

Comparison of reproducibility of dual-arch impression with conventional impressions

Hiroyuki Minami, DDS, PhD,¹ Shiro Suzuki, DDS, PhD,² and Takuo Tanaka, DDS, PhD¹

¹Department of Fixed Prosthetic Dentistry, Kagoshima University Graduate School of Medical and Dental Sciences, Kagoshima, Japan, and ²Department of Prosthodontics and Biomaterials, University of Alabama at Birmingham, School of Dentistry, Birmingham, AL, USA

Purpose: This study compared the reproducibility of dual-arch impression technique with conventional impression techniques.

Materials and Methods: Full-crown preparation was completed on posterior teeth of fresh porcine upper jaws. Dual-arch impression was made immediately after the preparation without gingival retraction cord or triple-tray (experimental group), followed by conventional 1-step and 2-step impressions (control groups). Sub-marginal impression lengths were measured at the center of mesial, distal, buccal and palatal surfaces and compared among three groups. The accuracy was compared by calculating the ratios of the widths among stone casts generated from each impression for mesial-distal and buccal-palatal measurements. Differences among the groups were analyzed by Wilcoxon signed-ranks test at 95% confidence level.

Results: Regarding sub-marginal lengths, there were no significant differences among three groups ($p>0.05$) at buccal site. However, dual-arch impression was significantly smaller than control groups at mesial site ($p<0.05$), smaller than 1-step impression group at distal site ($p<0.05$), and smaller than 2-step impression group at palatal site ($p<0.05$). There were no significant differences among three groups ($p>0.05$) for mesial-distal widths, however, buccal-palatal widths of the dual-arch impression was significantly smaller than the control groups ($p<0.05$); 99.1 % of 1-step group and 99.20 % of 2-step group.

Conclusion: Sub-marginal lengths of dual-arch impression without using retraction cord seemed to be clinically sufficient. However, the use of triple-tray is recommended when the dual-arch impression techniques are employed. (Int Chin J Dent 2006; 6: 9-16.)

Key Words: accuracy, dual-arch impression, gingival retraction, impression, triple-tray, sub-marginal area.

Introduction

Polyvinylsiloxane impression materials have been widely used by clinicians, as the materials possess high accuracy.^{1,2} A two-step impression technique has been used to compensate for the shrinkage of the impression material.¹ A preliminary impression is usually made with a very high viscosity material (putty) and used as a tray, and then the final impression using a low-viscosity impression material is employed. This technique has the potential to lessen the polymerization shrinkage,^{3,4} however, it takes longer time, compared to a one-step impression technique. The one-step impression technique sometimes produces incorrect impressions due to rapid polymerization and poor flow,⁵ although the literature reported no significant difference with the two-step impression.^{6,7}

Gingival retraction is one of the keys for success of impression whenever the prepared margin is located sub-gingivally. However, it also takes some additional chair time that is disadvantageous for both clinicians and patients. Therefore, it is essential to select an adequate impression system with an acceptable clinical technique.

Dual-arch impression techniques have been introduced a decade ago as a unique technique,⁸ which enables the dentist to capture an impression of the prepared tooth, the opposing teeth and the occlusal registration in one procedure.^{9,10} The efficacy and problems of this technique have been discussed⁹⁻¹² and compared with complete-arch impressions,¹³⁻¹⁵ however, the use of them is limited to the impression of one or possibly two restorations.^{10,16} Besides the limitation of impression size, it revealed that this technique was quite technique sensitive, as the distortion of impression was provoked due to lack of the rigidity of dual-arch tray especially

when patients bit the tray tightly. The distortion of the tray was also provoked by impinging the alveolus or palate,^{15,16} and tori.¹³ Furthermore, some of the double-arch trays are virtually sideless,¹⁶ causing insufficient fit, consequently leading to the distortion of the impression. Therefore, it is hypothesized that exclusion of the dual-arch tray during dual-arch impressions improve the accuracy of dual-arch impressions.

The purported advantages of dual-arch impressions are savings in time and material, patient comfort, and ease of use.¹⁵ Elimination of gingival retraction, which is most time consuming process during making impression, will make the most of these advantages.

The purpose of this study was to evaluate the reproducibility of dual-arch impression technique without using a dual-arch tray, by comparing it with conventional impression techniques. It was also the purpose of this study to evaluate the ability of reproducing the subgingival area without gingival retraction and the accuracy.

Materials and Methods

Materials, impression techniques, and specimen preparation

Materials used in this study are presented in Table 1. Aquasil putty material was hand-mixed, and all others were dispensed using an auto-mix cartridge system (Cartridge Dispensing Gun, J. Morita USA Inc., Irvine, CA, USA). Five fresh porcine jaws were used for the evaluation of reproducibility. The porcine head was dissected by a veterinarian at the animal facility in the University of Alabama at Birmingham. The periphery of the tongue was trimmed to obtain impression space between the tongue and palatal surfaces. Full crown preparation was carried out on maxillary posterior teeth including a premolar and two molars (Fig.1). The preparation was completed with full heavy-chamfer margin using high-speed engine with #018 (coarse) and #021 (fine) diamond burs (Shofu Dental Corporation, San Marcos, CA, USA) under a copious irrigation. The prepared margin was finished 0.5 mm below the gingival margin.

Table 1. Impression materials used.

Impression method/Type	Product name	Manufacturer	Batch number
Dual-arch impression			
Medium-viscosity	Perfectim Systems 30 second Blue Velvet	J Morita USA, Irvine, CA, USA	334335
Low-viscosity	Perfectim Systems 90 second Flexi-Velvet	J Morita USA	199200
Conventional impression			
Putty consistency	Aquasil Easy Mix Putty	Dentsply/Caulk, Milford, DE, USA	011128
Low-viscosity (type I)	Reprosil Cartridge System	Dentsply/Caulk	010104

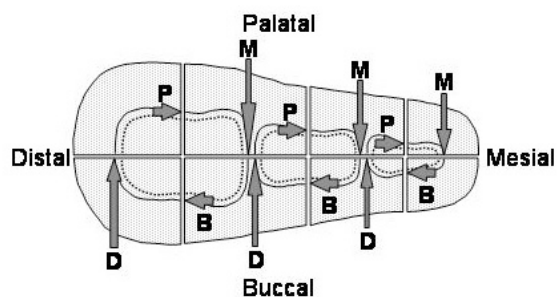
Dual-arch impression was made immediately after the tooth preparation as an experimental group, followed by conventional 1-step and 2-step impressions as control groups. Dual-arch impression was completed using neither a triple tray nor a gingival retraction cord. For the preliminary impression, a medium-viscosity material was injected onto and peripheries of the prepared teeth, then the upper and lower jaws were occluded. The cheek was kept by holding using fingers with light pressure. A single extrusion of medium-viscosity material through the dispensing gun was injected for each quadrant, which provided approximately 5 mm thickness of preliminary impression. After one minute from the mix the jaw was opened, and the preliminary impression was detached from the preparations but kept attached to the antagonistic dentition. Then, the low-viscosity material was injected to both the prepared teeth and preliminary impression. The jaws were closed again for three minutes from the beginning of mix and the impression was completely removed from the dentition.

For both the 1-step and 2-step impression techniques, the gingivae around the prepared teeth were retracted using a retraction cord (Ultrapack #0, Ultradent Product, Salt Lake, UT, USA). The cord was removed prior to each impression. For the 1-step impression technique, a low-viscosity (type I) material was injected onto and peripheries of the prepared teeth, and a putty consistency on a stock plastic quadrant-arch tray (Coe Impression Tray, GC America, Chicago, IL, USA) was placed onto it immediately, and held in place for 12 minutes. For the 2-step impression technique, surgical gauze was placed on the prepared teeth as a spacer. The putty consistency material was placed on it using the plastic tray and held for 10 minutes. The preliminary impression was removed, and the low-viscosity (type I) material was injected onto and around the prepared teeth and the preliminary impression. The definitive impression was held for 12 minutes. The setting time of each impression material was twice longer than the manufacturer's instruction to compensate prolonged setting time due to lower room temperature.

Each impression was made twice for right and left dentitions of five porcine jaws. One of the two impressions was used for measuring sub-marginal lengths, and the other was used for generating stone working casts to evaluate the accuracy. Finally, 10 quadrant impressions for measuring sub-marginal lengths and other 10 impressions for generating stone working casts were obtained for each impression methods. All the impressions were rinsed with tap water for 10 s, then dried and left for one hour, prior to each investigations.



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Fig. 1. Prepared posterior teeth of porcine upper jaw with full heavy-chamfer margin.

Fig. 2. Segmentation of the impression for measuring sub-marginal impression length at each measuring site. M, Mesial measuring site; D, Distal measuring site; B, Buccal measuring site; P, Palatal measuring site.

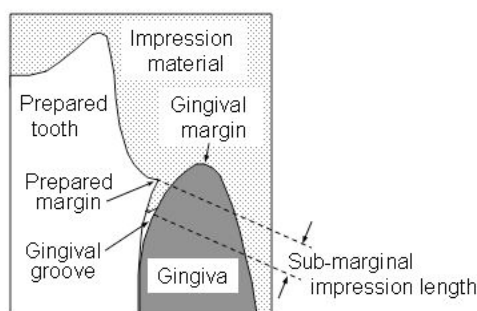
Measurements of sub-marginal impression lengths

The lengths of sub-marginal impression for respective techniques were compared to each other. Each impression was cut into pieces parallel to the tooth axis at the center of the mesial, distal, buccal, and palatal surfaces using a surgical blade (Fig. 2). The distance from the prepared margin to the tip of the impression material infiltrated into gingival groove was measured (Fig. 3) on a series of sections. The images of sectioned areas were captured by a monochrome CCD video camera (XC-77, Sony Co., New York, NY, USA) and digitized by a computer soft wear (NUBus, Neotech Ltd, Eastleigh, England). The lengths were measured using image analysis software (Image 1.45, NIH, Bethesda, MD, USA).

Comparisons were performed among three impressions made from an identical tooth. Impressions were made for 10 dentitions, and each dentition included three teeth. Therefore, 30 values were accumulated for each measuring surface of each impression technique. Statistical analysis was performed by repeated measure ANOVA with impression techniques and measuring surfaces as independent factors. Differences among the groups were analyzed by Wilcoxon signed-ranks test at 95% confidence level.

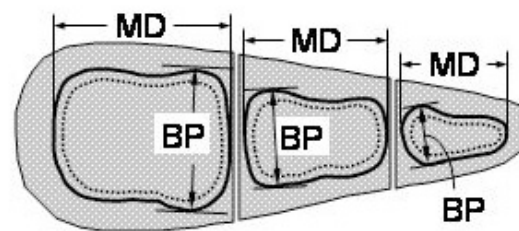
Evaluation of accuracy

The accuracy of each impression technique was evaluated by comparing both mesial-distal and buccal-palatal widths of stone casts generated from each impression. Type IV improved dental die stone (Vel-Mix, Kerr, Orange, CA, USA) with a ratio of 10 mL of distilled water to 50 g of powder was hand mixed for 10 s, then mixed under reduced pressure for 40 s. Each impression was poured with mixed die stone while being vibrated. All casts were allowed to set for 24 hours before being removed from the impressions. Casts were mounted into custom-made mold made by the putty silicone, which was fabricated individually for respective porcine dentitions. Base of the stone casts was adjusted by the mold to give each cast constant and reproducible arrangement during the measurement. The casts were sectioned using diamond disks to fabricate stone dies of respective prepared teeth, then gingival areas around the teeth were trimmed to enable the measurements. Both buccal-palatal and mesial-distal dimensions were measured at the prepared marginal areas (Fig. 4). A custom-made indicator, which was made for each prepared tooth using a silicone material (Fit Checker Black, GC America Inc., Alsip, IL, USA), was used to indicate the identical and reproducible measurement portion of three casts generated by each impression. The measurements were performed using a traveling magnifying scope assembled with a CCD camera and a 2-dimensional traveling table (Fig. 5), which is capable of measuring up to 0.001 mm (1 μ m). The cross-hair was placed on the starting point and the position (x_s , y_s) was recorded. The cross-hair was then moved to the end point and the position (x_e , y_e) was also recorded. The distance between these two points was calculated according to following equation; $l = [(x_e - x_s)^2 + (y_e - y_s)^2]^{0.5}$. The measurements were repeated three times for each measuring portion and averaged to determine the value. All the measurements were completed by single examiner. The intra-examiner variability for all measurements ranged between 5 and 8 μ m, indicating 0.05% to 0.08% of measurement errors.



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Fig. 3. Measurement of the length of sub-marginal impression.



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Fig. 4. Measuring sites of the stone cast. MD, Maximum mesial-distal width; BP; Maximum buccal-palatal width.

Comparisons were carried out among casts acquired from the identical tooth. Casts were acquired from 10 dentitions, and each dentition included three teeth. Therefore, 30 values were collected for both buccal-palatal and mesial-distal widths of stone casts generated from each impression technique. The ratios of the corresponding values of conventional 1-step impression to conventional 2-step impression (1-step/2-step), dual-arch impression to conventional 1-step (dual-arch/1step), and dual-arch to conventional 2-step (dual-arch/2step) were calculated for both buccal-palatal and mesial-distal widths, and the averages of corresponding 30 comparisons were described in percentages. Differences among the groups were analyzed by Wilcoxon signed-ranks test at 95% confidence level.

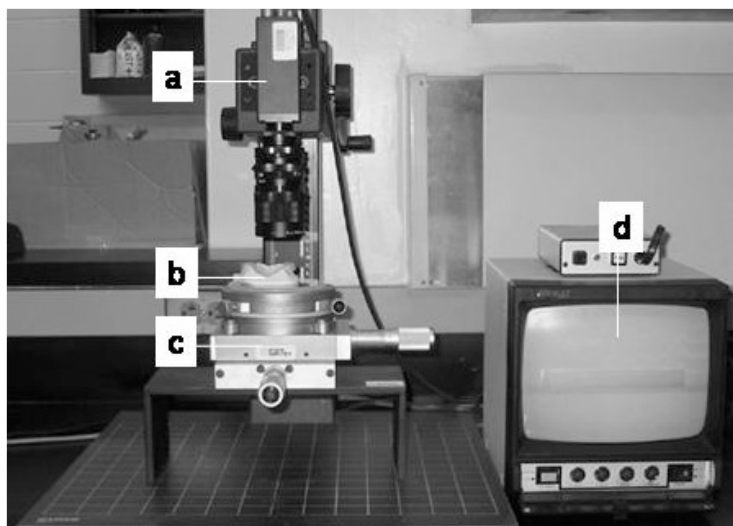


Fig. 5. Measuring apparatus.
 a, CCD camera
 b, Stone cast
 c, 2-dimensional traveling table
 d, Display

Results

The results of the measurements of sub-marginal impression are presented in Table 2. The results of repeated measure ANOVA demonstrated that there were no significant differences among impression sites ($p > 0.05$), but significant differences existed among impression methods ($p < 0.05$). In addition, there was no significant interaction between the impression site and the impression method ($p > 0.05$). For the sub-marginal lengths of the buccal site, there were no significant differences among three impression techniques ($p > 0.05$). However, the sub-marginal length of dual-arch impression was significantly smaller than those of the conventional impressions at mesial site ($p < 0.05$), smaller than those of the conventional 1-step impression at distal site ($p < 0.05$), and smaller than those of the conventional 2-step impression at palatal site ($p < 0.05$).

Table 2. Results of sub-marginal impression lengths in mm.

Method	Site N=30	Mesial Mean SD	Distal Mean SD	Buccal Mean SD	Palatal Mean SD
Dual-arch		0.52 0.27 a A	0.61 0.35 c A	0.60 0.46 e A	0.59 0.35 f A
Conventional 1-step		0.70 0.38 b B	0.89 0.58 d B	0.84 0.43 e B	0.79 0.31 f g B
Conventional 2-step		0.69 0.30 b C	0.84 0.58 c d C	0.69 0.29 e C	0.75 0.33 g C

Values with the identical lower case letters denote no significant difference within the same impression site ($p > 0.05$). Values with the identical capital letters denote no significant difference within the same impression method ($p > 0.05$).

Table 3. Summary of the comparison of stone casts generated from respective technique.

Measurements	Combinations for comparison between the impression methods		
	1-step / 2-step	Dual-arch / 1-step	Dual-arch / 2-step
Buccal-palatal widths	100.14%	99.07%	99.20%
Mesial-distal widths	100.12%	99.91%	100.02%

Comparisons for the sizes of stone casts generated from each impression technique are listed in Table 3, and results of statistical analysis are summarized in Table 4. Buccal-palatal length of the group obtained from dual-arch impression was 99.07 % of 1-step impression group and 99.20 % of 2-step impression group. The value of the dual-arch impression group was significantly smaller than conventional impression groups ($p < 0.05$).

For mesial-distal measurements, there were no significant differences among three impression groups ($p>0.05$).

Table 4. Results of statistical analysis for buccal-palatal and mesial-distal measurements.

	Buccal-palatal measurements			Mesial-distal measurements		
	1-step	2-step	Dual-arch	1-step	2-step	Dual-arch
1-step	-----	NS	S	-----	NS	NS
2-step	■	-----	S	■	-----	NS
Dual-arch	■	■	-----	■	■	-----

NS denotes no significant difference ($p\geq 0.05$). S denotes significant difference ($p<0.05$).

Discussion

The management of gingival tissue is one of the important tasks for making successful impressions of prepared teeth. Therefore, the gingiva is usually retracted with a retraction cord prior to making impression, especially for the cases in which the prepared margins are located sub-gingivally. Therefore, the potential for making sub-marginal impression plays an important role for the clinical success. Sub-marginal lengths obtained from dual-arch impression without gingival retraction (0.52-0.61 mm) was less than those of conventional techniques (0.69-0.89 mm). Although insufficient sub-marginal impression lengths occasionally lead to difficulties while trimming marginal areas of the working cast, all of the cavo-surface margins were successfully impressed by the dual-arch impression. Aimjirakul et al.¹⁷ have studied by use of the sulcus simulating model and reported that the penetration ability of elastic impression materials was greater with wider sulci, however, the penetration depths during conventional impressions without gingival retraction have never been clarified. Furthermore, the appropriate sub-marginal impression lengths have not been defined. It is obvious that manipulation of working casts will be easier with greater sub-marginal impression lengths, however, the lengths of sub-marginal impression obtained from dual-arch impression might be also acceptable for clinical situation. Therefore, the exclusion of gingival retraction will make the impression time short and facilitate the patients' comfort.

Although distortion of impression is a three-dimensional problem, only two-dimensional evaluation including buccal-lingual and mesial-distal dimensions of the gingival margin were chosen in this study. Addition of occluso-gingival measurements and the inter-abutment distances might have provided more reliable information. Most of the studies have evaluated the accuracies of impression techniques by use of an in vitro models, which include standard master dies of machined stainless steel^{8,12} or prepared plastic teeth in a typodont.^{10,13} The use of standard master dies facilitates the measurements and comparison of stone dies obtained from various impression techniques. This study evaluated the sub-marginal impression lengths and the accuracy using fresh porcine jaws. An advantage of this method was that impressions were made under the existence of soft tissue. Furthermore, some gingival fluid existed instead of bleeding from marginal area, which is one of the most annoying problems during impression. The size and configurations of porcine teeth used in this study were different from those of human teeth; porcine teeth had a bucco-palatally compressed configuration, and mesio-distal widths of porcine molar were greater than those of human molar. Furthermore, there is no consensus cited in literatures regarding the gingival groove depths of porcine jaw. However, judging from the experience through gingival retraction procedure, the depths seemed similar to those of human gingiva, and porcine gingiva seemed stiffer than human gingiva. Therefore, clinical evaluation might be the best method for

the comparison among impression techniques; however, it could only be achieved on the basis of the subjects' cooperation. Therefore, the method used in this study might be the second best method for the evaluation of impression techniques.

The disadvantage of this method was that there were many difficulties in measuring the size of prepared teeth on porcine jaws as standard. Therefore, conventional impression techniques were used as control groups and resulted in the comparison using stone dies obtained from each impression technique.

As some studies have already reported,^{13,15,16} the distortion of dual-arch impression due to the lack of rigidity of triple tray can cause rebound that will result in distortion of impression. Therefore, dual-arch impression was performed without using a triple tray. The hypothesis of this study was partially rejected, because the results of buccal-lingual measurements of dual-arch impression were significantly smaller compared to the conventional impressions. For the comparison of buccal-palatal distances between master die and stone die obtained by dual-arch impression, the values showed an inconsistency. Ceyhem et al. reported that the stone die showed greater value than the master die,¹⁵ however, and a smaller value of the stone die when impression was made using metal and plastic trays,¹² greater value with plastic tray and smaller value with metal tray,¹⁰ have also been reported. Although it is quite difficult to compare the results between these studies and current study, distortion of triple tray during insertion or removal may not be the main cause of the inaccuracies and unstableness of triple impression. As the preliminary impression of dual-arch impression is made without using spacers, the preliminary impression might be stretched buccal-palatally during definitive impression and any rebound after the removal of the impression would result in reduced buccal-palatal dimension. Introduction of any kinds of spacers during preliminary impression, moreover, addition of least amount of low-viscosity material to the prepared marginal area of preliminary impression, may bring higher accuracy to the dual-arch impression.

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Correspondence to:

Dr. Hiroyuki Minami
Department of Fixed Prosthetic Dentistry
Kagoshima University Graduate School of Medical and Dental Sciences
8-35-1, Sakuragaoka, Kagoshima 890-8544, Japan
Fax: +81-99-275-6218 E-mail: minami@dentb.hal.kagoshima-u.ac.jp

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