CLASSIC ARTICLE

The effect of various finish line preparations on the marginal seal and occlusal seat of full crown preparations

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The full veneer crown is one of the most important restorations in the armamentarium of the restorative dentist. The restoration can restore severely deteriorated teeth. One problem recognized by clinicians is that the cementing medium may prevent the seating of the full crown, positioning it in hyperocclusion and causing inadequately sealed margins. Investigators report the film thickness of cement along the axial walls of the preparation influences the seating of the restoration. The factors of cementation pressure,[1-3] duration of cementation,[2,3] powder/liquid ratio of the cement,[2,4-6] preparation dimensions,[1,2,4] type of cement,[6,7] occlusal perforations,[1,2] die spacers,[7] and relief of the internal crown surface[4,8] have been related to the film thickness. One study related the type of finish line of the preparation to the film thickness. Fusayama et al[3] cemented cast full crowns onto extracted teeth prepared with the 90-degree shoulder, the 45-degree shoulder, and featheredge margins. They reported that the featheredge margin provided the best sealing effect followed by the 45-degree shoulder and 90-degree shoulder, respectively. In an earlier study, Fusayama et al[9] found that, even without cement, crowns fail to seat completely owing to the numerous variables associated with the casting process.

Teteruck and Mumford[10] also reported similiar findings while comparing castings made with various gold alloys and investments. All investigations in which patterns were waxed and cast and the castings returned to the original dies were affected by the casting variables. In an effort to eliminate the casting error, McCune[6] fabricated castings on the Bureau of Standards' die and then poured improved dental stone directly into the castings to form the dies.

The purpose of this study was to correlate margin design with the seating and sealing of cemented full cast crowns under standardized, simulated clinical conditions.

METHODS AND MATERIAL

Eight stainless steel dies were machined to produce a crown preparation similar in volumetric size to an average molar. Seven dies were 10 mm in diameter and the eighth was 8 mm in diameter at the finishing lines. Each die measured 6 mm from the occlusal surface to the end of the preparation, and each had a 5-degree taper of the axial walls with a convergence angle of 10 degrees. Two dies had featheredge finish lines, one 8 mm in diameter and the other 10 mm. The other margin designs were: a 1 mm 90-degree shoulder; a 45-degree shoulder; a 90-degree shoulder and a chamfer with bevels 1 mm long parallel to the axial walls; a 1 mm 90-degree shoulder with a 45-degree bevel; and a 1 mm 90-degree shoulder with a 30-degree bevel (Fig. 1).

Five crowns were fabricated from each die. The crowns were waxed on the steel dies, invested (Beauty Cast; Whip Mix Corp, Louisville, Ky), and cast (Firmilay; J. F. Jelenko, New Rochelle, NY) in type III gold (Fig. 2). Because of the casting variables reported in previous studies,[9,10] a method similar to that described by McCune[6] was used to fabricate dies directly into the castings. After the castings were pickled and the sprues removed, the castings were boxed with masking tape. The castings were lubricated with a fluorocarbon dry release agent (Crown Industrial Products Co, Hebron, Ill) and a measured volume of methyl methacrylate (Duralay; Reliance Dental Mfg. Co, Chicago, Ill) was vibrated into the castings to make direct dies. Twenty-four hours later, the dies were undercut below the finish line to facilitate measurements and indexed to aid proper repositioning at cementation (Fig. 3).

The crowns were cemented onto the Duralay dies with an Instron testing machine (Instron Corp, Canton, Mass) (Fig. 4, *A*). An orange wood stick was placed between the compression head of the testing machine

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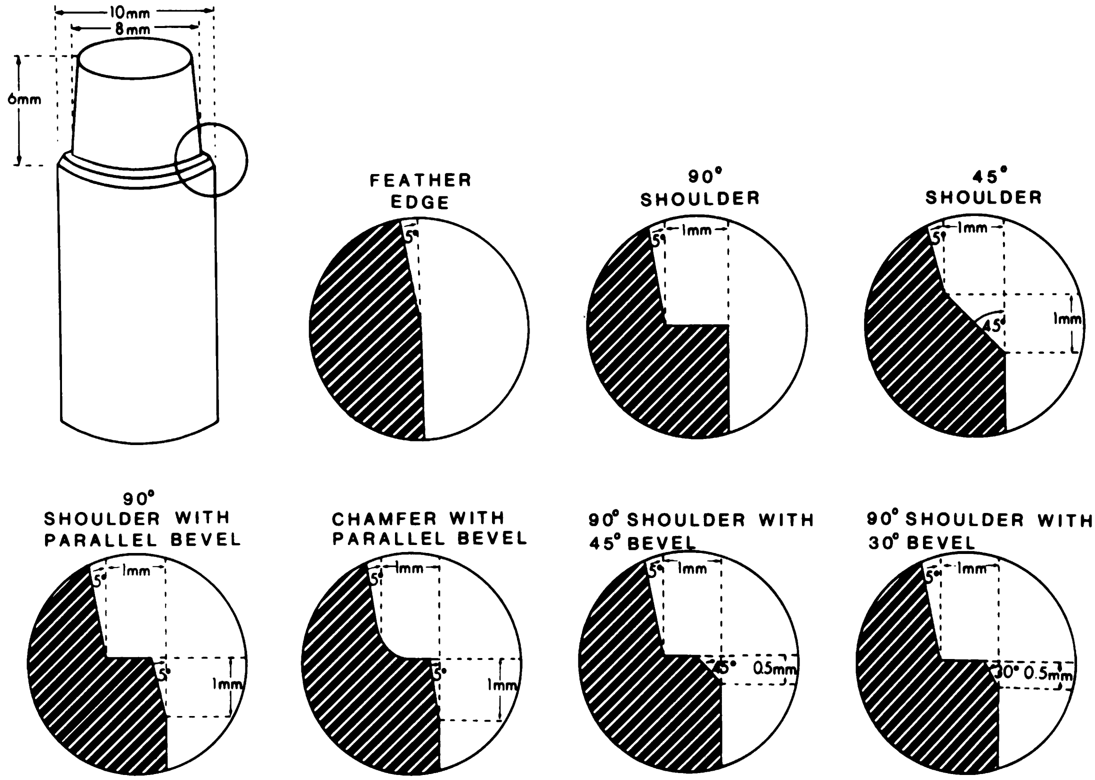

Fig. 1. Diagram of standard die used in study, with various finish line preparations in inserts.

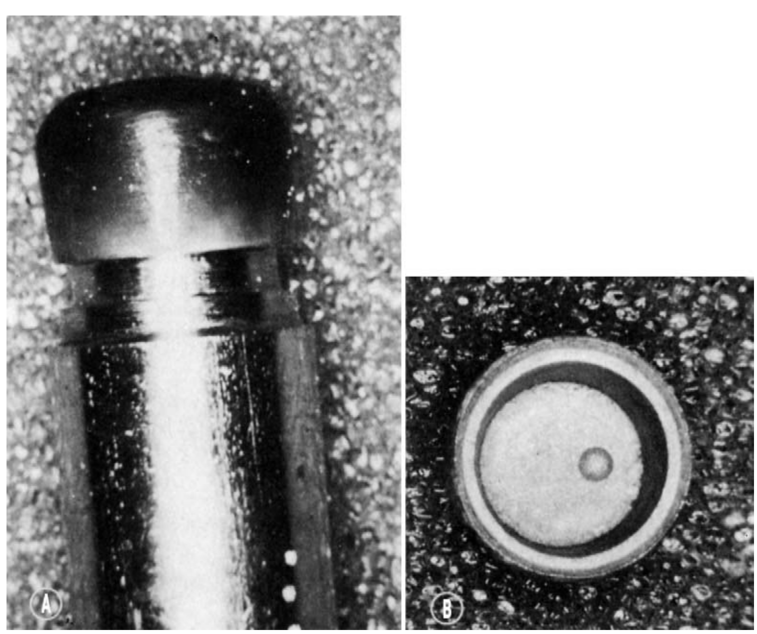

Fig. 2. Crowns were waxed on steel dies **(A)** and cast in a type III gold alloy **(B)**.

and the crown to simulate clinical practice and to distribute the cementation pressure more evenly (Fig. 4, *B*). Initially cementation pressure was 100 pounds, but this was slowly reduced to 57 pounds over the 10-minute cementation interval. Then the cemented crowns were embedded in plastic and sectioned through the center of the crown with a diamond disk on an ultrastructural analysis cutting machine (Buehler Ltd, Evanston, Ill) (Fig. 5). The cut surfaces were wet polished with progressively finer grit sandpaper, 240 to 600 grit, toward the crown to eliminate flash. The cement spaces were measured to the nearest micron with an eyepiece

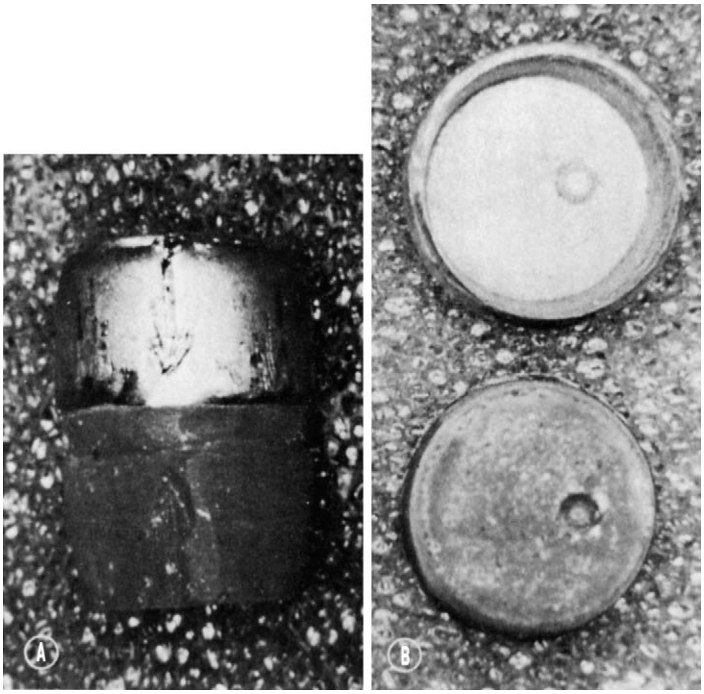

Fig. 3. Dies were indexed to facilitate repositioning during cementation **(A)** with arrows and **(B)** with a depression and corresponding dimple.

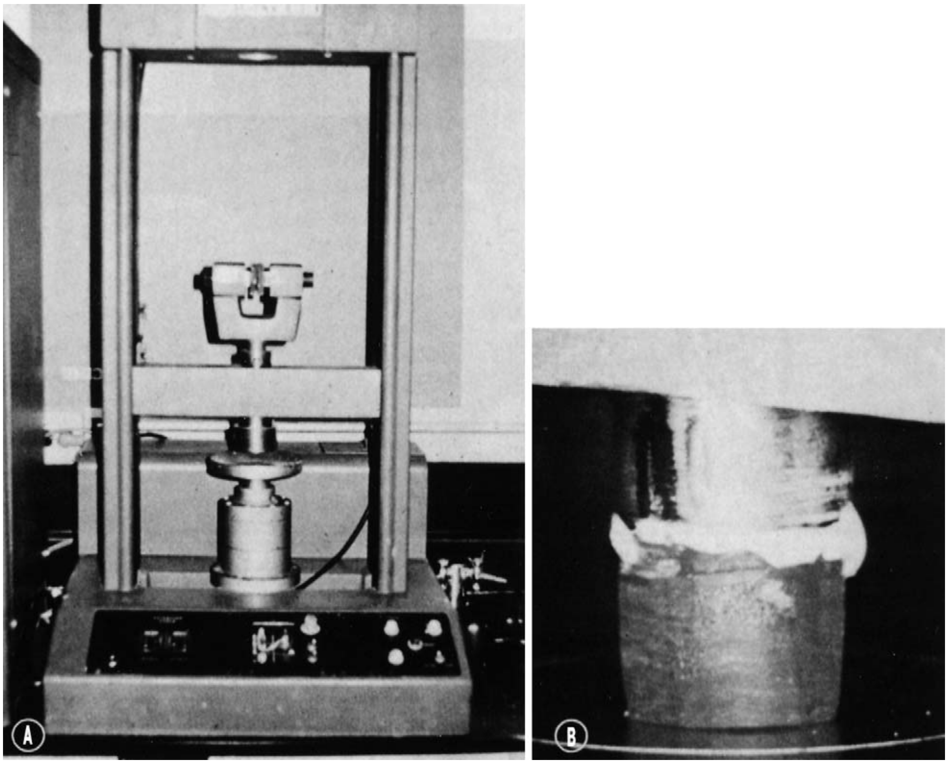

Fig. 4. A, Crowns were positioned for cementation with an Instron testing machine. **B,** An orange wood stick was used to distribute pressure evenly during cementation.

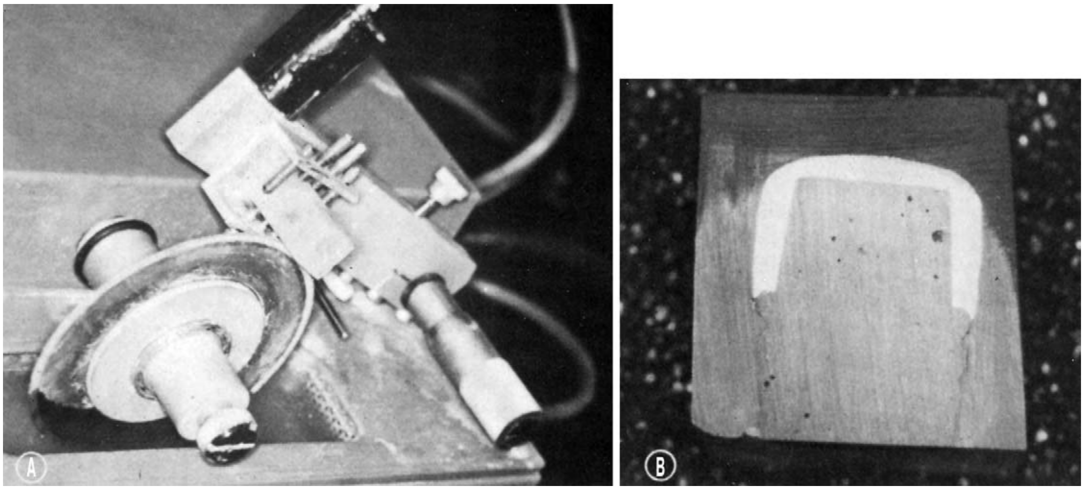

Fig. 5. Cemented crowns were sectioned with diamond disk **(A)** through center of crown **(B)**.

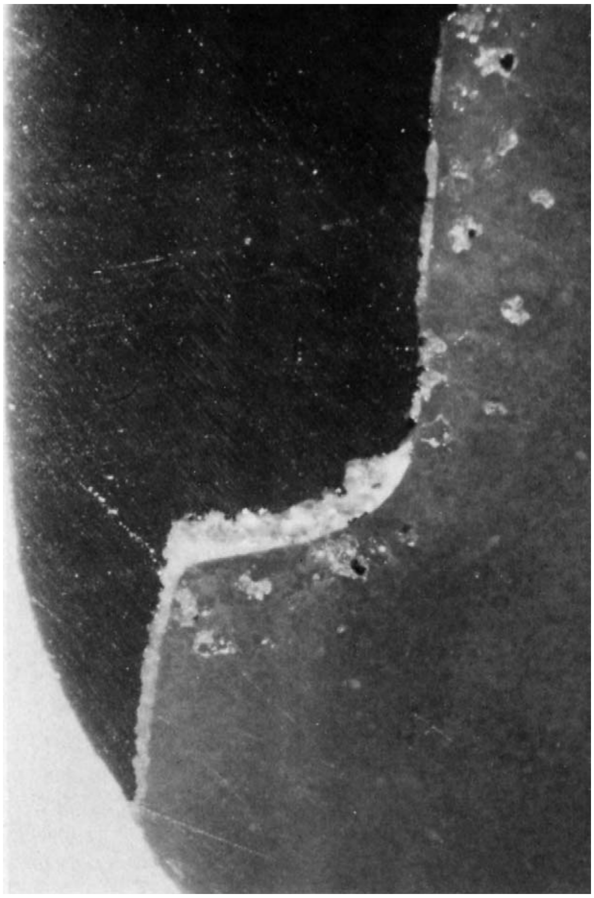

Fig. 6. Photomicrograph of cement spaces at margins.

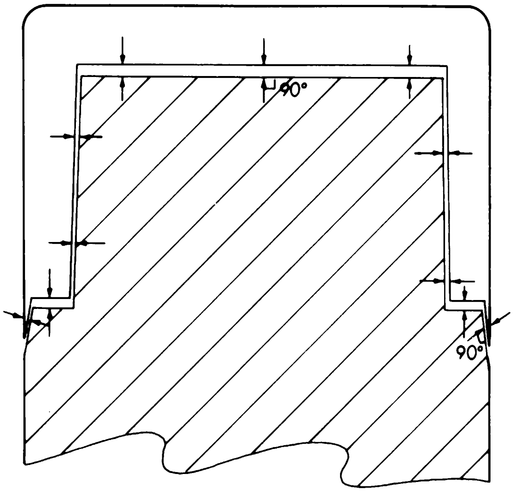

Fig. 7. *Arrows* show orientation and location where cement lines were measured.

micrometer mounted on a reflecting microscope (Fig. 6).

RESULTS

Measurements were made of the cement lines at points shown in Fig. 7. The measurements from each half of the sectioned crowns were averaged to arrive at thickness values of the cement line at the margin, shoulder, axial wall, and occlusal surface. The cement thicknesses at the margin and occlusal surface were analyzed to find the amount of seal and seat afforded by the various preparations. Statistical analysis consisted of one-way analysis of variance with multiple comparisons using Tuckey's test and Scheffe's test. Significance was determined at the $P<.05$ level.

The data in Table I and Fig. 8 show that the featheredge preparations had the best marginal seal, 31 and 34 μ. The parallel bevel preparations followed, with marginal seals of 41 and 44 μ. No statistical difference was found between the featheredge and parallel bevel preparations. The 90-degree shoulder had a cement space of 67 μ at the margins. The 45-degree shoulder, shoulder with 30-degree bevel, and shoulder with

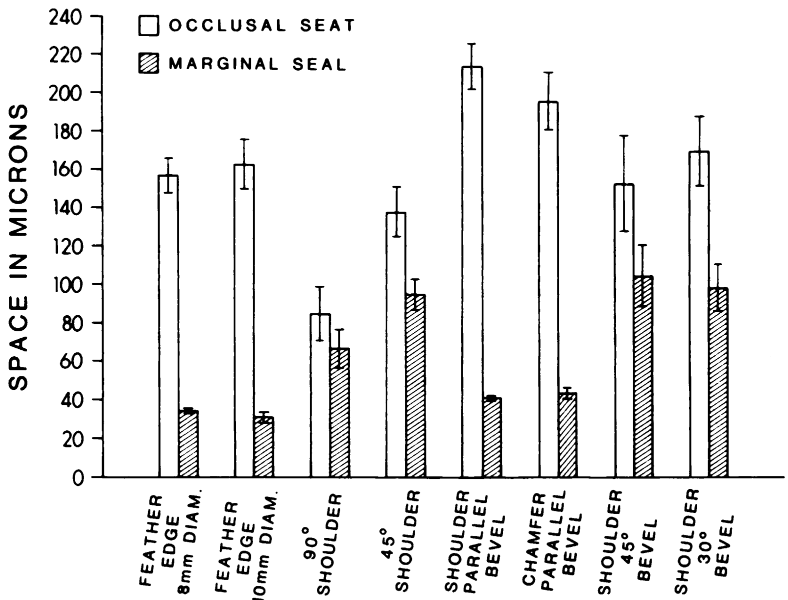

Fig. 8. Comparison of cement space at margins and occlusal surface of various finish line preparations.

Table I. Marginal seal and occlusal seating as measured in microns

	Marginal seal			Occlusal seat		
Marginal design	**Measurement (μ)**	**SEM**	**SD**	**Measurement (μ)**	**SEM**	**SD**
Featheredge, 10 mm diameter	31	± 3.30	7.4	163	± 12.66	28.3
Featheredge, 8 mm diameter	34	0.98	2.2	157	8.81	19.7
45-degree shoulder	95	7.65	17.1	138	12.66	28.3
90-degree shoulder	67	10.20	22.8	85	14.49	32.4
Shoulder, parallel bevel	41	0.72	1.6	214	12.48	27.9
Chamfer, parallel bevel	44	3.44	7.7	196	15.07	33.7
Shoulder, 30-degree bevel	99	11.72	26.2	170	18.29	40.9
Shoulder, 45-degree bevel	105	15.83	35.4	153	25.13	56.2

45-degree bevel followed, with spaces of 95, 99, and 105 μ, respectively. There was no significant difference between these three finish lines, but the differences between this group and the 90-degree shoulder group and the featheredge and parallel bevels group were significant.

The measurements at the occlusal surface found the shoulder preparation restorations to be the most completely seated with an 85 μ cement space. Ideally, the space at the margin and that at the occlusal part of the shoulder preparation should be identical. The discrepancy in these areas was found not to be statistically significant. The order of seating after the shoulder preparation was the 45-degree shoulder at 138 μ, the shoulder with 45-degree bevel at 153 μ, the featheredges at 157 and 163 μ, the shoulder with 30-degree bevel at 170 μ, the chamfer with parallel bevel at 196 μ, and the shoulder with parallel bevel at 214 μ. Differences were not significant between the following groups: 45-degree shoulder, featheredges, and shoulders with 45-degree and 30-degree bevels. The differences between members of these groups, the 90-degree shoulder group, and the group with parallel bevel preparations were significant.

DISCUSSION

By using standardized steel dies of volumetric size similar to that of teeth, rather than prepared natural teeth, castings of duplicate size and shape are produced, thus decreasing the variation within each group of finish line preparations. The machined dies also enable the investigator to accurately control the variables of preparation dimensions, degree of axial wall taper, and the finish line dimensions. The Bureau of Standards' die was not utilized because it is 15 mm in diameter, which is much larger than a natural molar, and the convergence angle of the Bureau of Standards is 3 degrees, which is too severe for the clinical situation. Textbooks recommend a convergence angle of 4 to 14 degrees.[11,12] For

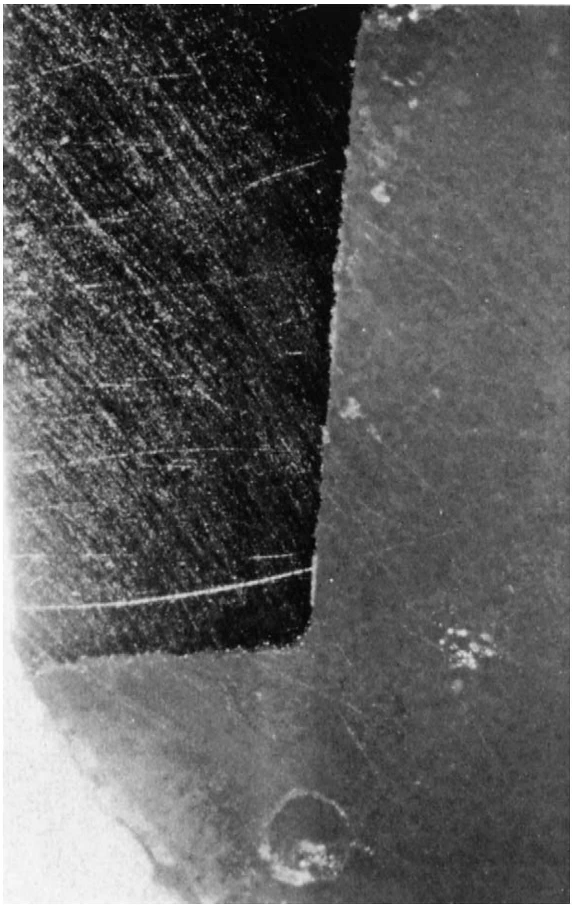

Fig. 9. Control showing no shrinkage of acrylic resin away from crown.

these reasons, the dies were machined to a convergence angle of 10 degrees with a 5-degree taper on each axial wall.

Perhaps the most significant source of variation between the results of previous studies[3-6,8-10] stems from casting variables. This source of error was controlled with acrylic resin dies poured directly into boxed castings. It is accepted that methyl methacrylate resin shrinks on polymerization. However, this factor did not affect the present study. Controls were established by pouring dies into castings, followed by embedding (unseparated) and sectioning 24 hours after polymerization. Microscopic examination revealed no shrinkage spaces between the die and the internal surface of the crown (Fig. 9). Shrinkage did occur, but it was limited to the open end of the boxed castings, thus causing meniscus formation.

To further relate this study to the clinical situation, the crowns were cemented with an orange wood stick placed between the crown and the compression head of the Instron testing machine. The stick aided in dispersing the cementation forces more evenly.

The findings of this study supported those of previous studies and the predictions based on the geometry of the preparations. Most of the crowns seated obliquely on the dies, a finding also reported by Jorgensen[1] and Bassett.[8] As geometrically predicted, the featheredge margin had the best marginal seal. There was no significant difference between the featheredge preparations of 8 mm and 10 mm diameters. Ranked next were the parallel bevel margins with acceptable[13] marginal seals in the 40 μ range.

A finding which was not consistent with other studies[3,11,12,14] was that the 90-degree shoulder preparation ranked after the parallel bevel margins with an opening of 67 μ. The 45-degree shoulder and shoulders with 30-degree and 45-degree bevels were the worst seals, with openings ranging from 95 to 105 μ. For geometric design, the shoulder would be expected to have the greatest opening at the margins. This finding is explained by evaluating the measurements of the occlusal space.

The 90-degree shoulder preparation had the best seat with an 85 μ cement space. The other preparations followed, with the parallel bevel preparations the worst observed with 196 to 214 μ cement spaces. The seating of the 90-degree shoulder preparation improved the marginal seal. However, the featheredge and parallel bevel preparations were superior in sealing the margins despite the poor seating. The differences in measurements of occlusal seating is an interesting finding since the only variable was the type of finish line. If the degree of seating were solely dependent on the film thickness of the axial wall cement, all specimens would have seated to the same degree occlusally. This indicates that the variation of the finish line is related to the different degrees of crown placement.

The question is how the finish lines affect cementation. When the crown is cemented the axial wall of the preparation approaches the axial wall of the internal crown surface. The escape path for the cement decreases, causing the hydrostatic pressure within the crown to increase until it matches the patient's biting pressure. At this point, the crown fails to seat further. If the cement does not set, it will continue to escape until the particles at the axial walls prevent further seating. Certain finish lines apparently facilitated the escape of cement early in the cementation process under the conditions of the study.

It is thought that less hydrostatic pressure results in greater seating of the restorations.

However, the explanation is not simple. The filtration process observed by Jorgensen[1,2] and Petersen[15] is thought to contribute to the differences observed in this study. Hoard et al[16] demonstrated that peak hydrostatic pressures are short-lived and are redistributed into intracoronal pressures. They concluded that this leads to various localized filtration processes which affect the flow of cement and final seating of the crown.

The better seating of the castings with shoulder preparations is due to the poor seal prior to complete cementation. This design allows the cement to escape marginally more readily without filtration. With the other finish line preparations, the margins seal earlier and start filtration sooner. With the parallel bevel preparations, the comparatively large number of internal angles produces the greatest amount of filtration and poor seating. Venting,[1,2] die spacing,[7] and internal relief of the crown[4,8] help to reduce filtration and enable the parallel bevel preparations to seat more completely.

In relating this study with actual clinical practice it must be remembered that the dies fit the crowns perfectly. In clinical practice the casting variables may have greater effect on the fit of the crowns than the variation of the finish lines. Further studies are needed to evaluate the filtration process and hydrostatic pressures within the crown. Studies also should be done to correlate the increases in hydrostatic pressure in crown restorations with different finish lines with the seating of the crowns.

SUMMARY

The influence of the marginal design of a full crown on the occlusal seat and marginal seal of a cemented full crown restoration was examined. Under the conditions of the study, the featheredge and parallel bevel preparations demonstrated the best marginal seal, followed in order by the full shoulder, 45-degree shoulder, and finally the 90-degree shoulders with 30-degree and 45-degree bevels. With regard to seating of the restoration, the 90-degree full shoulder demonstrated the best seat, followed in order by the 45-degree shoulder, 90-degree shoulder with 45-degree bevel, featheredge, 90-degree shoulder with 30-degree bevel, chamfer with parallel bevel, and finally 90-degree shoulder with parallel bevel.

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