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Comparative Evaluation of Accuracy of Digital and Conventional Impressions and Internal Fit of Zirconia Copings Fabricated From Digital and Conventional Impressions: An In -Vitro Study

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Abstract

Purpose: The Invitro study was two- folded: comparing the accuracy of conventional and digital impressions in recording the full arch impressions, and evaluating the internal fit of zirconia copings made from digital and conventional impressions.

Materials and methods: A customized mandibular typodont master model with three metal inserts (two posterior and one anterior) and a master die served as a reference model. Crown prepared on typodont tooth #35. The accuracy of the digital and conventional impressions was evaluated by comparing the cross-arch (CA), anterio-posterior (AP1), anterior-posterior (AP2) dimensions of the master model as well as the Bucco-lingual (BL), mesio-distal (MD), occluso- gingival (OG) dimensions of the master die. Subsequently zirconia copings were manufactured and the internal fit was verified by 11 conventional and 11 digital impressions using the replica technique. The replica was measured under stereo microscope at 5x magnification in 8 different locations in each cross section. The data obtained was subjected to one- way ANOVA and independent t-tests. Results: Significant difference ($p<0.05$) was observed in AP1 dimensions, BL and MD dimensions of the die compared with the original values. No significant differences were found between the methods for the internal fit of the zirconia copings.

Conclusion: Conventional techniques demonstrated superior outcome over digital methods for the full arch impressions. Within the limitations of this study, concluding that Digital and Conventional impressions can be used to fabricate crowns, inlays, on lays and short span FDPs. Regarding the use of digital impression techniques for full arch prostheses, additional investigations are needed.

Keywords: Intra oral scanner; Zirconia copings, Replica technique, Digital impressions, Accuracy.

Introduction

Clinical and laboratory procedures are numerous and stringent in prosthodontic practice [1]. Achieving good marginal and internal fit is of utmost importance in improving the prognosis of prosthodontic restorations [2]. Literature evidence has shown the importance of accuracy of fit for clinical success of the prosthesis [3, 4]. In order to fabricate a single crown or a multiunit fixed prosthesis (FPD), an accurate cast is required. To achieve this, accurate negative dental impressions are needed and also precision in transfer of the finest details to dental technician's laboratory [5]. The technician then uses these negative impressions to fabricate accurate gypsum casts that duplicate the intraoral structures. In each step of obtaining the accurate impression, there is a high possibility for potential errors (human or material related) to occur and are inevitable [6]. Undoubtedly, achieving an accurate impression is an essential step in fabricating fixed dental prosthesis [7]. However, factors like impression technique, storage condition of the impression, poured cast type, and disinfectant material plays major role in quality and precision of the impression.

Both digital imprisoning and conventional impression taking are described as procedures of intraoral data acquisition. Even though designing and manufacturing of a prostheses using digital technology is gaining more and more importance, most of the approaches in prosthodontic practice are still based on a conventional impression technique[8].Every procedure has its own set of advantages and disadvantages. Conventional impression procedures are mainly inexpensive. Their disadvantages include patient discomfort (gagging, odor or taste complaints), the need for disinfectant material (may cause material distortion), variation in temperature and humidity, distortion due to mixing of the impression materials etc[9-11]. On the other hand, digital impression technologies found to have eliminated the problems associated, and for many patients, it is more comfortable than conventional impressions [12]. Digital impressions eliminate several time-consuming steps, no need for disinfection, cost-effectiveness, ability to make immediate corrections during preparation and can be stored easily. The disadvantages of digital impression systems are high cost of the equipment, need of the initial expertise, limited access of the intraoral scanner to some regions like the retromolar region of patients with limited mouth opening etc. Despite all the evidence regarding the superiority of digital impression techniques, few investigations have showed the similar accuracy of both techniques [13], and also the better accuracy of conventional impressions over digital for full-arch impressions[14].

The purpose of this invitro study is to analyze the accuracy of the reproduction of a model and a die obtained from digital impressioning system and conventional impression technique. This study was also aimed to compare the marginal fit of zirconia coping fabricated based on the data of the digital scanner and conventional impression technique. The null hypothesis was that there is no difference between the digital and conventional impressions in regards the full arch impressions and the marginal fit of the zirconia coping.

Materials and methods

Measuring body: This Invitro experimental study was conducted on a customized mandibular typodont model (D91SHD-200, Nissin Dental products INC Kyoto, Japan), served as a reference/ master model. The master model was modified with three metal inserts, positioned on right mandibular first molar and left mandibular first molar and lingual to mandibular central incisors along the midline (Figure 1).Tooth 44 and 45 were replaced by a standardized poly methyl methacrylate (PMMA) die, with a 360-degree occlusal and gingival shoulder, a total angle

of convergence (TOC) of 12 degrees, four grooves each of 2mm in length and 2mm depth in buccal, lingual, mesial and distal axial surfaces were incorporated as a reference to locate axial point on the surfaces to measure the diameter of the die buccolingually and mesiodistally (Figure 2).

Secondly, tooth preparation was done in mandibular left second premolar (FDI #35) with smooth and continuous 1-mm modified shoulder finish line, 6 to 10 degrees combined convergence angle, a functional cusp bevel, 1.5-2mm of occlusal reduction, 1- 1.5mm of axial reduction and an overall rounded and smooth finish line.

Digital impressions: Eleven digital impressions were taken with anintra oral digital scanner 3D progress (MHT SPA, Verona, Italy) according to the manufacturer's recommendations. It works on the principle of confocal microscopy and *moiré* effect. At this, the model was sprayed with titanium dioxide (powder scan spray, vita, UK) that aids in reducing the light reflection on the model and allows for accurate scanning of the master model. Afterwards, the scans were transferred to CAD software tool for further processing. The digital scan was directly transferred to a milling center for the fabrication of 11 zirconia (Sage Max Bioceramic, USA) copings.

Conventional impressions: Single step putty light body impressions (Photosil soft putty, DPI, Mumbai) were made on the master model using a stock metal perforated mandibular trays. The impressions are poured with Type IV Gypsum (Die stone - Ultrarock, Kalabhai Karson, Mumbai) over a vibrator.The resulting working casts were then subjected to further processing. All the 11 working casts were scanned using Lab scanner (DS-X model, Shining 3D, China) for fabrication of zirconia copings with a die spacer of 40µm. All the copings were prepared by a single technician to reduce operative bias.

5.4 Measurement procedures

Measurements were performed with a CAD software tool for the digital scans and the die. For the working casts and die (from conventional impression) measurements were made using coordinate measuring machine (CMM) (Contura G2 -Ziess). Table1, figures 2and 3 showed the detaileddescription of the measurements carried out both on the digital scans/ working casts and die.

After fabrication of copings, the marginal and internal gaps were evaluated by means of the replica technique. The replicas were then sectioned in the bucco-lingual and mesio- distal directions to carry out measurements. For each coping, measured data was obtained from eight different locations, four marginal, two axial walls, and two occlusal measurements (Figure 4). The stabilized cross-sections were then studied under stereomicroscope with surface illumination (Lieca DMC 2900, Leica Microsystems, India). Measurements were done using a software tool.

Statistical analysis

Statistical analysis was performed using software (SPSS Statistics for Windows, Version 20.0; IBM Corp., Armonk, New York, USA). The mean values and standard deviations per group were calculated. ANOVA test was used to reveal statistically significant differences between the different groups for all the parameters ($p<0.05$).Independent sample t- test was done to compare mean values between Digital and Conventional impression measurements in bucco- lingual and mesio- distal cross-sections of the zirconia copings.The level of significance was set at 0.05.

Results

Mean and standard deviation values of the master model (CA, AP1 and AP2) and die measurements (BL, MD and OG) were calculated and displayed for different groups in tables 2 and 3.

Dimensions on the master model (Typodont)

One- way ANOVA shows that there is significant difference between the groups for CA (p= 0.197) and AP2 (p=0. 544) measurements. However, statistically significant difference was observed between groups for AP1 measurement (p= 0.005). The output of post- hoc analysis shows that the mean value of AP1 in conventional impressions (31.94mm) was higher than the digital impression (31.51mm) and was statistically significant (p= 0.004). However, no significant difference was observed between the conventional or digital with master model.

Dimensions on the master die

On the other hand, one- way ANOVA for die measurements produced a statistically significant difference for BL (p= 0.000) and MD (p= 0.010) measurements between groups. The output of post- hoc analysis shows that the mean value of BL width of the die measured using digital impression was significantly lower than the master model (p=0.000) and conventional impression (p=0.001). However, no significant difference observed between master model and conventional impression. Similarly, for the mean value of MD with of the die, statistically significant differences were seen between the digital impression and master model (p=0.013), digital and conventional impressions (p=0.039).

Dimensions of the zirconia coping

Tables 4 and 5 shows the mesio- distal and bucco- lingual cross section values obtained from the zirconia coping using digital and conventional impressions. In bucco- lingual cross section, it was observed that there is no statistically significant difference between both impressions in all locations (marginal, occlusal and axial). However, in mesio- distal cross- section, except at marginal- 4 location (p=0.001), significant differences were not observed.

Figure 1: A Customized Mandibular Typodont Model

Figure 2: A Standardized Poly Methyl Methacrylate (Pmma) Die In The Right Mandibular Premolar Region

Figure 3: Measurements on the digital scans / working casts

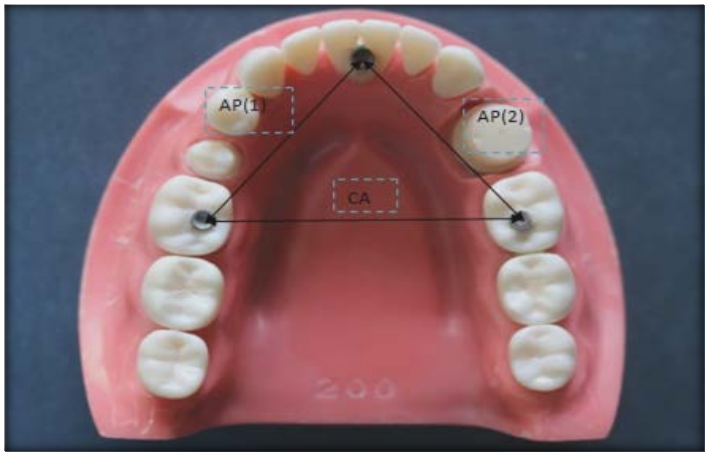

Figure 4: Location of Areas of Measurements in Bucco-Lingual And Mesio-Distal Cross Section

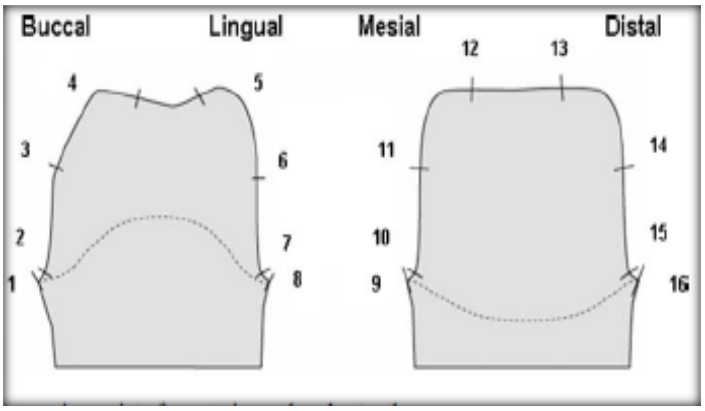

Table 1: Measurements on digital scans/ working casts and die

Measurement	Description
Digital scans/ working casts	
AP1	Anteroposterior distance on the left side
AP2	Anteroposterior distance on the right side
CA	Cross arch distance
Master Die	
BL	Buccolingual width
MD	Mesiodistal width
OG	Occlusogingival height

Table 2: Measurement and comparison of mean values between master model, conventional and digital impressions

	N	Mean	Std. Deviation	95% Confidence Interval for Mean		p-value
				Lower	Upper	
1. Cross arch						
Master model	11	41.22	0.00	41.22	41.22	
Digital	11	41.485	0.28	41.297	41.674	0.197
Conventional	11	41.557	0.72	41.068	42.045	
2. AP1						
Master model	11	31.72	0.00	31.72	31.72	
Digital	11	31.51	0.35	31.27	31.75	0.005*
Conventional	11	31.94	0.34	31.71	32.17	
3. AP2						
Master model	11	31.51	0.00	31.51	31.51	

Digital	11	31.61	0.28	31.42	31.80	0.544
Conventional	11	31.30	1.11	30.55	32.05	

Statistically significant (p<0.05)

Table 3: Comparison of mean values of die measurements between master model, conventional and digital impressions

	N	Mean	Std. Deviation	95% Confidence Interval forMean		p-value
				Lower	Upper	
1. Buccolingual						
Master model	11	8.15	0.00	8.15	8.15	0.000*
Digital	11	7.44	0.28	7.25	7.62	
Conventional	11	7.99	0.49	7.66	8.32	
2. Mesiodistal						
Master model	11	8.18	0.00	8.18	8.18	0.010*
Digital	11	7.37	0.37	7.11	7.62	
Conventional	11	8.05	1.01	7.37	8.73	
3. Occlusogingival						
Master model	11	3.86	0.00	3.86	3.86	0.441
Digital	11	3.67	0.18	3.54	3.79	
Conventional	11	3.66	0.69	3.19	4.13	

Statistically significant (p<0.05)

Table 4: Independent sample t- test to compare mean values between Digital and Conventional impression measurements in bucco- lingual cross- section dimensions

Measurement	Impression	N	Mean	Std. Deviation	p-value
Marginal (1)	Digital	11	290.05	111.8	0.191
	Conventional	11	215.64	144.08	
Marginal (2)	Digital	11	210.08	59.3	0.273
	Conventional	11	179.43	67.9	
Buccal	Digital	11	171.04	49.20	0.152
	Conventional	11	237.70	136.3	
Occlusal (1)	Digital	11	228.29	92.4	0.287
	Conventional	11	297.50	185.8	
Occlusal (2)	Digital	11	284.49	147.8	0.115
	Conventional	11	448.60	289.1	
Lingual	Digital	11	156.67	38.6	0.264
	Conventional	11	204.23	128.7	
Marginal (3)	Digital	11	216.59	75.09	0.073
	Conventional	11	338.37	193.1	
Marginal (4)	Digital	11	285.66	214.3	0.509
	Conventional	11	355.31	268.5	

Table 5: Independent sample t- test to compare mean values between Digital and Conventional impression measurements in mesio- distal cross- section dimensions

Measurement	Impression	N	Mean	Std. Deviation	p-value
Marginal (1)	Digital	11	216	86.1	0.761
	Conventional	11	203.43	104.5	
Marginal (2)	Digital	11	181.57	63.02	0.727
	Conventional	11	170.93	77.3	
Mesial	Digital	11	153.93	92.3	0.856
	Conventional	11	159.77	50.3	
Occlusal (1)	Digital	11	321.41	149.7	0.231
	Conventional	11	251.47	113.3	
Occlusal (2)	Digital	11	270.45	113.3	0.156
	Conventional	11	202.71	101.9	
Distal	Digital	11	116.59	43.4	0.367
	Conventional	11	93.03	72.6	
Marginal (3)	Digital	11	194.9	51.8	0.001*
	Conventional	11	120.65	36.1	
Marginal (4)	Digital	11	301.69	178.2	0.101
	Conventional	11	191.30	116.7	

Statistically significant ($p<0.05$)

Discussion

Clinical studies have shown the importance of accurate definitive casts for fabrication ofanaccurately fitting prosthesis, that can be achieved through a precise impression. The present study compares the linear distortion and marginal fit of the zirconia copings among two different impression methods i.e. digital impression using intra oral digital scanner 3D progress and conventional impression using putty light body. The results of this study rejected the null hypothesis as results demonstrated that there is significant difference between digital and conventional methods.The study findings showed that conventional impressions had lower discrepancies than those of the details produced by digital methods.However, no significant difference for marginal fit of the zirconia copings was seen between the methods. These findings were in accordance with those of Anadioti et al [15]where the adaptation of the ceramic crowns was similar for both conventional and digital impression techniques. In contrast, few studies shown that the ceramic crowns or copings produced with the aid of digital methods showed better marginal and internal fit than conventional methods[16- 18]. The possible explanation for differences when compared to previous results is due touse of different intraoral scanners, different measurement methodologies, coping materials, scanning design etc. According to Sachs et al [19], factors such as scanning, designing, milling and sintering can influence the accuracy of zirconia. Considering these variations in such high extent it is difficult compare different studies [16].

The results of the first part of this study showed that both the digital and conventional impressions resulted in larger casts compared to the master model. However, measurements of conventional impressions were not significantly differed, thereby supporting the use of conventional over digital method for full arch impressions. This is in agreement with the in- vitro findings of Ender and Mehl [20], where dies produced using digital method were smaller in size compared to original and did not show superior accuracy over conventional impression technique. In addition to this, Ahlholm et al [2]in their review indicated that conventional impression technique is better choice over digital, especially for large, full-arch fixed partial dentures.

In the second part of the study, when internal fit of the zirconia copings fabricated using digital and conventional impressions were evaluated, there was no significant difference and are in clinically acceptable range. According to McLean and von Fraunhofer stated clinically accepted marginal discrepancy for all ceramic crown is 120 μm[21]. In the buccolingual cross section, both the impression methods produced comparable margins, but axially and occlusally digital impressions produced smaller discrepancies than conventional. At the margins, digital impressions performed better with lesser gaps. Marginal discrepancies were lesser with conventional than digital impressions mesiodistally.

The reported inaccuracies in the present study could be due to reflections of the surface to be scanned countered by layering with powders. This resulted in additional thicknesses which led to reduction in the efficiency of the scanners. In addition, inaccuracies could also be due to the errors in the image captured. Intraoral scanners lack fixed references. Therefore, they use the first image captured as a reference, and all subsequent images are “stitched” to the previous one by a best-fit algorithm, resulting in possible overlap of images[22]. Inherent error in each overlap summed up and resulted in gradual increase of final error. This indicates that, longer the scanning process, the larger the errors would be presented [23].

This study has several limitations. Firstly, it was conducted in an in- vitro set up. Clinical conditions could have produced different results. The results from this laboratory testing should be considered carefully. Secondly, the hand position of the intraoral scanner was standardized. However, it would be a different scenario in clinical situation. Thirdly, factors like sulcus bleeding during impression taking, tissue undercuts, saliva flow rate, limited access during scanning and restricted direction for tray removal were not evaluated. In addition, a very sample was used in this study. Therefore, additional investigations with more sample size and in intraoral conditions should be performed to confirm these findings.

Conclusion

Within the limitations of this study, the following conclusions can be made:

1. The mean values of the conventional measurements for the full arch impressions were closest to the actual measurements (master model) than that of the measurements from digital impression technique.
2. Type of impression technique does not have any effect on the internal fit of the zirconia copings
3. Marginal discrepancies in both impression techniques were within the limits of clinical acceptability.

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