MARGINAL FITNESS OF PORCELAIN-FUSED-TO-METAL CROWN ACCORDING TO MATERIAL AND TECHNIQUE

Associate professor, Dept. of Prosthodontics, School of Dentistry, Pusan National University

Young Chan Jeon

I. INTRODUCTION

Although metal ceramic restorations have some advantages and it is continually challenged by newly developed all ceramic restorations, it is the most commonly used restoration in dentistry for a number of reasons.[1,2]

One of the biological disadvantages is greater reduction of tooth structure, and esthetic one is the light obstruction due to the presence of a metal substructure. And futhermore, one of the important mechanical disadvantages is the technique sensitive to achieve a good marginal fidelity because there is tendency of distortion of a substructure during high temperature cycling.[3,4]

Marginal adaptation is considered a paramount factor in the success and longevity of a cast restoration, and it has been considered as the most controversial subject in the metal ceramic restoration because studies of this have yielded mixed results.[5-7]

Various techniques and materials have been used to make metal ceramic restorations that can satisfy the biomechanical and esthetic requirements, based on different tooth preparation forms, different metal coping designs, and different alloys and porcelain powders.[8-11]

Several researchers[3,4,6] have noted a general trend toward poorer marginal adaptation after each successive stage in the firing schedule, and when considering metal framework distortion, studies have investigated the wrapage of the thin metal margins and the deformation of the framework body as a whole.

Studies[12-14] of the marginal distortion reported the causative factors were: the firing shrinkage of the porcelain, the interfacial stress due to the differential between the TEC(Thermal exp. coeff.) of the alloy and that of the veneere porcelain, the release of stresses resulting from casting solidification and surface grinding, the compositional difference in alloy, the changes in a microscopic structure of the form of alloy resulting from repeated firing.

Although what is clear from the literatures is lack of agreement on the actual cause of the thermal cycling distortion, most investigators[4,12,13] indicate agreement in that the thermal cycling

'본 논문은 1993년도 부산대학교 기성회 해외파견지원에 의하여 작성되었음.'

distortion of a metal coping is affected by the physical properties of alloys, and the form of a metal coping.

As many of these causes originate from the properties of materials themselves, it may be impossible to prevent distortion. However, to minimize distortion it is reasonable to determine the factor contributing most to distortion and to plan an acceptable procedure to eliminate it if possible. Other causes should be minimized if they cannot be eliminated.

Yamamoto[15] has noted the means to minimize distortion of casting as four separate factors: selection of alloy, design of framework, preheating, and the grinding technique. The shape of a metal coping is closely related to the contour of the abutment tooth. As one of the factors that may affect the marginal fit, the degree of the marginal curvature of a metal ceramic crown have not been studied enough. Faucher and Nicholls[16] have found the narrowing of the orifice labiolingually with the concomittant increase of the width mediodistally, and this had an effect on the amount of marginal opening combined in the convergence angle of the preparation.

To diminish the marginal opening caused by the incomplete seating of a crown, the structural design to augment a casting stiffness should be kept.

According to Miller's concept[8] of a buttressing shoulder, the metal coping that its degree of a marginal curvature is steep is more susceptible to distort than the metal coping that its degree of a marginal curvature is normal.

The purpose of this study were to quantify the magnitude of marginal distortion incurred during the thermo-cycling procedures, to compare the susceptibility to distortion of various alloys, and to ascertain the effect of the degree of a marginal curvature on the marginal fit of a metal ceramic crown with metal and collarless margin.

II. MATERIAL AND METHOD

An ivorine maxillary central incisor(Columbia Dentoform Corp., New York, N.Y.). was prepared in a standardized manner using a tapered round-tipped diamond bur, a flat-ended diamond bur, a football-shaped diamond bur and a hand instrument.

The ivorine tooth with a normallized marginal curvature(NMC) had a 1.3mm-wide facial shoulder, a 1.0mm-wide lingual chamfer, a 6-degree taper of axial walls, and 2mm of incisal reduction.

A handpiece-mounted milling machine was used to produce a 6-degree taper. The normal degree of a marginal curvature means that a cervical margin is placed 1mm incisally from a cemento-enamel junction of an ivorine tooth. To make 4 silver-plated working dies, four impressions were taken by polysulfide rubber base with custom trays, and silver plating was processed successively by the Yater-Tak metal plating machine.

A master die with an exaggerated marginal curvature(EMC) was created by additional reduction at the faciocervical wall of the NMC-typed ivorine tooth. The difference in the shape was the mid facial margin was placed 2mm apical to cemento-enamel junction, and was blended to the mid proxiamal margins of the firstly prepared ivorine tooth gradually. After the marginal modification of the facial shoulder, no other changes were made resulting in a preparation with the same taper, a 90-degree shoulder and a 1.1mm reduction. This modified, EMC-typed ivorine tooth was duplicated in four silver-plated dies by taking the polysulfide rubber base impression and using silver plating machine.

Pattern resin were poured into each the siver-plated impression. A total of 8 siver-plated dies(4 as NMC, 4 as EMC) were made for the fabrication of the metal ceramic crowns and the measurement of marginal fidelity.

Four measuring reference marks were recorded on each silver-plated die: Sites 1 was located 1mm apically to the mid mesial margin, site 2 was for the mid labial margin, site 3 was for the mid distal margin, and sites 4 was for the mid ligual margin.

To get uniformed wax patterns for metal copings, 3-pieced mold were made using vinylpoly siloxane impression material, plastic base, and dowel pins. With the exception of the margin, the silver-plated dies received two coats of a die spacer. After placement of each die in the mold, molten casting wax was injected into the mold by using jeweler's wax injector.

After the wax cooled, the silicone mold was separated from the die. Subsequent waxing and trimming for the uniform dimension was accomplished. 8 wax patterns were made from each silver-plated die, and a total of 64 wax patterns were made (Table I).

Table I. Classification of the specimens

Group No.	Alloy type	Marginal curvature*	Facial margin	No. of specimen
1	Olympia	NMC	METAL	8
2	Olympia	NMC	Porcelain	8
3	W-1	NMC	Metal	8
4	Rexillium III	NMC	Metal	8
5	Olympia	EMC	Metal	8
6	Olympia	EMC	Porcelain	8
7	W-1	EMC	Metal	8
8	Rexillium III	EMC	Metal	8

*NMC: Normal Marginal Curvature,
EMC: Exaggerated Marginal Curvature

The wax patterns were sprued after remargined. Three wax patterns were attached to a crucible former, and invested in vacuum-mixed phosphate investment (CeraFina, Whip-Mix Corp.). Alloys were cast with a gas-oxygen torch. Types of alloy were Olympia(52Au-39Pd), W-1(54Pd-38Ag), and Rexillium III(Ni-Cr) (Table II).

The castings were recovered by air-alumina abrasion and ultrasonically cleaned. Using a microscope, internal adjustments were made as required to fit the castings to their silver plated die, and the marginal discrepancies on the 4 predetermined measuring sites were measured.

The castings were degassed according to manufaturer's recommendations.

Each of the opaque and the body porcelain were fired twice and the glaze firing was done according to manufacturer's recommendations.

The all-porcelain margin of the collarless metal ceramic crown were fabricated with the porcelain-wax suspension by using the technique described by Prince.[17]

Measuring stages were divided into five stages(Table III), and the vertical discrepancies of the margins at the four predetermined sites were measured at ×250 magnification on a metallurgical microscope model BHMJ(Olympus Optical Co., Ltd, Tokyo, Japan).

Table II. Casting alloys and technical data

Alloys	Major components (%)	Casting temperature (°F)	Thermal exp. coefficient (10^{-6}/°C)	Yield strength (psi)	Manufacturer
Olympia	52Au, 39Pd	2,450	14.1	83,000	JF Jelenko
W-1	54Pd, 38Ag	2,420	15.2	84,300	Williams gold
Rexillium III	Ni, Cr	2,500		74,000	Jeneric/Pentron

Table III. Measuring stages of marginal discrepancy

	Metal-collared crown	Collarless crown
1st	As cast	none
2nd	After degassing	After degassing
3rd	After 2nd opaque firing	After 2nd shoulder firing
4th	After 2nd body firing	After 2nd body firing
5th	After glaze firing	After glaze firing

III. RESULTS

All castings were evaluated whether they fit their respective silver-plated dies before the porcelain firing cycling of the copings.

The mean marginal distortion for labial measurement site following degassing of the specimens that had their surfaces finished with white stone minimally were 22um in group 1(Au-Pd alloy, NMC) and 2um in group 5 (Au-Pd alloy, EMC). The mean marginal opening for the same measurement sites following glazing were decreased 1um in group 1 and 2.2um in group 5, and also showed decreasing tendency in group 4 and 5.

The mean marginal distortion for the labial measurement site following degassing showed varied results. This results mean that distortion of the casting specimens could be affected significantly by other causative factors and seating method of the casting specimen for measurement.

Ni-based casting specimens with EMC showed that marginal distortion was increased by the body porcelain firing and glazing in comparison with other alloy specimens.

The mean marginal distortion in the collarless group were decreased following body porcelain firing and glazing at the labial measurement site.

Table IV. Marginal discrepancies(㎛) of the NMC groups in Olympia specimens

Measuring stage	Measuring site	Minimum	Maximum	Mean	S.D.
As casting	Mesial	8	65	32.0	21.1
	Labial	15	76	38.0	18.2
	Distal	10	99	48.6	29.5
	Lingual	6	105	51.6	31.6
Degassing	Mesial	17	77	48.1	21.6
	Labial	15	150	60.7	45.4
	Distal	19	138	73.6	38.2
	Lingual	32	128	73.3	37.4
Opaque firing	Mesial	21	71	48.2	17.4
	Labial	28	137	64.1	37.4
	Distal	8	151	74.0	50.2
	Lingual	36	129	72.7	34.4
Body firing	Mesial	29	69	51.6	15.3
	Labial	27	137	71.8	36.7
	Distal	22	151	88.2	51.3
	Lingual	32	124	72.2	34.1
Glazing	Mesial	14	75	46.1	21.9
	Labial	34	142	70.8	35.4
	Distal	16	153	83.1	51.8
	Lingual	36	128	76.6	35.8

Table V. Marginal discrepancies(μm) of the NMC groups in W-1 specimens

Measuring stage	Measuring site	Minimum	Maximum	Mean	S.D.
As casting	Mesial	9	169	64.0	62.4
	Labial	23	137	73.2	41.9
	Distal	6	116	71.0	37.0
	Lingual	37	175	95.2	51.7
Degassing	Mesial	5	168	56.0	61.7
	Labial	34	113	66.1	27.8
	Distal	15	133	73.8	37.6
	Lingual	34	179	91.2	50.2
Opaque firing	Mesial	8	176	49.5	62.5
	Labial	30	87	57.7	20.1
	Distal	7	100	63.5	29.4
	Lingual	35	137	82.7	41.7
Body firing	Mesial	26	204	70.2	66.6
	Labial	34	94	61.1	21.2
	Distal	14	99	69.3	28.3
	Lingual	46	146	93.0	43.6
Glazing	Mesial	16	181	61.7	62.2
	Labial	23	102	61.6	23.5
	Distal	14	91	63.3	27.3
	Lingual	45	136	87.2	41.6

Table VI. Marginal discrepancies(μm) of the NMC groups in Rexillium III specimens

Measuring stage	Measuring site	Minimum	Maximum	Mean	S.D.
As casting	Mesial	12	83	46.0	25.3
	Labial	23	104	53.8	27.3
	Distal	20	105	67.8	27.9
	Lingual	4	115	61.0	33.7
Degassing	Mesial	6	74	49.2	22.1
	Labial	17	72	50.0	18.5
	Distal	30	89	67.0	22.5
	Lingual	20	110	59.8	29.2
Opaque firing	Mesial	7	71	36.8	22.2
	Labial	19	70	46.8	18.3
	Distal	24	81	63.5	19.6
	Lingual	14	102	56.3	27.9
Body firing	Mesial	16	70	49.0	19.7
	Labial	17	106	56.2	32.9
	Distal	35	96	66.6	20.6
	Lingual	31	130	66.0	33.5
Glazing	Mesial	8	78	48.3	26.5
	Labial	15	91	51.0	25.7
	Distal	16	79	59.6	20.8
	Lingual	24	104	62.6	27.9

Table VII. Marginal discrepancies(㎛) of the EMC group in Olympia specimens

Measuring stage	Measuring site	Minimum	Maximum	Mean	S.D.
As casting	Mesial	13	189	6.5	6 57.0
	Labial	15	230	60.2	70.6
	Distal	15	157	73.0	41.2
	Lingual	14	104	63.6	34.5
Degassing	Mesial	39	171	74.8	42.7
	Labial	21	224	62.2	69.5
	Distal	26	166	72.0	42.4
	Lingual	26	103	68.8	29.5
Opaque firing	Mesial	41	176	80.6	45.8
	Labial	20	218	63.3	66.3
	Distal	12	182	71.2	50.2
	Lingual	25	96	66.1	30.2
Body firing	Mesial	47	213	100.7	63.7
	Labial	25	228	68.3	67.5
	Distal	21	177	84.5	47.1
	Lingual	18	134	73.6	39.1
Glazing	Mesial	31	189	77.7	54.0
	Labial	13	213	66.1	64.5
	Distal	33	167	80.2	41.3
	Lingual	34	125	74.3	35.6

Table VIII. Marginal discrepancies(㎛) of the EMC group in W-1 specimens

Measuring stage	Measuring site	Minimum	Maximum	Mean	S.D.
As casting	Mesial	19	107	65.8	32.6
	Labial	58	193	88.2	44.3
	Distal	35	100	65.3	22.2
	Lingual	28	131	83.2	36.9
Degassing	Mesial	22	123	74.6	36.8
	Labial	70	216	101.0	49.3
	Distal	33	132	65.2	30.7
	Lingual	37	130	85.2	36.3
Opaque firing	Mesial	13	103	9.3	34.1
	Labial	67	187	102.0	47.8
	Distal	33	113	67.2	26.4
	Lingual	38	128	85.8	32.7
Body firing	Mesial	39	117	79.8	28.7
	Labial	61	214	110.0	45.0
	Distal	47	107	74.2	20.1
	Lingual	45	137	95.6	29.6
Glazing	Mesial	38	114	79.2	23.7
	Labial	68	214	107.4	44.3
	Distal	23	90	60.1	19.9
	Lingual	41	117	83.6	24.4

Table IX. Marginal discrepancies(㎛) of the EMC group in Rexillium III specimens

Measuring stage	Measuring site	Minimum	Maximum	Mean	S.D.
As casting	Mesial	78	200	128.0	45.8
	Labial	74	250	150.6	62.5
	Distal	38	151	98.0	38.7
	Lingual	63	302	155.1	70.6
Degassing	Mesial	59	178	117.5	40.2
	Labial	65	213	121.8	54.5
	Distal	30	123	75.5	30.6
	Lingual	47	322	144.7	79.3
Opaque firing	Mesial	54	177	111.8	41.2
	Labial	63	206	114.8	50.5
	Distal	35	132	71.5	35.1
	Lingual	57	311	139.3	74.3
Body firing	Mesial	77	250	153.0	65.5
	Labial	87	307	160.0	70.4
	Distal	48	216	110.2	60.9
	Lingual	54	323	171.3	80.1
Glazing	Mesial	48	263	139.8	77.6
	Labial	80	277	139.1	69.2
	Distal	48	185	97.2	49.4
	Lingual	53	312	163.2	76.5

Table X. ANOVA comparision of the marginal fit in ceramometal crowns

Source	df	Sum of squres	F Value	Pr>F
Curvature	1	235689.337500	113.15	0.0001
Alloy	2	99562.089585	23.90	0.0001
Stage	4	24650.995833	2.96	0.0191
Site	3	39578.570833	6.33	0.0003

Significant comparison of $p < 0.05$

Table XI. Duncan's multiple range test for variable of marginal curvature

Grouping	Curvature	N	Mean(㎛)
A	EMC	480	94.271
B	NMC	480	62.933

$p < 0.05$

Table XII. Duncan's multiple range test for variable of alloy

Grouping	Alloy	N	Mean
A	Rexillium III	320	92.019
B	W-1	320	76.428
C	Olympus	320	67.359

$p < 0.05$

Statistical evaluation by analysis of variance and multiple comparison testing(Duncan's test) was completed to determine if there were significant differences within or between the experimental groups or measurement sites or measurement stages.

Table XIII. Duncan's multiple range test for variable of measuring stage

Grouping	Stage	N	Mean
A	Body firing	192	87.401
A, B	Glazing	192	80.901
B	Degassing	192	76.365
B	As casting	192	75.016
B	Opaque firing	192	73.328

$p < 0.05$

Table XIV. Duncan's multiple range test for variable of measuring site

Grouping	Site	N	Mean
A	Lingual	240	88.525
B	Labial	240	80.008
B	Distal	240	73.321
B	Mesial	240	72.554

$p < 0.05$

Table XV. MANOVA results for interaction between variables

Source§	DF	Type I SS	F value	Pr>F
A	1	235689.337	129.16	0.0001
B	2	99562.089	27.28	0.0001
C	4	24650.995	3.38	0.0094
D	3	39578.570	7.23	0.0001
A*B	2	200831.756	55.03	0.0001
A*C	4	6008.745	0.82	0.5104
A*D	3	47372.004	8.65	0.0001
B*C	8	17986.941	1.23	0.2767
B*C	6	35545.385	3.25	0.0037
C*D	12	1178.304	0.05	1.0000

§ : A;curvature, B;alloys, C;measuring stages, D;measuring sites

VI. DISCUSSION

The precision of marginal seal is paramount in a dental restoration, whether to satisfy biologic, physical, or cosmetic requirements. Nevertheless, cosmetic demands of the patient often, if not always, results in a compromised margin to eliminate or mask the metal collar. Various techniques[5,11,18,19] have been used to make ceramometal restorations based on different metal coping designs such as metal collar, collarless and facial-butted porcelain. Likewise, different tooth preparation designs are advocated, and to complicate matters even more, many different ceramometal alloys are in use.[16,20]

Metal coping of ceramometal crown have a poorer intraoral fit after the degassing procedure and application of porcelain compared to the initial fit of the casting.[20,21] When considering metal framework distortion in the ceramometal fixed partial dentures, two separate aspects prevail. Warpage of the thin metal margins and deformation of the framework body as a whole are they.[2,3] To single ceramometal crown, warpage of thin labial margins has been investigated studied after each successive stage in the firing schedule. And several suggestons[3,4,14,22] have been proposed in the scientific literatures to explain the distortion.

Shillingburg et al.[12] and Faucher and Nicholls[16] showed that the marginal fit after various firing cycles was dependent on the design of the margin. They found that shoulder finish lines with or without a bevel produced less distortion in labial margins compared with chamfered margins, Shillingburg et al.[12] advoated a shoulder-bevel preparation, and, regarding the metal coping design, they showed that the noble alloys require a certain amount of bulk in the cervical area to resist distortion when subjected to the repeated firing cycles of porcelain.

Hamaguchi et al.[2] could not find significant distortion of the facial margin on any of the four margin designs after porcelain application. Fisher et al[23] Buchanan et al.[13] showed that marginal fit was affected by the alloy, and the amount of marginal discrepancy was found to be more pronounced in the nonprecious alloys. The difference between precious and nonprecious alloys was thought to be thr result of the thickness of the oxide layer that formed on the inside of the nonprecious castings during the various firing stages.

But this finding may be affected by the thickness of the die spacer applied on the die surface and tapered angle of the prepared axial wall. Lesser application of die spacer and steep inclination of the axial wall may affect ed by the oxide layer of the inner surface of the coping.

Most researchers[4,12,14,24] noted a general trend toward poorer marginal adaptation after each firing procedure, and Shaffner[25] concluded that this distortion was not clinically significant. But, studies[3,22,23,26,27] of marginal distortion associated firing porcelain-fused-to-metal restorations have yielded mixed results.

Morris[28] reported the effect of the porcelain firing cycle on the physical properties of the metal ceramic alloys. Seven alloys were used, Au-Pd, Pd-based, and nickel-based. After heat treating, the Au-Pd alloy became harder, stronger, and had greater elongation. The Pd-based alloys produced various results, with decreasing hardness and increasing elongation. The nickel-based alloys showed a decrease in hardness and an increase in elongation. The modulus of elasticity for any of the alloys was not significantlyy affected.

Buchanan et al.[13] also demonstrated that marginal distortion was markedly greater after degassing when the copings were made from nonprecious metals. They postulated that the formation of an oxide layer on the inner surface of the coping could have caused the increased marginal opening. If the oxide were the principal cause of marginal distortion and the propensity for for nonprecious alloys to form oxides at high temperature is acknowledged, the physical properties of these metals requires further investigation.

Nitkin and Asgar[27] ranked the marginal fit of nonprecious metal copings as inferior to precious or semiprecious castings when same technique was used. Buchanan et al.[13] found that the marginal opening changed more in the specimen made from the higher strength metal than it did in those made from lower strength metal. But Strating et al.[26] showed that a nickel-chromium alloy can be cast as accurately as presious or semi-precious alloys, and metal distortion, at least on a marginal level, is not a significant factor between alloys if a single unit of 0.4mm thickness is used.

The alteration after porcelain firing in fit may be due to porcelain contamination of the internal surface, or to distortion of metal framework. Distortion in a fixed partial denture framework is reparesented by an increased space between the restoration and the prepared tooth, and this space provides a niche for bacterial plaque which may lead caries and gingival inflammation. When considering metal framework distortion, two separate areas of investigation prevail-warpage of the thin metal margins and deformation of the framework body as a whole.[3]

It is imperative to distinguish between incomplete seating of castings that id due to contamination and that due to the marginal distortion. It is not known whether deterioration in marginal integrity is a result of thin metal margins or changes in the framework body.

4 methods for measuring marginal fidelity were showed.[29] Direct view is often used to monitor stepwise distortion by virtue of its nondestructive nature. To monitor the distortion of metal ceramic restoration margins during various steps of the firing cycle requires the repeatable manner on a measuring stages. Cooney et al.[30]made resin replicas formed in the impression for SEM measurement of marginal gaps. Fauchers and Nicholls[16] followed marginaldistortion during porcelain firing steps bu replacing the casting in a jig and measured with a profile projector. The direct view method is convenient, easy because the crown is retrievable, unlike the cementation, embedment, and sectioning method which causes destruction of the crown. However repeated seating the specimen crowns on a master die can damage the marginal abrasion. In this study, each silver-plated master die was made for fabrication and measurement for each group. Researcher could feel the silver-plated die was abraded as number of reseating specimen was increased. Silver-plated die is more resistant to abrasion but it is not sufficient to get accurate data. And holding force and direction of a specimen in the holding device on the travelling stage of microscope was not sured whether the force was consistent throughout whole measuring stages. This study used spring-loaded device which was specially designed for this study, but few researcher remarked for this problem. Disadvantages of direct view were that it is difficult to determine what point to measure with a rounded margin, and it is less presision due to inaccuracies in repositioning crowns on master die, and it is difficult to assess overcontouring of margin.

A scientific method for measurement of crown margin discrepancy should be consistent, reproducible, and have stadardized points of measurement. Consistent points of measurementare necessry for an impartial comparisonof different crown systems. In this study, consistent measuring points were made by needle under microscope. These four referential points per each master die were too small to distinguish under naked eyes.

Actually for consistency of measurement and a realistic evaluation of the marginal gap, the crown-die complex should be sectioned and viewed in cross-section. This view produces a more reliable assessment of the actual surface of marginal opening for plaque habitation.

V. SUMMARY

Thermal cycling distortion in ceramometal alloy coping for maxillary central incisor was measured. Three types of ceramometal alloy(Au-Pd, Pd-based, Ni-based) were used and two types of marginal curvature that were normar marginal curvature and exaggerated marginal curvature were designed.

Test specimens were divided into 8 groups and each group had 8 specimens. Sixty four ceramometal crowns were made totally.

Measurement stages were following degassing, opaquing, body porcelain firing, and glazing, and digital, travelling measuring microscope (0.5 um precision, Olympus, Japan) was used under ×250 magnification.

Within the limitation of this investigation, it was concluded as belows:

1. The pattern of marginal distortion was varied. Degassing stage was not a specific, causative stage that induce most of total marginal distortion during whole procedure fabricating a ceramometal crown. Body firing stage induced discrepancy relatively more than other firing stages.
2. The specimens that were Ni-based alloy

and had EMC were distorted persistently following successive fabricating procedures. But marginal openings were decreased after glazing.

3. The release of metal grinding-induced stress was presumed as a cause that induce marginal distortion.
4. The amount of discrepancies of the labial and lingual margins were greater than that of the mesial and distal margin in the specimen that had EMC.
5. Silver-plated die was not enough to resist abrasion during repeated seating of metal copings on the die-holding device.

REFERENCES

1. Participants of CSP No 147/242 and Morris HF, Quantitative and qualitative evaluation of the marginal fit of cast ceramics, porcelain-shoulder, and cast metal full crown margins. J Prosthet Dent 1982;67:198.
2. Hamaguchi H, Cacciatore A, Tueller VM, Marginal distortion of porcelain -fused-to-metal crown: An SEM study. J Prosthet Dent 1982;47:146.
3. Bridger DV, Nicholls JI, Distortion of ceramometal fixed partial dentures during the firing cycle. J Prosthet Dent 1981:45:507.
4. Cambell SD, Pelleiter LB, Thermal cycling distortion of metal ceramics :Part II Etiology. J Prosthet Dent 1982;68:284.
5. Richter-Snap K, Aquilino SAA, Svare CW, Turner KA, Change in marginal fit as a related to margin design, alloy type, and porcelain proximity in porcelain-fused-to-metal restorations. J Prosthet Dent. 1988:60:435.
6. Hunter AJ, Hunter AR, Gingival margins for crowns: A review and discusion. Part II:Discrepancies and configurations. J Prosthet Dent 1990;64:636.
7. Preston JD, Berger R, Some laboratory variables affecting ceramo-metal alloys. Dent Clin Nor Am 1977;21:717.
8. Miller L.L., Framework design in ceramo-metal restorations. Dent Clinic Nor Am 1977;21:699.
9. Prince J, Donovan T, The esthetic metal-ceramic margin: A comparison of techniques. J Prosthet Dent 1983;50:185.
10. Balles DM, Cronin RJ, Duke ES, Effect of metal design and technique on the marginal characteristics of the collarless metal ceramic restoration. J Prosthet Dent 1991; 65:611.
11. Boyle JJ, Naylor WP, Blackman RB, Marginal accuracy of metal ceramic restorations with porcelain facial margins. J Preosthet Dent. 1993;69:19.
12. Shillingburg HT, Hobo S, Fisher DW, Preparation design and margin distortion in porcelain-fused-to-metal restorations. J Prosthet Dent 1973;29:276.
13. Buchanan WT, Svare CW, Turner KA. The effect of repeated firings and strength on marginal distortion in two ceramometal systems. J Prosthet Dent. 1981;45:502.
14. DeHoff PH, Anusavice KJ, Effect of metal design on marginal distortion of metal-ceramic crowns. J Dent Res 1984;63:1327.
15. Yamamoto M, Metal-Ceramics. Quinte. Pub. Co. 1985;206-18.
16. Faucher RR, Nicholls JI, Distortion related to margin in porcelain- fused-to-metal restorations. J Prosthet Dent 1980;43:149.
17. Prince J, Donovan TE, Presswood RG, The all-porcelain labial margin for ceramometal restorations: A new concept. J Prosthet Dent 1983;50 :793.
18. Schwartz IS, A review of methods and techniques to improve the fit of cast restorations. J Prosthet Dent 1986;56:279.
19. Lomanto A, Weiner S, A comparative study

of ceramic crown margins constructed using defferent techniques. J Prosthet Dent 1992:67:773.

20. Phillips RW, Jendresen MD, Klooster J, McNeil C, Preston JD, Schallhorn RG, Report of the committee on scientific investigation of the American Academy of Restorative Dentistry. J Prosthet Dent. 1990;64:74.
21. Hunter AJ, Hunter AR, Gingival crown margin configurations: A review and discussion. Part I:Terminology and widths. J Prosthet. Dent 1990;64:548.
22. Rensburg FV, Strating H, Evaluation of the marginal integrity of ceramometal restorations:Part II. J Prosthet Dent 1984;52:210.
23. Duncan DJ, Casting accuracy of nickel-chromium alloys: Marginal discrepacies. J Dent Res. 1980;59:1164.
24. Silver MG, Howard MC, An evaluation and comparison of porcelain fused to cast metals. J Prosthet Dent 1960:10:1055.
25. Shaffner VB, Porcelain-fused-to-metal restoration. The effect of the firing schedule on the shoulder and chamfer-type restorations. MSD Thesis, Indiana University School of Dentistry, 1972.
26. Strating H, Pameijer H, Gildenhuys G, Evaluation of the marginal fidelity of ceramometal restorations: Part I J Prosthet Dent 1981;46:59.
27. 113. Nitkin DA, Asgar K, Evaluation of alternative alloys to type III gold for use in fixed prosthodontics. J Am Dent Assoc. 1976;93:622.
28. Morris HF, Veterans Administration Cooperative Studies Project No.147.:A five-year report. J Prosthet Dent 1989;61:160-9.
29. Sorensen JA, A standardized method for determination of crown margin fidelity. J Prosthet Dent. 1990;64:18.
30. Cooney JP, Richter WA, MacEntee MI, Evaluation of ceramic margins for metal-ceramic restorations. J Prosthet Dent 1985;54:1.

ABSTRACT

MARGINAL FITNESS OF PORCELAIN-FUSED-TO-METAL CROWN ACCORDING TO MATERIAL AND TECHNIQUE

Young Chan Jeon

Associate professor, Dept. of Prosthodontics, School of Dentistry, Pusan National University

This stusy was to investigate the marginal fitness of porcelain-fused-to- metal crown after succesive firing cycle. Main variables were the degree of marginal curvature of labiocervical margin and the type of alloy.

The exaggerated marginal curvature(EMC) was created by additional reduction at the faciocervical wall of the normallized marginal curvature (NMC)-typed ivorine tooth by using milling machine. The difference in the shape was the mid facial margin was placed 2mm apical to cemento- enamel junction in labial surface.

Three types of alloy were high noble, noble, and base metal alloy.

Test specimens were divided into 8 groups and each group had 8 specimens. Sixty four ceramometal crowns were made totally.

Measurement stages were following degassing, opaquing, body porcelain firing, and glazing, and measuring sites were 4.(midmesial, midfacial, middistal, and midlingual). Digital, travelling measuring microscope (0.5 um precision, Olympus, Japan) was used under ×250 magnification.

Within the limitation of this investigation, it was concluded as belows:

1. The pattern of marginal distortion was varied. Degassing stage was not a specific, causative stage that induce most of total marginal distortion during whole procedure fabricating a ceramometal crown. Body firing stage induced discrepancy relatively more than other firing stages.
2. The specimens that were Ni-based alloy and had EMC were distorted persistently following successive fabricating procedures. But marginal openings were decreased after glazing.
3. The release of metal grinding-induced stress was presumed as a cause that induce marginal distortion.
4. The amount of discrepancies of the labial and lingual margins were greater than that of the mesial and distal margin in the specimen that had EMC.
5. Silver-plated die was not enough to resist abrasion during repeated seating of metal copings on the die-holding device.