MARGINAL FIT RELATED TO MARGIN TYPES OF GLASS INFILTRATED ALUMINA CORE FABRICATED FROM AQUEOUS-BASED ALUMINA TAPE

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Statement of problem. In-Ceram system is one of the all-ceramic crowns that can be used in anterior 3 unit fixed partial dentures and posterior single crowns. The alumina core used in In-Ceram system is manufactured using slip-casting technique. The slip-casting technique is difficult and technique sensitive. To improve this problem, tape-casting method was introduced into dentistry. There were no studies to examine the effect of margin design on the margin fitness of all-ceramic crowns fabricated from alumina tape.

Purpose. The purpose of this study was to compare the marginal fitness of glass infiltrated alumina core fabricated from aqueous-based alumina tape according to different margin types (90°, 110°, 135° shoulder margin).

Material and method. Three upper central resin incisors were prepared with 90°, 110° and 135° shoulder margins for all-ceramic crowns, respectively. The resin teeth were duplicated and master die and special plaster die were made as usual. After alumina cores were fabricated from aqueous-based alumina tape, cores were cemented to each 15 epoxy dies replicated from three resin teeth with resin cement. These cemented cores were embedded in epoxy resin. Specimens were cut mesiodistally and buccolingually. Marginal gap and discrepancy were measured under microscope.

Results. The marginal gap and discrepancy of 90° marginal angle was 75.1μm, 86.6μm, 110° marginal angle was 41.5μm, 50.7μm and 135° marginal angle was 51.7μm, 54.2μm, respectively. The smallest value was seen in 110 (angle, which was statistically significant compared to that of 90° angle ($p<0.05$).

Conclusion. Marginal fitness of alumina cores made of alumina tape with 110° shoulder margin was best and others were clinically acceptable.

Key Words

Alumina tape, All-ceramic crown, Marginal fitness, Margin type

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Esthetics in dentistry is not auxiliary but essential demand to both patients and clinicians. In the past, on introduction of metal-ceramic restoration, it has taken a considerable proportion of all full veneer restoration and still is one of the most commonly used restoration materials. Despite the extensive application of ceramometal restorations, the metal coping underneath the ceramic layer limits the translucency and excessive reflectivity produce insufficient esthetics. To overcome these problems, various studies on all-ceramic restoration are in progress.

The materials used in all-ceramic crowns today are: In-Ceram, IPS Empress, OPC, etc. Of these, IPS Empress employs lost-wax technique and heat-pressed technique. High heat pressed leucite-reinforced ceramic can reproduce accurate morphology and realistic shade can be produced through staining and layering. The flexural strength, however, is 160~180 MPa, which is suitable for anterior single tooth restoration but not sufficient for fixed partial dentures.[1]

After the development of IPS Empress, Schweiger[2] and Ivoclar developed IPS Empress 2 (Ivoclar, Schaan, Liechtenstein) with improvement in strength. The newly developed IPS Empress 2 had different chemical component and crystal from the previous IPS Empress. Flexural strength of IPS Empress 2 is 350~450 MPa, making it possible for 3-unit anterior fixed partial dentures.[3,4]

The Recently introduced Procera Allceram (Nobel Biocare A B & Sandvik, Hard Material, Malmo, Sweden) has increased the strength and translucency through HIP (Hot Isostatic Press) process. This Procera system utilizes the CAD-CAM for producing copings. Wagner and Chu[5] et al. reported that the strength of Allceram, In-Ceram, and IPS Empress were 687 MPa, 352 MPa, and 134 MPa, respectively. Although the Procera system has excellent strength, special equipments for core fabrication are needed.

As a method for fabricating high strength all-ceramic core, slip-casting technique[6] was introduced by Mickael Sadoun in 1985. The cores made from this technique has the strength above 300 MPa[7], which can be used in anterior fixed partial dentures or posterior single crown.[8] In 1989, Vita company of German developed In-Ceram system (Vita Zähnfabrik, Bad Sackingen, German) containing above 78% alumina particle size of 2~5㎛ using slip casting technique. The slip casting technique uses slurry, a mixture of alumina powder and liquid, which is placed on a special plaster-working die with a brush. The liquid from slurry placed on the die is absorbed and core is produced. After glass infiltration of porous core,[9-12] the flexural strength increases to 320~600 MPa[13-15]. This system can be applied to anterior fixed partial dentures and posterior crowns.[15-17]

Despite the excellent mechanical properties compared with traditional dental porcelains, manufacturing process of alumina core by slip-casting technique is somewhat troublesome and time consuming in achieving a uniform core thickness, requiring a skilled technician.[16]

In 1998, Oh et al.[18] investigated marginal fit of all-ceramic crowns fabricated from alumina tape and In-Ceram. Alumina tape is manufactured through Dr. Blade Casting method. This casting method is a process used widely to form thin and flat ceramic sheets mainly in the electronic industry.[19,20] Microscopic ceramic powder is mixed with a solvent, dispersed with a binder that combines inorganic filler and plasticizer to increase flexibility. This produces a slurry state mixture which is laid on a moving film tray at an uniform thickness. The solvent will evaporate leaving alumina tape. The tape-casting has traditionally been performed using non-aqueous organic solvents such as alcohol and ketone, to ensure the dispersion of alumina powder and dissolution of organic components such as dispersant, binders and plasticizers. The main concern regarding using the non-aqueous solvent is health and environmental risks.[21] In 1999, Lee et al.[22] introduced a method to resolve the above risks, an aqueous-based tape-casting process.

The purpose of this study was to compare the marginal fitness of glass infiltrated alumina core fabricated from aqueous-based alumina tape according to different margin types (90°, 110° and 135° shoulder).

MATERIALS AND METHOD

2.1. Material

2.1.1. Alumina tape fabrication

The alumina powder used in this experiment was an AL-M43 (Sumitomo, Tokyo, Japan) with a diameter of 3㎛ and used distilled water as the solvent. Added adhesive, dispersant, plasticizer to make alumina slurry,[23] utilizing the automatic Dr. Blade model (DP-150 of Japan Jin ChungjungGi manufacturer), fabricated tape with thickness of 0.5㎜.

2.2. Method

2.2.1. Tooth preparation

Three upper central resin incisors were prepared (Trimunt Corporation, Kyoto, Japan) with 90°, 110°, 135° shoulder margin for all-ceramic crown, separately. The incisal surface was reduced 1.8㎜, labial 1.2~1.5㎜ and the lingual 0.8~1.0㎜ with 10° convergence. Each side of tooth and angles were finished smooth and round.

2.2.2. Die fabrication

After covering the prepared tooth with paraffin sheet wax, individual impression trays were made with tray resins (Instant Tray Mix, Lang Dental MFG. CO., INC., Wheeling, IL., U.S.A.). Impression adhesives were applied to each trays followed by impression taking with vinyl polysiloxane (Exaflex light body type, GC America Inc. Chicago, IL., U.S.A.). Impressions of Individual tooth model were taken 15 times each and epoxy resin (Caldofix kit, Streurs A/S, Denmark) was poured to make 15 dies per tooth. Impressions of these 45 epoxy resin dies were taken with vinyl polysiloxane impression material as above and improved stone (Fujirock, GC Corporation, Tokyo, Japan) were poured, attaining 45 stone dies. After applying die spacer (Nice Fit, Shofu Inc., Kyoto, Japan) 3 times, the stone dies were again replicated with the special plaster supplied by the Vita Company for the In-Ceram system to form working dies.

2.2.3. Core fabrication and setting

Cores were made of alumina tape to each and every dies of the three different groups. First, having cut the alumina tapes into appropriate sizes, were seated on the dried special plaster dies and wrapped. These were placed in a preheated in a silicone oil bath to 80℃ for 10 minutes and warm isostatic press for 5 minutes under 25 MPa. With the help of a microscope (Stemi 2000, Zeiss, Germany), the margins were trimmed using a wax carver. The cores were sintered in the furnace, the temperature was increased 1℃ per minute until 500℃ and then 9℃ per minute to 1100℃. The cores were retained at the temperature for 2 hours, cooled afterwards. Sintered cores were placed on the improved stone dies to make needed corrections. Glass infiltration was done as instructed by the manufacturer.

Glass infiltrated cores were cleansed with steam and were set with Panavia (Kuraray Co., Osaka, Japan) on the epoxy resin dies. Remnants of cements were removed with dental explorers as in clinical situations.

2.2.4. Specimen fabrication

The cemented cores on the tooth models were embedded in epoxy resins. Then the core blocks were sectioned at 1㎜ away from the middle buccolingually and mesiodistally. The reason for this was to preserve the actual middle surface from being lost during the sectioning.

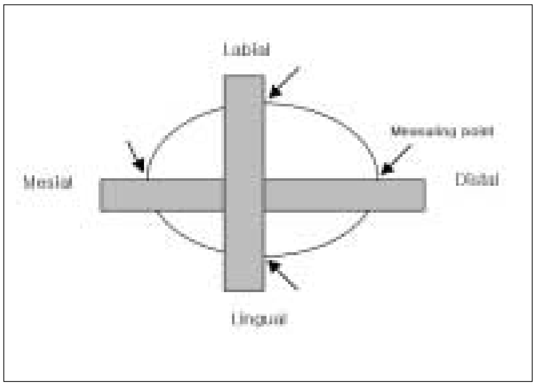
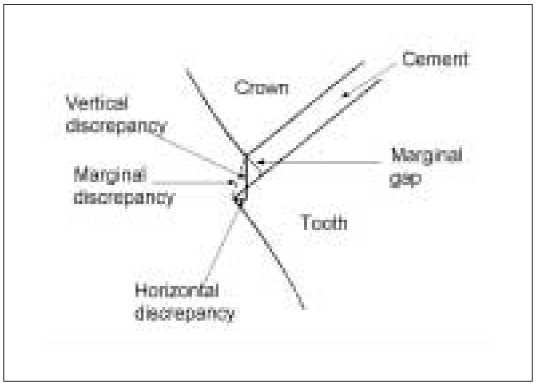


Fig. 1. Incisal view of core: Labiolingual and mesiodistal sectioning line

2.2.5. Measurement and Analysis

The cut surfaces of the specimens were polished to 1㎛ and cemented crowns were examined. Marginal gaps and discrepancies were measured at the centers of the buccal, lingual, mesial, and distal surfaces under 180 magnifications with KanScope (Sometech Vision, Korea).

The retained measurements were analyzed with Tukey's Studentized Range Test for marginal gaps and marginal discrepancies of each specimen.



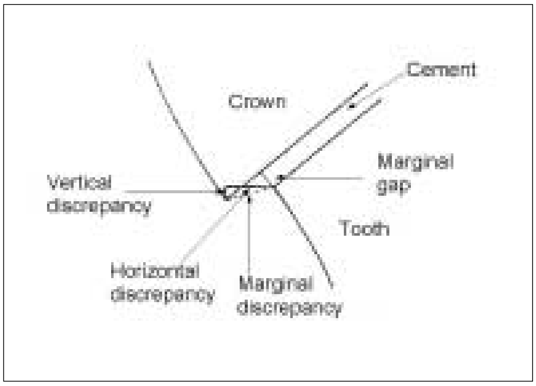


Fig. 2. Diagram of marginal gap and discrepancy

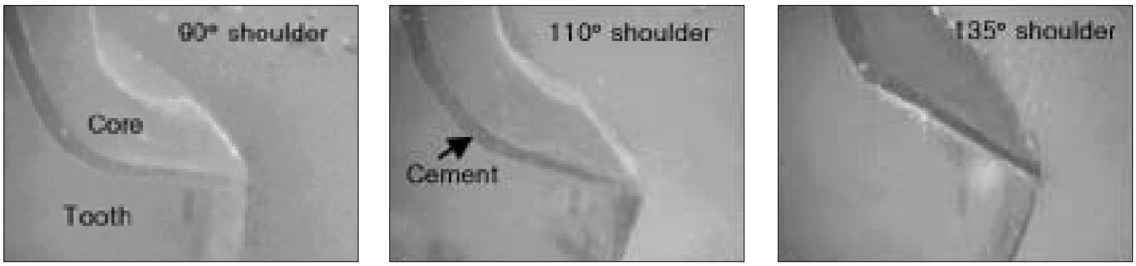


Fig. 3. Photographs of sectioned specimen (x180)

Table Ⅰ. Means of marginal gaps at the center of labial, lingual, mesial, and distal surface (㎛)

Group	Means of Marginal gap	S.D	Min	Max	Significant Difference
1(90°)	75.1	33.1	13.1	153.8	A
2(110°)	41.5	22.9	10.0	123.7	B
3(135°)	51.7	30.0	6.8	140.5	B

Table Ⅱ. Means of marginal discrepancy (㎛)

Group	Means of marginal discrepancy	S.D	Min	Max	Significant Difference
1(90°)	86.6	37.5	10.5	176.5	A
2(110°)	50.7	27.5	14.1	128.0	B
3(135°)	54.2	27.3	14.3	130.2	B

*Stastical signification: A-B, no stastical signification: B-B

RESULTS

The marginal fits of alumina cores made of alumina tapes showed the least marginal gap of 41.5㎛ in the 110° shoulder margin, and increasing with 135°, 90° shoulder margin (Table I).

The marginal discrepancy of specimens at the incisal from buccal, lingual, mesial, and distal aspect were increased in order of 110°, 135°, 90° (Table II).

DISCUSSION

In recent years the fabrication of all-ceramic restorations has improved and the application in practice has become successful due to newly introduced ceramic system and technique.

This newly introduced alumina tape has flexure strength of 498 MPa[22] that is in comparison with the In-Ceram at 320~600 MPa.[13-15]

Among the terminologies used in Fig. 2, vertical discrepancy is related to seating of restoration, horizontal discrepancy refers to overcontour and undercontour of the restoration and both discrepancies are related to plaque deposition. Marginal discrepancy has the combined meaning of vertical and horizontal discrepancy. Marginal gap is closely related to cement dissolution.[24]

Means of marginal gaps were 75.1㎛ in group 1(90°), 41.5㎛ in group 2(110°), 51.7㎛ in group 3(135°), increasing in the order of 110°, 135°, 90°. Marginal gaps of group 1 to both groups 2 and 3 were statistically significant ($p<0.05$).

Means of marginal discrepancy were 86.6㎛, 50.7㎛, 54.2㎛ in groups 1, 2 and 3 respectively, with its increasing order of group 2, 3 and 1. Group 1 to groups 2 and 3 were statistically significant and group 2 and 3 were not significant ($p<0.05$).

The measurements were higher than the values of Sorensen[25,26]; 24㎛(marginal gap of In-Ceram), Rinke[27]; 32.5μm. In 1993, Grey et al.[28] compared the film thickness of metal-ceramic restoration, aluminous porcelain, and glass infiltrated alumina core. The measurements being 95μm, 154μm, and 123μm, respectively. Shearer et al.[29] reported that marginal gap of In-Ceram is 19μm in 1996. In ADA specification, the film thickness should be below 25μm.[30]

Generally practitioners try to achieve definite shoulder margins for proper margin and strength.[31] The reason for this is because shoulder margins resist against vertical stress well and to gain enough margin thickness. Derand[32] advocated shoulder margins with angles higher than 90° is prone to fracture. A sharp internal line angle induces stress concentration and is hard to reproduce. Thus the internal line angle has to be rounded.[33-36] Baldwin Park and Calif et al.[37] suggested rounded shoulders to increase adaptation of oxide-alumina slip in In-Ceram.

In this study, marginal gap and discrepancy of 110° and 135° were smaller than 90°, and were statistically significant. Alumina tape adapts to the die in 110° and 135° shoulder margins better than 90°. The cause of higher outcomes in 135° shoulder margins is presumed to be easy fractures that occurred at the thin margins thickness during trimming and fabrication processes such as glass infiltration.

Though the results of this study had a little greater measurements than the results of Oh et al. in 1998[18]: marginal gap of 90°, 44.4μm and 135°, 40.2μm, they were clinically acceptable. So, by substituting aqueous solvents for non aqueous solvents, environmental hormone and carcinogenic factor releasing ketone, toluene, and etc. can be reduced.

SUMMARY

Marginal fit according to different margin preparation showed marginal gap to be 75.1μm in 90° shoulder, 41.5μm for 110°, 51.7μm for 135°, increasing in the order of 110°, 135°, 90°. The marginal discrepancies of 90°, 110° and 135° margin were 86.6μm, 50.7μm and 54.2μm, respectively. Also the 110° discrepancy being the smallest value, statistically significant compared to 90° ($p<0.05$).

The alumina tapes fabricated in aqueous method have marginal fitness that is not inferior to the non-aqueous method and is not so different from In-Ceram system referring to the possibility of clinical application.

On reviewing the results of this study, marginal fitness should be better in angles larger than 90°. The 135° shoulder failed to be the appropriate margin because of its low fracture resistance, making the 110° preparation margin the most appropriate angle. The 90° shoulder margin is never the less inferior to be used in practice.

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