
Polyvinyl siloxane	3.632	3.182	3.409	0.139
Polyether	3.611	3.277	3.445	0.129

Table 2: Analysis of precision for each measurement method (mesiodistal width in mm)

Method	Maximum	Minimum	Median	Interquartile range
Control	3.869	3.803	3.837	0.036
Shining 3D intraoral scanner	3.864	3.794	3.819	0.056
Polyvinyl siloxane	4.085	3.690	3.899	0.157
Polyether	3.915	3.720	3.804	0.104

Table 3: Analysis of trueness for each measurement method (buccolingual width in mm)

Method	Mean±SD
Control	3.562±0.053
Shining 3D intraoral scanner	3.515±0.048
Polyvinyl siloxane	3.410±0.104
Polyether	3.445±0.083

Table 4: Analysis of trueness for each measurement method (mesiodistal width in mm)

Method	Mean±SD
Control	3.834±0.021
Shining 3D intraoral scanner	3.827±0.027
Polyvinyl siloxane	3.879±0.103
Polyether	3.823±0.061

wherein *P*-value was found to be 0.034, except between the two impression materials wherein *P*-value was found to be 0.534 which was statistically not significant [Table 5].

Different groups were compared based on the mesiodistal measurements using the one-way ANOVA test (95% confidence interval with $P \leq 0.05$ being statistically significant) with *post hoc* Scheffe test. Statistically significant correlations were exhibited between Shinning 3D intraoral scanner and polyvinyl siloxane impression material with $P = 0.084$ and between the two impression materials wherein $P = 0.052$ was suggestive of statistically significant correlation [Table 6].

Table 5: One-way ANOVA test (buccolingual width in mm)

Descriptive					
Method	Mean	Std. deviation	Std. error	95% confidence interval for mean	
				Lower bound	Upper bound
Shining 3D intraoral scanner	3.515	0.048	0.011	3.492	3.537
Polyvinyl siloxane	3.410	0.104	0.023	3.362	3.459
Polyether	3.445	0.083	0.018	3.406	3.484

Post hoc Scheffe test		
Buccolingual width groups		*P*-value
Shining 3D intraoral scanner	Polyvinyl siloxane	<0.001
Shining 3D intraoral scanner	Polyether	0.034
Polyvinyl siloxane	Polyether	0.534

ANOVA: Analysis of variance

Table 6: One-way ANOVA test (mesiodistal width in mm)

Descriptive					
Method	Mean	Std. deviation	Std. error	95% confidence interval for mean	
				Lower bound	Upper bound
Shining 3D intraoral scanner	3.827	0.027	0.006	3.814	3.840
Polyvinyl siloxane	3.879	0.103	0.023	3.831	3.927
Polyether	3.823	0.061	0.014	3.794	3.851

Post hoc Scheffe test		
Mesiodistal width groups		*P*-value
Shining 3D intraoral scanner	Polyvinyl siloxane	0.084
Shining 3D intraoral scanner	Polyether	0.997
Polyvinyl siloxane	Polyether	0.052

ANOVA: Analysis of variance

Discussion

Intraoral impression making is a simple technique in dentistry that is used to create an engraving of the oral condition. A range of procedures is based on the intraoral impression, including therapeutic design, diagnostics, patient communication, cast fabrication, and fabrication of restorations and appliances. The exactness of intraoral impressions is specifically perilous for devising well-fitting restorations. Two major factors influence the accuracy: *Trueness* – which describes the aberration of the impression geometry from the original geometry and *Precision* – which describes the aberration between repeated impressions rather than to the original geometry (ISO-5725-1).[9,10] Precision resonances are the degree of aberration among impressions in a test cluster.

For recording the impressions by orthodox methods, sectional trays were used and the impression was obtained using polyether and polyvinyl siloxane impression materials. This was in agreement to the study carried out by Ender *et al*.[11] who used comparable sectional tray method to record quadrant impressions when analyzing the *in vivo* precision of conventional and digital methods for procuring quadrant dental impressions. Studies propose that the quadrant impressions can be taken for comparing the conventional impression techniques and digital intraoral scanners. The results obtained using quadrant impressions are congruently unswerving when comparing different conventional and digital impression techniques.[3,11,12]

The accurateness of master casts has been the focus of plenteous research projects and is contingent on several factors, including the water/powder ratio, vacuum mixing against hand mixing,[13] the type of dental stone or plaster used,[14] and the compatibility of dental stone or plaster with the impression materials.[15-17] Like conventional impressions, several factors also influence the accuracy of digital impressions.[18-20] Anatomic restrictions, movement of tongue, saliva, soft-tissues architecture around the adjacent tooth and prepared tooth, as well as movements of lower jaw during opening and closing are some of the factors that affect the accuracy of digital impressions.[21-23]

The results of our study were also concurring with that of Ender *et al*.[24] who found that higher precision was seen when using digital impression systems as compared to conventional impression materials, although they also showed that there were higher local deviations in case of digital impression systems in complete arch cast.[25] Moreover, our results were in harmony to the blind study carried out by Hankel *et al*.[26] wherein they studied the crowns prepared using digital impression techniques and conventional impression techniques. It was discovered in this study that crowns prepared using digital technique were more preferred due to better marginal fit, better contacts and occlusion, as well better adjustments (if any were required).[27]

Conclusion

To date, there is no consensus, on what is clinically acceptable in terms of trueness and precision for comparing accuracy of digital and conventional impressions of single tooth preparation. The results and statistical analysis of this study showed that Shinning 3D intraoral scanner showed higher precision and trueness values followed by polyether impression material and polyvinyl siloxane impression material. Although, all of them were within clinically acceptable ranges. Further study is required on a large scale for getting comparable results and for further clinical acceptance.

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