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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

Divya Rajesh Mehta[1*] Palak Abhishek Pandya[2] Siddhant Kulmendra Taneja[3] Vyoma Sanjaybhai Sheth[4] Shlesha Ketankumar Patel[5] Anuj Vasantray Mansata[6]

[1]PG Student, Department of Prosthodontics, Crown & Bridge, and Implantology, Bhabha college of Dental Sciences, Bhopal, MP, India.
[2]Consultant Prosthodontist, Gandhinagar, Gujarat, India.
[3]Graduate Student, Masters in Public Health, College of Public Health, University of South Florida, USA.
[4]Graduate Student, Masters in Bioinformatics and Computational Biology, Morsani College of Medicine, University of South Florida, USA.
[5]Intern, Karnavati School of Dentistry, Uvarsad, Gandhinagar, Gujarat, India.
[6]MDS, Advanced PG Diploma in Clinical Research, Pharmacovigilance and Clinical Data Management, Gandhinagar, Gujarat, India.

ABSTRACT

Background: Making an accurate dental impression is one of the most crucial and time-consuming 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 far-reaching 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 & trueness.

Materials and Methods: 40 samples were divided into 4 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 & POINT D were marked as reference points. The mean of bucco-lingual (POINT A - POINT B) & mesio-distal (POINT C - POINT D) width respectively were 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.

Conclusion: 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.

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

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*__Correspondence Dr. Divya Rajesh Mehta.__
Department of Prosthodontics, Crown & Bridge, and Implantology, Bhabha college of Dental Sciences, Bhopal, MP, India.
Email: divrajjag@gmail.com
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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 computer-aided design and computer aided manufacturing (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 amongst the dental office and the laboratory.[5] The benefits of the digital impressions and scanning systems are successful patient 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 viz. 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 & 1.0 mm width chamfer margin using diamond burs SO-21 (Fig. I). Four points namely A, B, C, & D were marked as reference points on bucco-occlusal, linguo-occlusal, mesio-occlusal & disto-occlusal line angles, respectively with the help of diamond bur BR-40 (Fig. II).

Impressions made with both the impression materials with smooth & 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.

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 was transferred in Standard Tesselation Language (STL) format for further calculation. The mean of bucco-lingual (point A – point B) & mesio-distal (point C - point D) width respectively were measured with the data collected from STL format (n=10) (Fig. III). The scan data of this reference scan was 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 towards 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 & light body Polyvinyl Siloxane impression material (Fig. IV) as well as soft Polyether impression material (Fig. V) under the manufacturer's recommendations using stock impression trays & all the casts were poured with Die Stone Class IV after 24 hours (Fig. 19) (Fig. VI). Then, cast was scanned with the help of reference scanner Sirona inEos X5 using scanning protocol and the data collected were exported in Standard Tesselation Language (STL) format for further calculation. The mean of bucco-lingual (point A - point B) & mesio-distal (point C – point D) width were measured with the data collected from STL format (n=10). (Fig. VII & Fig. VIII)

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≤0.05 was considered statistically significant. One-way Analysis of Variance (ANOVA) and post hoc Scheffé analysis was performed for quantitative variables.

Precision:

Maximum, minimum, median and interquartile range deviations for each group are listed in Table I for bucco-lingual measurements and in Table II for mesio-distal 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 bucco-lingual and mesio-distal measurements.

Trueness:

Mean and standard deviation for each group is listed in Table III for bucco-lingual measurements and in Table IV for mesio-distal measurements.

On comparing the mean and standard deviations of all 3 impression techniques for bucco-lingual 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 3 impression techniques for mesio-distal 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)**.

Fig I: Tooth preparation of Mandibular First Left Molar.

Fig 2: Prepared tooth with 4 reference points

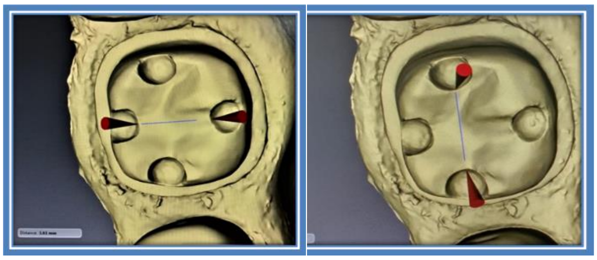

Fig 3: Bucco-lingual and Mesio-distal width of mandibular prepared molar scanned with reference scanner Sirona inEos X5.

Fig 4: Polyvinyl siloxane impression.

Fig 5: Polyether impression

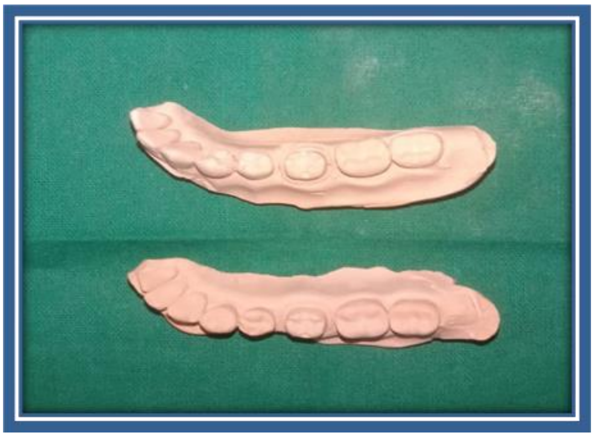

Fig 6: Die stone casts made from Polyvinyl Siloxane and Polyether impressions.

Different groups were compared based on the bucco-lingual 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 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 V).

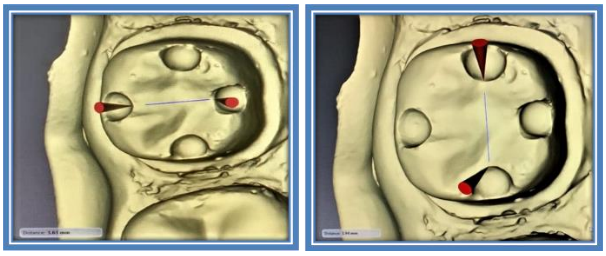

Fig 7: Bucco-lingual width and Mesio – distal width of Polyvinyl Siloxane Cast scanned with reference scanner Sirona inEos X5.

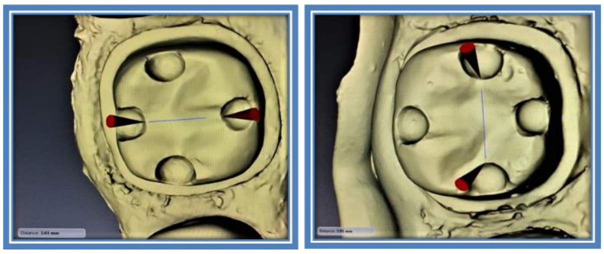

Fig 8: Bucco-lingual width and Mesio – distal width of Polyether Cast scanned with reference scanner Sirona inEos X5.

Table I: Analysis of Precision for each measurement method (Bucco-Lingual 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 II: Analysis of Precision for each measurement method (Mesio-Distal 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 III: Analysis of Trueness for each measurement method (Bucco-lingual 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 IV: Analysis of Trueness for each measurement method (Mesio-Distal 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

Table V: One Way ANOVA Test (Bucco-lingual 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		
Bucco – Lingual width groups		P value
Shining 3D intraoral scanner	Polyvinyl siloxane	<0.001
Shining 3D intraoral scanner	Polyether	0.034
Polyvinyl siloxane	Polyether	0.534

Table VI: One Way ANOVA Test (Mesio-distal 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		
Mesio - Distal width groups		P value
Shining 3D intraoral scanner	Polyvinyl siloxane	0.084
Shining 3D intraoral scanner	Polyether	0.997
Polyvinyl siloxane	Polyether	0.052

Different groups were compared based on the mesio-distal 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 VI)

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 are 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 the degree of aberration amongst 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 A et al* [11] who used comparable sectional tray method to record quadrant impressions when analysing 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 intra-oral 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 upon 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.[15,16,17] Like conventional impressions, several factors also influence the accuracy of digital impressions.[18,19,20] 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 A 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 GL 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. Though, 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.

CONFLICTS OF INTEREST

The authors declare they have no potential conflict of interests regarding this article.

REFERENCES

1. Patzelt SB, Lamprinos C, Stampf S, Att W. The time efficiency of intraoral scanners: An in vitro comparative study. J Am Dent Assoc 2014; 145:542-51

2. The glossary of prosthodontic terms. J Prosthet Dent 2005, 94(1):10–92.

3. Sason GK, Mistry G, Tabassum R, Shetty O. A comparative evaluation of intraoral and extraoral digital impressions: An in vivo study. The Journal of the Indian Prosthodontic Society. 2018 Apr;18(2):108.

4. De La Cruz JE, Funkenbusch PD, Ercoli C, Moss ME, Graser GN, Tallents RH: Verification jig for implant supported prosthesis: a comparison of standard impressions with verification jigs made of different materials. J Prosthet Dent2002,88:329–336.

5. Kim SY, Kim MJ, Han JS, Yeo IS, Lim YJ, Kwon HB:Accuracy of diescaptured by an intraoral digital impression system using parallelconfocal imaging.Int J Prosthodont2013,26(2):161–163.

6. Christensen GJ:Impressions are changing: deciding on conventional,digital or digital plus in-office milling.JADA2009,140:1301–1304.

7. Mörmann WH. The Origin of the Cerec Method: A Personal Review of the First 5 Years Die Entstehung der Cerec-Methode–die ersten 5 Jahre Ein persönlicher Rückblick. International journal of computerized dentistry. 2004; 7:11-24.

8. Moörmann WH. The evolution of the CEREC system. The Journal of the American Dental Association. 2006 Sep 1; 137:7S-13S.

9. Chandran DT, Jagger DC, Jagger RG, Barbour ME. Two- and three-dimensional accuracy of dental impression materials: effects of storage time and moisture contamination. Biomed Mater Eng 2010; 20:243-9.

10. Ender A, Mehl A. Accuracy in dental medicine, a new way to measure trueness and precision. J Vis Exp 2014;86.

11. Zimmermann M, Ender A, Mehl A. Local accuracy of actual intraoral scanning systems for single-tooth preparations in vitro. The Journal of the American Dental Association. 2020 Feb 1;151(2):127-35.

12. Yang X, Lv P, Liu Y, Si W, Feng H. Accuracy of Digital Impressions and Fitness of Single Crowns Based on Digital Impressions. Materials (Basel). 2015 Jun 29;8(7):3945-3957.

13. Duke P, Moore BK, Haug SP, Andres CJ: Study of the physical properties of type IV gypsum, resin-containing, epoxy die materials. J Prosthet Dent 2000, 83:466–473.

14. Powers J: Gypsum products and investments. In Craig's Restorative Dental Materials. Edited by Powers J. St Louis: Mosby; 2006:313–336.

15. Wöstmann B, Rehmann P, Balkenhol M: Influence of impression technique and material on the accuracy of multiple implant impressions. Int J Prosthodont 2008, 21(4):299–301.

16. Nassar, U.; Chow, A.K. Surface Detail Reproduction and Effect of Disinfectant and Long-Term Storage on the Dimensional Stability of a Novel Vinyl Polyether Silicone Impression Material. *J. Prosthodont.* **2014**, doi:10.1111/jopr.12244.

17. Johnson, G.H.; Lepe, X.; Aw, T.C. The effect of surface moisture on detail reproduction of elastomeric impressions. *J. Prosthet. Dent.* **2003**, *90*, 354–364.

18. Wadhwani, C.P.; Johnson, G.H.; Lepe, X.; Raigrodski, A.J. Accuracy of newly formulated fast-setting elastomeric impression materials. *J. Prosthet. Dent.* **2005**, *93*, 530–539.

19. Lee H, So JS, Hochstedler JL, Ercoli C. The accuracy of implant impressions: a systematic review. J Prosthet Dent 2008; 100:285-91.

20. Jansen VK, Conrads G, Richter EJ. Microbial leakage and marginal fit of the implant-abutment interface. Int J Oral Maxillofac Implants. 1997; 12(4):527–40. PMID: 9274082.

21. Faria AC, Rodrigues RC, Macedo AP, Mattos Mda G, Ribeiro RF. Accuracy of stone casts obtained by different impression materials. Braz Oral Res 2008; 22:293-8.

22. Ahlholm P, Sipilä K, Vallittu P, Jakonen M, Kotiranta U. Digital versus conventional impressions in fixed prosthodontics: a review. Journal of Prosthodontics. 2018 Jan;27(1):35-41.

23. Bilir H, Ayguzen C. Comparison of digital and conventional impression methods by preclinical students: Efficiency and future expectations. Journal of International Society of Preventive & Community Dentistry. 2020 Jul;10(4):402.

24. Ender A, Attin T, Mehl A. In vivo precision of conventional and digital methods of obtaining complete-arch dental impressions. J Prosthet Dent 2016; 115:313-20.

25. Seelbach P, Brueckel C, Wostmann B. Accuracy of digital and conventional impression techniques and workflow. Clin Oral Investig 2013; 17:1759-64.

26. Henkel GL. A comparison of fixed prostheses generated from conventional vs digitally scanned dental impressions. Compend Contin Educ Dent. 2007;28: 422-431.

27. Glassman, Steven. Digital impressions for the fabrication of aesthetic ceramic restorations: a case report. Practical procedures & aesthetic dentistry: PPAD (2009). 21. 60-4.