Study on Accuracy of Digital Scanning and Conventional Methods in Partially Edentulous Dental Impression

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***Abstract* - Intraoral impression making is a basic technique in dental practice that is used to generate an imprint of the oral situation. Inaccurate impression may result in prosthesis misfit, which may lead to mechanical and/or biological complications. The current gold standard is the physical impression made with an elastomeric impression material. Recently, the advent of digital technology is developing expeditiously. Digital impressions have emerged as alternative to conventional impression technique and materials. The purpose of this *in vivo* study was to compare the accuracy of digital scanning and conventional techniques in partially edentulous dental impressions. Complete-arch impressions were obtained using two conventional (polyvinyl siloxane, PVS; direct scannable condensational silicone, S-CS) and one digital (3Shape Trios, TRI) techniques. The cast measurements were compared with intraoral measurements. No significant differences in trueness and precision were found between digital impression and conventional silicone impressions (*p*>0.05). Within the limitations of this *in vivo* study, digital intraoral impression systems showed similar accuracy comparable to highly accurate conventional impression techniques. These techniques can also provide excellent clinical results within their indications and can be used as alternative to conventional impression techniques.**

Keywords; Keywords; digital scanner, dental impression, polyvinyl siloxane impression

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Introduction

Precise impression is critical for fabricating dental restorations with adequate fit (Wostmann *et al*., 2009). Since poor quality impressions can compromise the quality of restorations, detailed information on appropriate impression techniques is required for long-term clinical success (Reich *et al*., 2008). Numerous sources of inaccuracy can develop during conventional impression making, among which are the selection of type, size, and rigidity of impression tray, the application of tray adhesive, impression technique, and manipulation of the impression material. Again, errors inevitably occur when creating the cast from conventional impression. Errors are also caused by the impression materials used, expansion and shrinkage of the gypsum cast and impression distortion (Christensen, 2009).

The ‘setting’ of the impressions generally occurs dimensional changes which affects the accuracy. Many impression materials contain volatile substances as primary components or byproducts of the setting reactions. Loss of such volatile materials during storage results in a shrinkage of the impression material with a consequent decrease in accuracy. For greatest accuracy, dimensional changes should be minimal (McCabe & Storer, 1981).

Elastomeric impression materials can be stretched or compressed slightly, and they can rebound when the impression tray is removed from the mouth. They are capable of accurately reproducing both the hard and soft structures of the mouth, including the undercuts and interproximal spaces. The extent of the rebound determines the accuracy of the material (Anusavice, 2013). The current gold standard is the physical impression made with an elastomeric impression material and stock or custom trays, resulting in a physical gypsum cast (Ender & Mehl, 2013). Elastomeric impression materials are used extensively to prepare casts for fixed and removable partial dentures, as well as for single restorative units, such as crowns, onlays, and inlays (Anusavice, 2013).

The fast and continuous advances digital technology gives clinicians the option to use intraoral scanner (IOS) in place of conventional impression technique. Digital processes are applied for prosthetic-driven backward planning of implant surgery, orthodontic measurements and treatment planning combined with surgical planning (Metzger *et al*., 2008). Digital models are produced by digitizing the oral structures, either directly or indirectly, with intra or extraoral scanners, respectively. The direct method is scanning the oral cavity, whereas the indirect method is scanning an impression or cast. The digital data obtained from the scans are converted into stereolithography (STL) files, a format compatible with computer software. Restorations can then be directly produced. Moreover, digitalized casts can also be converted into actual casts if needed by using 3-D manufacturing.

Recently, digital impressions have emerged as an alternative to conventional impression techniques and materials. Clinical evaluation of intraoral digital impressions has shown very promising results and can eliminate the errors encounter in conventional impressions (Christensen, 2009). Digital impressions have several advantages over conventional impressions, (1) patient will more comfort and much more pleasant experience in the dentist's chair (2) reduction of patient stress and discomfort (3) tend to reduce visits and retreatment while increasing treatment effectiveness (4) time-efficient, data reproducibility and can simplify clinical procedures (5) eliminate plaster models, saving time and space (6) allow for better communication with dental technician and (7) improve communication with patients (Baheti *et al*., 2015; Ender *et al*., 2016).

However, disadvantages are difficulty in detecting deep margin lines in prepared teeth and/or in the case of bleeding. Additionally, purchasing and managing costs are relatively high. Currently, there are seven existing intraoral scanning devices: iTero, Lava Chairside Oral Scanner, Care stream dental's CS 3500, True Definition scanner, The Lythos scanner, 3Shape's Trios and Sirona's CEREC (Baheti, 2015).

Several impression materials and techniques have been investigated in vitro and show a high level of accuracy, however only a few in vivo studies have been conducted (DeLong *et al*., 2003). The accuracy of a dental impression is determined by two factors: "trueness" and "precision". Trueness is defined as the deviation of the impression geometry from the original geometry. Precision is defined as the deviation between repeated impressions rather than to the original geometry. Precision reflects the degree of deviation between impressions within a test group (Ender, 2016). The purpose of this study is to compare the accuracy of digital scanning methods (intra and extraoral scanners) and conventional standard silicone impression method.

Materials and Methods

Eight partially edentulous patients who are seeking prosthetic treatment at the Department of Prosthodontics, University of Dental Medicine, Yangon were collected according to inclusion criteria. Inclusion criteria are (1) Patients who agree to participate in this study and who gave the informed consent, (2) Patients with age between 15 to 35 years of both sexes, (3) Patients with well-defined canine cusp tips and non-functional cusp tip of first molar (Mesiobuccal for upper and mesiolingual for lower) and (4) Partially edentulous patients (Kennedy Class III- missing one first permanent molar, right or left side). Patients with severe crowding and dentofacial deformity and patients with temporo -mandibular problems were excluded in this study.

The maxillary or mandibular jaw was selected in each subject to test all impression methods. Before impression, the teeth were prepared to make a point to be measured. For each impression group, 3 impressions will be made of each jaw.

Conventional impression was performed by using standard perforated metal rim lock stock trays. The optimal tray was selected by rehearsing a stock tray in the oral cavity while ensuring adequate space for the impression material. The conventional impressions were made using polyvinyl siloxane (PVS) and scannable condensational silicone (S-CS) according to the manufacturers' instruction. Then, making the casts by using stone from PVS impressions.

Digital impression system was made by intraoral scanning device, 3Shape Trios Pod (3Shape Trios, Germany). Digital 3D dental casts from intraoral scanner and S-CS impressions were produced by digital 3D dental cast printer (ASIGA).

Measurements were taken by using digital caliper on the casts. Three measurements were made i.e. (1) intercanine width, (2) edentulous span length and (3) diagonal measurement of canine tip to non-functional cusp tip of first molar. All measurements were carried out 3 times for each distance in stone casts of PVS and 3D dental casts of S-CS and intraoral digital scanner. Mean measurements were recorded. Intraoral measurements were made by using divider and measurements were recorded as mentioned above.

This study was approved by Research and Ethical Committee of University of Dental Medicine, Yangon (ERC/UDMY/ 2019/007). Informed consents were obtained from all subjects participating in the study after thorough explanation of the study procedures.

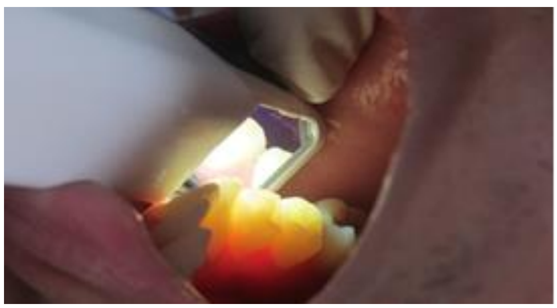

Figure 1. Impression taking with intraoral scanner (IOS)

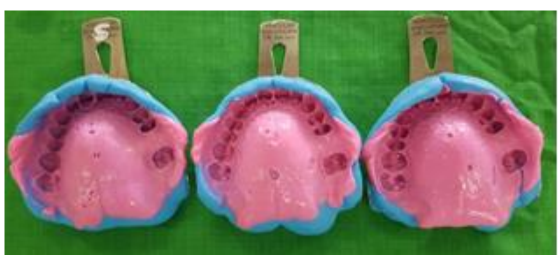

Figure 2. Impression making with polyvinyl siloxane (PVS)

Figure 3. Impression making with scannable condensational silicone (S-CS)

Statistical Analysis

The continuous variables were described by mean and standard deviation. Statistical analyses were performed using Statistical Package for Social Science (SPSS) (version 22.0) for One-way ANOVA test and Intraclass Correlation Coefficient (ICC) to detect trueness and precision. Statistical significance was considered at $p<0.05$.

Results

Table 1. Comparison of mean deviation of inter-canine distance (C-C) among study impression methods (n=21)

Impression methods	Mean (SD)	*F* statistics (df)	*p* value*
IOS	-0.35 (0.81)	0.095	0.910
S-CS	-0.21 (0.89)		
PVS	-0.17 (0.72)		

*One-way ANOVA

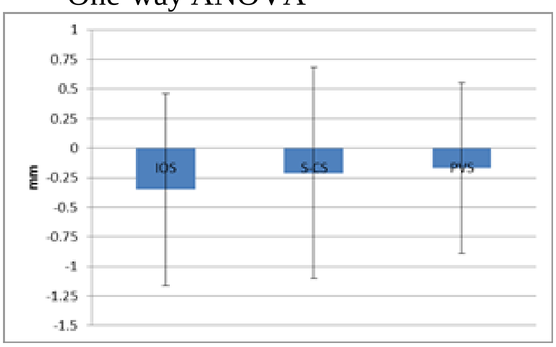

Figure 4. Mean deviation of inter-canine distance among study impression methods

Table 2. Comparison of mean deviation of canine-molar distance (C-M) among study impression methods (n=21)

Impression methods	Mean (SD)	*F* statistics (df)	*p* value*
IOS	0.16 (1.19)	0.028	0.927
S-CS	0.30 (1.28)		
PVS	0.27 (0.92)		

*One-way ANOVA

Since $p>0.05$, there is no significant difference of mean deviation of canine-molar distance (C-M) among different study impression methods.

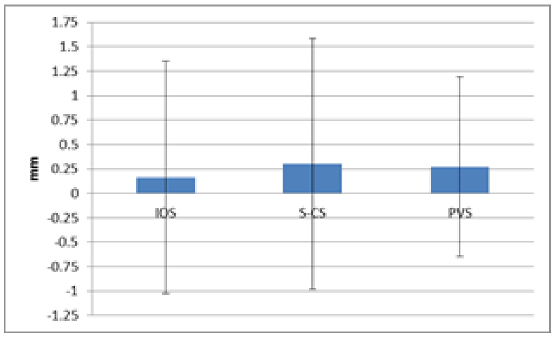

Figure 5. Mean deviation of canine-molar distance among study impression methods

Table 3. Comparison of mean deviation of edentulous span length (ESL) among study impression methods (n=21)

Impression methods	Mean (SD)	*F* statistics (df)	*p* value*
IOS	-0.54 (0.96)	0.623	0.548
S-CS	-0.65 (0.96)		
PVS	-0.17 (0.56)		

*One-way ANOVA

Since $p>0.05$, there is no significant difference of mean deviation of edentulous span length (ESL) among different study impression methods.

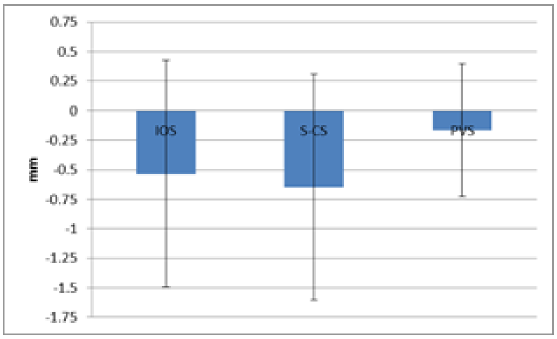

Figure 6. Mean deviation of edentulous span length (ESL) among study impression methods

Table 4. Mean deviation of different distances among study impression methods (n=63)

	IOS	S-CS	PVS
C-C	-0.35	-0.21	-0.17
C-M	0.16	0.30	0.27
ESL	-0.54	-0.65	-0.17

The distance C-M (canine-molar) of casts fabricated from intra-oral scanning gets the lowest mean deviation value among the other distances.

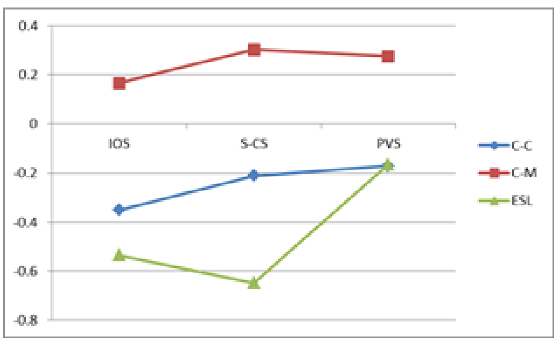

Figure 7. Mean deviation of different distances among study impression methods

Table 5. Intra class correlation coefficient of different study impression methods for distance C-C (n=63)

	Intra class Correlation	95% Confidence interval	
		Lower bound	Upper bound
IOS	0.996	0.986	0.999
S-CS	0.998	0.994	1.000
PVS	0.997	0.989	0.999

The ICC results of study impression methods IOS, S-CS and PVS for C-C are 0.996, 0.998 and 0.997 with 95% confident interval = 0.986-0.999, 0.994-1.000 and 0.989-0.999, respectively.

Table 6. Intra class correlation coefficient of different study impression methods for distance C-M (n=63)

	Intra class Correlation	95% Confidence interval	
		Lower bound	Upper bound
IOS	0.999	0.995	1.000
S-CS	0.999	0.995	1.000
PVS	0.999	0.996	1.000

The ICC results of study impression methods IOS, S-CS and PVS for C-M are 0.999 with 95% confident interval = 0.995-1.000, 0.995-1.000 and 0.996-1.000, respectively.

Table 7. Intra class correlation coefficient of different study impression methods for distance ESL (n=63)

	Intra class Correlation	95% Confidence interval	
		Lower bound	Upper bound
IOS	0.993	0.973	0.999
S-CS	0.995	0.981	0.999
PVS	0.994	0.978	0.999

The ICC results of study impression methods IOS, S-CS and PVS for ESL are 0.993, 0.995 and 0.994 with 95% confident interval = 0.973-0.999, 0.981-0.999 and 0.978-0.999, respectively.

Based on these ICC results, it can be concluded that the reliability of study impression methods is excellent.

Discussion

Clinical indications of intraoral scanner in Prosthodontics and Implantology are resins, inlays/onlays, all ceramic frameworks and fixed partial dentures in zirconia (4-8 elements), single-implant crowns, implant bridges (4-5 implants), posts and cores, partial removable dentures, digital smile design, obturators and guided implant surgery. Contraindications are long-span fixed partial dentures and/or fixed full arches (6-8 elements), long-span implant-supported fixed partial dentures and/or fixed full arches (6-8 implants) and complete removable prostheses (Mangano *et al*., 2017).

The trueness of conventional impressions is commonly tested by measuring the change in linear distance between an original master model and a gypsum cast derived from the impression. This procedure is difficult to perform intraorally and many *in vivo* studies used an indirect approach and verify the impression trueness by measuring the fit of the definitive restoration based on that impression (Seelbach *et al*., 2013). The present study investigated the accuracy of casts produced by the digital and conventional impression and cast fabrication methods.

For trueness, there are no significant differences of mean deviations of inter-canine distance (C-C), canine-molar distance (C-M), and edentulous span length (ESL) among different study impression methods since $p>0.05$. Conventional impression and cast fabrication methods showed the statistically superior accuracy and reproducibility of complete arch casts than digital impression methods (Cho *et al*., 2015). However, in terms of short edentulous span length area, no statistically significant difference was found between the two methods in this study. Another study showed that working dies made by conventional impression methods were significantly more accurate than those obtained through digital impression. However, no significant difference was found in accuracy on the marginal form areas of the dies (Kim *et al*., 2013). The differences in the current results with Kim's works may be attributed to the use of different conventional impression materials and procedures and to different digital impression methods. Guth *et al*., (2013) reported that the intraoral Lava COS system showed significantly higher accuracy than the conventional impression procedure and indirect digitalization. The resolution of a scanner affected its ability to read the sharp contours of a scanned surface but did not affect its general trueness or precision. The different technologies (light, laser, or contact) do not affect scanners' overall reliability, but specific aspects of the scanning procedure do (Gonzalez & Martinez-Rus, 2016).

In this study, the intra class correlation coefficient results of study impression methods IOS, S-CS and PVS for ESL are 0.993, 0.995 and 0.994 with 95% confident interval = 0.973-0.999, 0.981-0.999 and 0.978-0.999 respectively. Based on these ICC results, it can be stated that the reliability of all study impression methods is excellent. However, intraoral conditions such as saliva, powder, and limited space could contribute to inaccuracies in the digital scan.

Conclusion

Within the limitations of this *in vivo* study, digital intraoral impression systems showed similar accuracy comparable to highly accurate conventional impression techniques. This technique can also provide excellent clinical results within their indications and can be used as alternative to conventional impression technique.

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The authors declare there is no potential conflict of interest.

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