치의학석사학위논문

Marginal accuracy of digital impression system using parallel confocal imaging

평행 공초점 영상을 이용한 디지털 인상법의 변연 정확도에 관한 연구

2013년 2월

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2012년 10월

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2012년 12월

위 원 장 _____ (인)

부위원장 _____ (인)

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ABSTRACT

Marginal accuracy of digital impression system using parallel confocal imaging

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1. Objectives

The purpose of this study was to measure the marginal accuracy of iTero digital impression method to conventional impression method in four prosthetic copings(PFM, Empress-2, Cercon®, ARUM).

2. Methods

A typodont model with the prepared upper premolar metal tooth was used as the master model. A buccal shoulder and the other chamfer preparation was made on the upper premolar.

Three digital impressions of the master model were taken with the iTero system. Working models were milled from a polyurethane block using a CAD/CAM system. As a conventional impression

group, three silicone impressions were taken on prepared master metal model and poured into a class IV resin-reinforced. Four copings was made of PFM, Empress-2, Cercon® and ARUM on each of working models. 24 copings are totally manufactured. After seating a series of copings on the master die, the digital images were captured with a stereoscopic microscopen75 magnification. 10 images(5 buccal images and 5 lingual images) were acquired on the each of the copings. And then, the marginal distance was measured on ten random points of each digital image. The mean and standard deviation were calculated from the total of 2400 data and analyzed statistically using the 2-sample t test, one-way ANOVA. The level of significance was set at 5%.

3. Results

1. Mean marginal gap dimensions and standard deviations at the marginal opening for the maxillary premolar copings were 89.15±43.66㎛ for PFM, 77.44±33.91㎛ for Empress-2, 75.93±28.71㎛ for Cercon®, 74.87 ± 27.79㎛ for ARUM zirconia on conventional impression, 90.84±35.06㎛ for PFM, 72.51±32.83㎛ for Empress-2, 78.94±30.58㎛ for Cercon®, 62.14±29.96㎛ for ARUM zirconia respectively on iTero digital impression. Compared conventional with digital impression technique, there was not significant difference(P>0.05) in marginal gap.
2. There did not show significant difference among 4 prosthetic copings in the conventional, and also iTero digital impression method (P>0.05).
3. Mean marginal gap dimensions and standard deviations at the marginal opening for the maxillary premolar copings

were 77.94±33.90㎛ for Shoulder, 80.76±35.14㎛ for Chamfer by conventional impression, 80.94±39.38㎛ for Shoulder, 76.25±37.14㎛ for Chamfer respectively by iTero digital impression. There did not show significant difference between shoulder margin and chamfer margin in the conventional, and also iTero digital impression groups (P>0.05).

4. Conclusions

The marginal accuracy was clinically acceptable in iTero digital impression method as well as conventional impression method and also was not significantly different in 4 different types of prosthetic coping.

Keywords : Marginal fit, iTero digital impression, conventional impression, PFM, Empress-2, Cercon®, ARUM

Student Number : 2009-22669

목 차

표 목차

그림 목차

I. INTRODUCTION

Marginal fit is a very important aspect for fixed restorations because large marginal opening allows more plaque accumulation, gingival sulcular fluid flow, and bone loss, resulting in microleakage, recurrent caries, and periodontal disease.[1] The most critical step in the process of fabricating precisely fitting fixed or removable dental prostheses is the capture of an accurate impression of prepared or unprepared teeth, dental implants, edentulous ridges, or intraoral landmark or defects.[2] Until recently, the only available means to accomplish this was by taking a physical intraoral impression with polyether or polyvinylsiloxane materials, which could be difficult for both the dental practitioner and the patient.[3] The analog impressions with bubbles on the margins of the tooth preparation, tears in the impression material, partially set streaks of impression material, cords, cotton rolls or other debris impregnated in the impression material, release of the impression material from the tray and lack of full representation of all of the necessary teeth in the impression.[4] A patient with a strong gag reflex or who cannot tolerate impression material in his or her mouth for several minutes may have problems with physical impressions. Therefore, the need of digital impression has been raised.

The use of CAD/CAM technology for dental restorations has numerous advantages over traditional techniques. These advantages include speed, ease of use, and quality. Digital scans have the

potential to be faster and easier than conventional impressions because casts, wax-ups, investing, casting, and firing are eliminated.[9] Another benefit is that all the scans can be stored on the computer; whereas, standard stone models take up space and can chip or break if stored improperly.

The iTero system is one of the digital impression system. Cadent introduced iTero in 2007 as the first digital impression system for conventionally manufactured crowns and bridges. Unlike the other digital impression systems, which acquire images using triangulation, iTero employs parallel confocal imaging. Specifically, the device projects 100,000 parallel beams of red laser light at the teeth and transforms the reflected light into digital data through the use of analog-to-digital converters. This technology allows scans to be taken without coating the teeth in powder. The absence of powder means that the scanner can be rested directly on the teeth during scanning. After the scan is approved, a dedicated wireless connection transmits the scan to Cadent for cleanup and initial design. The file then gets transmitted to the dental laboratory.

The purpose of this investigation was to measure the marginal accuracy of iTero digital impression method to conventional impression method in various prosthetic copings. The primary null hypothesis was that there was no difference in marginal distance between master metal teeth fabricated from iTero digital impressions and those from conventional impressions in 4 different prosthetic copings(PFM, Empress-2, Cercon®, ARUM zirconia). And the secondary null hypothesis was that there was no difference

in the marginal distance among 4 different prosthetic copings in each of conventional and digital impression method. The third null hypothesis was that there was no difference in the marginal distance between shoulder margin and chamfer margin in each of conventional and digital impression method.

II. MATERIAL and METHODS

A typodont model with the prepared upper premolar metal tooth was used as the master model. A buccal shoulder and the other chamfer preparation was made on the upper premolar (Figure 1). All the margin were prepared equi-gingivally in order to not interfere in the digital impression process. The preparation was completed with a surveyor using a carbide bur to ensure that the preparation had a a total taper of 12° .

Three digital impressions of the master model were taken with the iTero system. The data was transmitted electronically to the manufacturing center (Dio Health Care, Pusan, South Korea) where the streolithography(SLG) working models were milled from a polyurethane block using a CAD/CAM system (Figure 2). Individual dies of prepared tooth were anchored to the SLG models through a pin system and could be detached if necessary.

As a conventional impression group, three silicone impressions (Exafine Putty, GC and Imprint 2 Grant Quick Step Light Body, 3M

ESPE, Seoul, South Korea) were taken on prepared master metal model and poured into a class IV resin-reinforced (ISO type IV) die stone (ResinRock, Whip Mix, Seoul, South Korea). Three individually separated working dies were fabricated. The bases of the dies were fabricated in the same dental stone in order to allow the mechanical scanning instrument to view the dies in several directions without obstruction or instability (Figure 3).

Four copings was made of PFM, Empress-2, Cercon® and ARUM on each of working models (Figure 4). 24 copings are totally manufactured (Table 1). Group1-1 is PFM coping which is manufactured with conventional impression, making die, wax-up, and casting procedure. Group1-2 is Empress-2 coping which is manufactured with conventional impression, making die, wax-up, and casting procedure with Empress-2 ingot. Group1-3 is Cercon® zirconia coping which is manufactured with conventional impression, making die, and CAD-CAM procedure with Cercon® system. Group1-4 is ARUM coping which is manufactured with conventional impression, making die, and CAD-CAM procedure with ARUM system(Doowonsangi, Seoul, South Korea). Group2-1 is PFM coping which is manufactured with iTero impression, making die by CAD-CAM, wax-up, and casting procedure. Group2-2 is Empress-2 coping coping which is manufactured with iTero impression, making die by CAD-CAM, wax-up, and casting procedure Group2-3 is Cercon® zirconia coping which is manufactured with iTero impression, making die by CAD-CAM, wax-up, and CAD-CAM procedure. Group2-4 is ARUM zirconia

coping which is manufactured with iTero impression, making die by CAD-CAM, wax-up, and CAD-CAM procedure with ARUM system. After seating a series of copings on the master die, the digital images were captured with a stereoscopic microscope (NIS-ELEMENTS F 2.20 (Nikon, Tokyo, Japan), Figure 5) of 75 magnification. 10 images(5 buccal images and 5 lingual images) were acquired on the each of the copings. And then, the marginal distance was measured on ten random points of each digital image. Gap is measured of the minimal distance from one point of the coping edge to the tooth margin. A total of 100 measurements (50 buccal measurements and 50 lingual measurements)were acquired on each copings. So the 300 points were obtained by adding all points of the three groups. Marginal fit of one coping was defined as a mean value of theses 300 measurements. The mean and standard deviation per group were calculated and statistical analyses among the groups were made using the two-sample t test, one-way ANOVA. The level of significance was set at 5%.

III. RESULTS

Table 2,3 shows the means and standard deviations of PFM, Empress-2, Cercon®, ARUM zirconia coping made by conventional impression method and digital impression method respectively. The means and standard deviations were 89.15±43.66㎛ for PFM, 77.44±33.91㎛ for Empress-2, 75.93±28.71㎛ for Cercon®, 74.87

± 27.79㎛ for ARUM zirconia made by conventional impression technique (table 2). And 90.84±35.06㎛ for PFM, 72.51±32.83㎛ for Empress-2, 78.94±30.58㎛ for Cercon®, 62.14±29.96㎛ for ARUM zirconia made by digital impression technique (table3). Table 4 shows the 2-sample t-test of the marginal gap and one-way ANOVA of all copings. There was no significant difference found between conventional impression method and digital impression method in all prosthetic coping (>0.05). There was no significant difference among four different prosthetic copings within digital impression technique groups and conventional technique groups (p>0.05) (table 4).

Table 5 shows the means and standard deviations of shoulder and chamfer margin made by conventional impression method and digital impression method respectively. The means and standard deviations were 77.94±33.90㎛ for shoulder margin, 80.76±35.14 ㎛ for chamfer margin made by conventional impression technique. And 80.94±39.38㎛ for shoulder margin, 76.25±37.14㎛ for chamfer margin made by digital impression technique. Table 6 shows the 2-sample t-test of the marginal gap. There was no significant difference found between shoulder margin and chamfer margin in the conventional impression groups, and also iTero digital impression groups (p>0.05) (table 6).

IV. DISCUSSION

In this study, 100 measurements per crown and total 300 measurements per group in random manner were selected. According to Groten, approximately 50 measurements along the margin of a crown yielded clinically relevant information and a consistent estimate for the gap size and it was of minor importance whether 50 measurements along the margin were randomly selected or systematically recorded in distances of about 500μm.[10] Therefore, our measurements in this study are clinically relevant information. As the measurements were enough to analyze and follow a normal distribution, the two sample t-test and one-way ANOVA were performed.

The primary null hypothesis was that there was no difference in marginal distance between master metal teeth fabricated from iTero digital impressions and those from conventional impressions in 4 different prosthetic copings. This hypothesis was accepted since there was no significant difference in the mean marginal gap between conventional impressions and iTero digital impression($P>0.05$). But, can we accept clinically marginal gap of 8 copings itself? There are no definite criteria in clinically acceptable marginal accuracy. McLean and von Fraunhofer[11] proposed that a successful restoration was possible if restorations could be constructed so that marginal gaps and cement films of less than 120 μm were achieved. This criterion has been cited in various

articles.[12-15] The value of 120 μm was, therefore, used as the clinically acceptable margin opening in this study. ARUM zirconia was made by ARUM DeG-5X100 Milling Machine(Doowonsangi, Seoul, South Korea) which was composed of 5-axis. ARUM DeG-5X100 Milling Machine had 5 travel distances (X-axis, Y-axis, Z-axis, A-axis, B-axis) and high precision system. ARUM DeG-5X100 Milling Machine adopted High Precision Servo Encoder Control system which had 170,000 points resolution and circular type system. Therefore in comparison with other CAD/CAM machines which had 3-axis, ARUM copings showed the best mean marginal gap.

The secondary null hypothesis was that there was no difference in the marginal distance among among 4 different prosthetic copings) in each of conventional and digital impression method. This hypothesis was accepted since marginal gap among PFM, Empress-2, Cercon®, ARUM copings in conventional impression method and iTero digital impression method was not shown significant difference(P>0.05).

The third null hypothesis was that there was no difference in the marginal distance between shoulder margin and chamfer margin in each of conventional and digital impression method. This hypothesis was accepted since marginal gap between shoulder margin and chamfer margin in the conventional impression groups and iTero digital impression was not shown significant difference(P>0.05).

Limitations of this investigations include followings. As the metal tooth and copings had a round surface, it is hard to focus a

microscope in all points. This would disturb to measure marginal gap accurately. In addition, we measured vertical distance only as a marginal gap index. Horizontal index was ignored as a marginal gap index. And the experimental conditions differed from natural oral environment. Soft tissue, saliva, tongue movement and sulcular fluid were present in natural oral environment. The waiting time before pouring affected the dimensional accuracy for stone.[16] To improve the accuracy of the optical scanner, the maximum permitted errors should be decreased with an increase in the number of sampling points.[17] Finally, this study only examined four types of coping and iTero system among various digital impression systems. More research is needed to measure various prosthetic types of coping and other digital impression systems.

V. CONCLUSIONS

Within the limits of this study, the marginal accuracy was clinically acceptable in iTero digital impression method as well as conventional impression method and also was not significantly different in 4 different types of prosthetic coping. And there was no significant difference found between shoulder margin and chamfer margin in iTero digital impression method as well as conventional impression method

REFERENCES

1. Sorensen JA. A rationale for comparison of plaque-retaining properties of crown systems. J Prosthet Dent 1989;62(3):264-9.
2. Birnbaum NS, Aaronson HB. Dental impressions using 3D digital scanners: virtual becomes reality. Compend Contin Educ Dent 2008;29(8):494, 96, 98-505.
3. Christensen GJ. Impressions are changing: deciding on conventional, digital or digital plus in-office milling. J Am Dent Assoc 2009;140(10):1301-4.
4. Christensen GJ. The state of fixed prosthodontic impressions: room for improvement. J Am Dent Assoc 2005;136(3):343-6.
5. Duret F, Preston JD. CAD/CAM imaging in dentistry. Curr Opin Dent 1991;1(2):150-4.
6. Priest G. Virtual-designed and computer-milled implant abutments. J Oral Maxillofac Surg 2005;63(9 Suppl 2):22-32.
7. Duret F, Blouin JL, Duret B. CAD-CAM in dentistry. J Am Dent Assoc 1988;117(6):715-20.
8. Gary Davidowitz PGK. The Use of CAD/CAM in Dentistry; 2011.
9. Mormann WH, Brandestini M, Lutz F, Barbakow F. Chairside computer-aided direct ceramic inlays. Quintessence Int 1989;20(5):329-39.
10. Groten M, Axmann D, Probster L, Weber H. Determination of

the minimum number of marginal gap measurements required for practical in-vitro testing. J Prosthet Dent 2000;83(1):40-9.

11. McLean J, Von Fraunhofer J. The estimation of cement film thickness by an in vivo technique. British dental journal 1971;131(3):107.

12. May KB FM, Razzoog ME. Precision of ift: The Procera AllCeram crown. J Prosthet Dent 1998;80:394-404.

13. Leong D, Chai J, Lautenschlager E, Gilbert J. Marginal fit of machine-milled titanium and cast titanium single crowns. The International journal of prosthodontics 1994;7(5):440.

14. Sulaiman F, Chai J, Jameson LM, Wozniak WT. A comparison of the marginal fit of In-Ceram, IPS Empress, and Procera crowns. The International journal of prosthodontics 1997;10(5):478.

15. Hunter A, Hunter A. Gingival margins for crowns: a review and discussion. Part II: Discrepancies and configurations. J Prosthet Dent 1990;64(6):636-42.

16. Lacy AM, Bellman T, Fukui H, Jendresen MD. Time-dependent accuracy of elastomer impression materials. Part I: Condensation silicones. J Prosthet Dent 1981;45(2):209-15.

17. Kamegawa M, Nakamura M, Fukui Y, Tsutsumi S, Hojo M. Direct 3-D morphological measurements of silicone rubber impression using micro-focus X-ray CT. Dent Mater J 2010;29(1):68-74.

TABLES

Table 1. Experimental groups in this study

Group1 (conventinal impression)	Group 1-1	PFM coping which is manufactured with conventional impression, making die, wax-up, and casting procedure.
	Group 1-2	Empress-2 coping which is manufactured with conventional impression, making die, wax-up, and casting procedure with Empress-2 ingot.
	Group 1-3	Cercon® zirconia coping which is manufactured with conventional impression, making die, and CAD-CAM procedure with Cercon® system.
	Group 1-4	ARUM coping which is manufactured with conventional impression, making die, and CAD-CAM procedure with ARUM system.
Group2 (digital impression)	Group 2-1	PFM coping which is manufactured with iTero impression, making die by CAD-CAM, wax-up, and casting procedure.
	Group 2-2	Empress-2 coping coping which is manufactured with iTero impression, making die, by CAD-CAM, wax-up, and casting procedure with Empress-2 ingot.
	Group 2-3	Cercon® zirconia coping which is manufactured with iTero impression, making die by CAD-CAM, wax-up, and CAD-CAM procedure with Cercon® system.
	Group 2-4	ARUM zirconia coping which is manufactured with iTero impression, making die by CAD-CAM, wax-up, and CAD-CAM procedure with ARUM system.

Table 2. Marginal distance of copings by conventional impression method (mean and standard deviation)

Experimental Groups	Type of prostheses	Number of measurement	Marginal distance (μm)	
			Mean	Standard deviation
Group 1-1	PFM	300	89.15	43.66
Group 1-2	Empress-2	300	77.44	33.91
Group 1-3	Cercon® zirconia	300	75.93	28.71
Group 1-4	ARUM zirconia	300	74.87	27.79

Table 3. The marginal distance of copings by digital impression method (mean and standard deviation)

Experimental Groups	Type of prostheses	Number of measurement	Marginal distance (μm)	
			Mean	Standard deviation
Group 2-1	PFM	300	90.84	35.06
Group 2-2	Empress-2	300	72.51	32.83
Group 2-3	Cercon® zirconia	300	78.94	30.58
Group 2-4	ARUM zirconia	300	62.14	29.96

Table 4. Statistical significance of marginal gap

Type of prostheses	Marginal gap(μm)		P value
	Conventional impression (Group1)	iTero impression (Group2)	
PFM	89.15 ± 43.66	90.84 ± 35.06	p>0.05
Empress-2	77.44 ± 33.91	72.51 ± 32.83	p>0.05
Cercon® zirconia	75.93 ± 28.71	78.94 ± 30.58	p>0.05
ARUM zirconia	74.87 ± 27.79	62.14 ± 29.96	p>0.05
P value	p>0.05	p>0.05	

Table 5. The marginal distance of shoulder and chamfer margin by conventional and digital impression method (mean and standard deviation)

Experimental Groups	Type of prostheses	Number of measurement	Marginal distance (μm)	
			Mean	Standard deviation
Group 1-Shoulder	All (4 types)	600	77.94	33.90
Group 1-Chamfer	All (4 types)	600	80.76	35.14
Group 2-Shoulder	All (4 types)	600	80.94	39.38
Group 2-Chamfer	All (4 types)	600	76.25	37.14

Table 6. Statistical significance of marginal gap

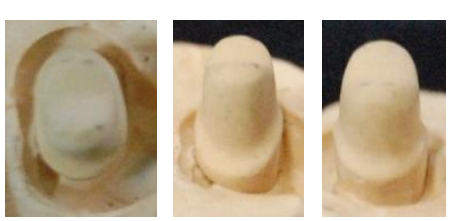
Margin	Marginal gap (μm)		P value
	Conventional impression (Group1)	iTero impression (Group2)	
Shoulder	77.94 ± 33.90	80.94 ± 39.38	p>0.05
Chamfer	80.76 ± 35.14	76.25 ± 37.14	p>0.05
P value	p>0.05	p>0.05	

FIGURES

A B C

Figure 1. A. A typodont model(occlusal surface). **B.** Buccal(shoulder margin) **C.** Lingual surface (chamfer margin)

Figure 2. Polyurethane working dies fabricated by the iTero digital impression and CAD/CAM milling system



A B C

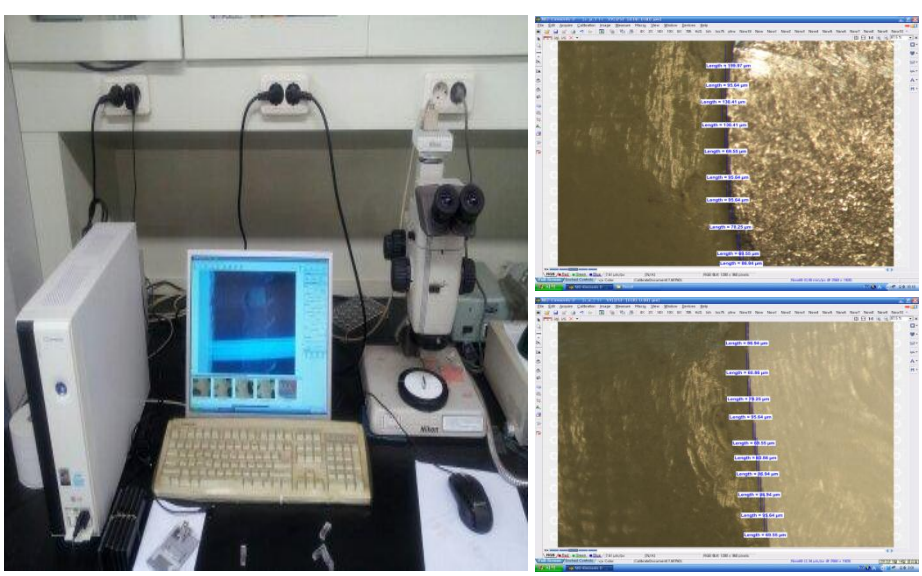
Figure 3. Stone working die fabricated by conventional impression

A. Occlusal surface **B.** Buccal surface(shoulder margin) **C.** Lingual surface(chamfer margin)

A B C D

Figure 4. 24 copings were fabricated at working die by conventional and digital impression.

A. PFM copings **B.** Empress-2 copings **C.** Cercon® copings **D.** ARUM copings



A B

Figure 5. A. Stereoscopic microscope NIS-ELEMENTS F 2.30 (Nikon, Tokyo, Japan) **B.** Images for measuring marginal distance between master model and copings

국문초록

평행 공초점 영상을 이용한 디지털 인상법의 변연 정확도에 관한 연구

서울대학교 치의학대학원

치 의 학 과

김 정 주

1. 연구목적

본 연구의 목적은 상악 제1소구치에서 기존의 인상채득법과 iTero 를 이용한 디지털 인상채득법의 변연적합도를 PFM, Empress-2, Cercon®, ARUM zirconia coping 을 이용하여 비교, 분석 해보는 것이다.

2. 연구대상 및 방법

금속으로 된 typodont의 상악 제1소구치를 협면은 shoulder margin으로 설면은 chamfer margin으로 제작하여 master model로 사용하였다. iTero system을 이용하여 3번의 인상을 떠서 polyurethane block 으로 3개의 작업모형을 제작하였다. 기존의 인상법을 이용하여 3번의 실리콘 인상을 채득하여 type IV resin-reinforced (ISO type IV) die stone (ResinRock, Whip Mix, Seoul, South Korea)으로 3개의 작업모형을 제작하였다. 각각의 작업모형에서 PFM, Empress-2, Cercon® zirconia and ARUM zirconia coping

형태로 24개의 보철물을 제작하였다. master model에 제작된 각각의 coping을 적합 시킨 상태에서 실체현미경을 이용하여 75배 배율로 확대하고 NIS-ELEMENTS F 2.20 (Nikon, Tokyo, Japan) 프로그램을 이용하여 확대된 변연부를 각 시편 당 10군데 부위(협면 5군데, 설면 5군데)를 무작위로 촬영하고, 각 이미지당 10개 포인트씩 선택하여 모형의 변연과 보철물 변연 간의 거리를 계측하였다. 총 2400점에서 계측된 데이터에서 평균값과 표준편차를 얻었고, 95% 신뢰수준에서 t-검정과 일원분산배치분석(one-way ANOVA)로 통계 처리하였다.

3. 결과

1. 기존 인상채득법에 의한 코핑의 변연간격은, PFM군 89.15±43.66㎛, Empress-2군 77.44±33.91㎛, Cercon® zirconia 군 75.93±28.71㎛, ARUM zirconia 군 74.87 ± 27.79㎛이었고, 디지털 인상채득법의 경우 PFM군 90.84±35.06㎛, Empress-2군 72.51±32.83㎛, Cercon® zirconia 군 78.94±30.58㎛, ARUM zirconia 군 62.14±29.96㎛ 이었다. 기존 인상채득법과 디지털 인상채득법 간에 유의한 차이가 없었다(P>0.05).
2. 네가지 코핑간의 변연 적합도는 기존의 인상채득법과 디지털 인상채득법 모두 유의한 차이를 보이지 않았다(P>0.05).
3. 기존 인상채득법에서 shoulder군 77.94±33.90㎛, chamfer군은 80.76±35.14㎛의 변연간격을 나타냈고, 디지털 인상 채득법의 경우 shoulder군은 80.94±39.38㎛, chamfer군은 76.25±37.14㎛의 변연간격을 보였다. 기존 인상채득법과 디지털 인상채득법 모두에서 shoulder margin과 chamfer margin간의 변연 적합도는 유의한 차이가 없었다(P>0.05).

4. 결론

기존 인상채득법과 디지털 인상채득법을 이용하여 제작한 PFM, Empress-2, Cercon® and ARUM zirconia coping의 변연적합도는 유의한 차이를 보이지 않았으며, 모두 임상적으로 받아들일만한 범주 내에 존재하였다.

주요어 ; 변연적합도, PFM, Empress-2, Cercon®, ARUM, 디지털 인상채득법, 기존 인상채득법

학번; 2009-22669