Five Years’ Clinical Experience With a Leucite-Reinforced Porcelain Crown System

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This paper reports on 5 years’ experience using a leucite-reinforced porcelain crown system in a private practice setting. A total of 159 units of the porcelain were placed between November 1987 and November 1992. The porcelain can be employed in equigingival and supragingival cases, thereby reducing iatrogenic periodontal problems. The technique and theory of its use is discussed as well as its failure rate due to fracture, in the various regions of the mouth. Three cases are presented to demonstrate the use of the porcelain. (Int J Periodont Rest Dent 1994;14:139–153.)

Recent advances in dentinal bonding coupled with a new translucent leucite-reinforced porcelain allow cervical margins to be placed to the height of the gingival crest, or even slightly coronal to it. This is possible due to the porcelain’s vitality and translucency, which mimics natural tooth structure. The all-ceramic crown is an alternative to metal ceramics in cases where light transmission is critical. Geller et al. found the opaque nature of the metal-ceramic crown can prevent critical transillumination of the gingiva, which adds to the vitality of a restoration. This is especially true during the partial shadowing that takes place during normal lip draping.

The porcelain Optec HSP (Jeneric Pentron) has been available for use for over 5 years. The Optec system combines a translucent high-strength porcelain with a refractory die system and luting kit. Refractory dies are not new;
the basic idea is more than 100 years old. Refinements, such as silane coupling, dentin bonding, and the use of dual-curing hybrid luting composites, have enhanced the clinical uses of the porcelain. Jensen et al reported favorable in vitro fracture resistance of an all-porcelain veneer crown using Gluma (Miles Dental) as the dentinal bonding agent and silane with composite resin as the luting medium. This pilot study indicated that the all-porcelain veneer crowns were almost as strong as natural teeth. The authors surmised that "the use of a luting resin and a strong dentinal adhesive helps transfer the occlusal load to the underlying natural tooth structure, rather than resulting in stress accumulation and catastrophic failure within the luting interface." The porcelain has color throughout the restoration and excellent light transmission, which is an advantage over more opaque systems using core porcelain. The translucency allows the clinician to place the margin at or slightly above the crest of the gingival tissue when employing a long chamfer design (Fig 1). Occasionally the operator may find short axial tooth length requires slight subgingival placement of the margin (0.5 mm), but it is rarely necessary to place the midfacial margin into the sulcular area. This is an advantage as clinical probing depths of less than 1 mm are frequently present midfacially, especially in highly scalloped thin tissue with minimal zones of attached gingiva.
Method and materials

The tooth reduction required for the full-coverage all-porcelain crown requires 1.5 to 2.0 mm occlusally and 1.0 to 1.5 mm axially, with no sharp line angles. The finish line will often be a rounded shoulder interproximally and lingually, and a chamfer on the facial aspect. The authors prefer to use a long chamfer facially on anterior teeth and premolars when some facial recession has taken place (Figs 2a and 2b). This situation is not uncommon in older adults or in individuals exhibiting thin, highly scalloped gingival architecture. When the free gingival margin is at the level of the cementoenamel junction (CEJ), it becomes necessary to develop a rounded shoulder or slight chamfer (Fig 3).

Perhaps the single most critical clinical step is to develop a provisional restoration that will be the blueprint or prototype for the final restoration. Careful measurement of the provisional restoration prior to taking impressions will confirm proper tooth reduction has been achieved (Figs 4a to 4d).

Impressions should be made with a poly(vinyl siloxane) material, because multiple pours will be necessary when using refractory die materials. Reversible hydrocolloids and other rubber impression materials can be used if the laboratory uses the plat-

Fig 2a  Finish line established using a bullet-shaped diamond bur at the crest of the free gingival margin. This finish line design can be used when a fairly long clinical crown is present. The resulting long chamfer finish line results in a better optical blend at the transition from crown to dentin.

Fig 2b  Final preparation with cord placement prior to making impression. Equigingival margin development results in minimal trauma to the sulcular epithelium. Additionally, if the cord is placed gently, the junctional epithelium remains intact. This atraumatic technique assures a predictable tissue level at the delivery appointment. No tissue level changes should result if the preoperative tissue is healthy.

Fig 3  Schematic drawing of the rounded shoulder used on premolars with gingival architecture that approximates the dentin-enamel junction of the tooth on the facial aspect.
Prototype restoration is carefully measured to confirm proper tooth reduction has been achieved prior to final impression. Facial thickness of 1.0 to 1.5 mm is recommended and occlusal thickness of 1.5 mm is ideal.
inum foil swedge die technique. The authors prefer the refractory die technique.

The technician will fabricate the crown on a pearly refractory die. The first firing is usually an initial wash bake that adapts only a thin layer of porcelain to the die (Fig 5). One or two high-bisque bake firings usually follow to build up the final contours (Fig 6). Following all adjustments, the final glazing bake without vacuum is completed.

In the gingival 2 mm, slightly overbuilding the porcelain during the bisque firing allows the technician to polish the gingival areas of the crown with a rubber abrasive wheel down to the final emergence profile angle prior to final glazing (Fig 7). When the technician tries to condense the porcelain exactly to the final contour in this critical area, slight deficiencies in smooth surface contour often are noted. Polishing corrects this problem.

The lab will recover the final glazed crown by abrading the refractory material from inside the crown. The original die is thus lost. The crown should be returned from the laboratory on another die of epoxy or gypsum for inspection by the clinician (Fig 8). Often a second refractory die will accompany the final case in the event surface staining or contact correction is required (Fig 9).

Final delivery of the crown involves exacting clinical tech-
Fig 10a  Pretreatment view.

Fig 10b  View after treatment with the Oppec system.
### Table 1 Study results by tooth site (n = 159)

<table>
<thead>
<tr>
<th>Tooth site</th>
<th>n</th>
<th>Failure by fracture (%)</th>
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<tbody>
<tr>
<td>Molar</td>
<td>25</td>
<td>1 fractured at try-in</td>
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<tr>
<td></td>
<td></td>
<td>6 fractured within 3 years</td>
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<tr>
<td></td>
<td></td>
<td>3 debonded (recemented)</td>
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<tr>
<td></td>
<td></td>
<td>24.0</td>
</tr>
<tr>
<td>Premolar</td>
<td>88</td>
<td>2 fractured within 3 years</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 debonded (recemented)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.3</td>
</tr>
<tr>
<td>Anterior</td>
<td>46</td>
<td>1 debonded and lost by patient</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 debonded (recemented)</td>
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<tr>
<td></td>
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<td>0.0</td>
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Clinical experience

This report covers the period from November 1987 to November 1992, during which 158 units of full-coverage porcelain crowns were placed. The statistics can be seen in Table 1.

The clinical versatility of an all-ceramic crown depends on many factors, not least of which is resistance to fracture in the oral environment. This report of 5 years’ experience with the porcelain points to certain trends that seem to be emerging. In the molar region, a 12% failure rate was noted during the first year of service and a 24% failure rate was noted during the 5-year experience. This fracture rate is clearly unacceptable. Heavy occlusal forces, short axial clinical crowns, and clinical demands for uniform reduction all mitigate against choosing this porcelain in this region.

The premolars fared better: 2 of 88 luted crowns failed after approximately 3 years of service. This represents a 2.3% failure rate. To date, luting failure has occurred with 9 units: three molars, three premolars, and...
three incisors. Most failures were attributed to patient consumption of caramels or sticky candies. Interestingly, all units, except the one that was lost, were completely intact and were successfully recemented, using the manufacturer's recommendations, once all old composite was thoroughly cleaned from the inside of the crowns. Luting failure in all cases took place at the dental surface; all dual-cured composite remained bonded to the porcelain. Moisture contamination at delivery, water absorption, and short axial retention form may all be contributing factors to this problem.

Color is crucial when placing a highly esthetic, translucent restoration in the anterior zone. Remakes were necessary for 6 of 45 incisor crowns, because the shade returned from the laboratory was too dark or too light. Four of the six remakes were from a single case and the other two were individual units. Shade determination and matching with a new system such as Optec requires caution, because the clinician is accustomed to shade matching with an opaque system, such as porcelain fused to metal.

The author's experience has shown that when the porcelain is 1.5 mm thick, the final shade is not affected by the underlying dual-curing composite resin to any significant degree. However, when the porcelain is less than 1 mm thick, the shade of the luting composite may affect the color of the final restoration. There are modifiers within the luting system that can alter the shade.

The highly translucent nature of the restorative material allows some of the rather yellow and warm dentinal shade to show through in the gingival third, where the porcelain may be 1 mm or less in thickness. Additionally, the translucent nature of the porcelain seems to require more, but judicious, use of the lighter (I-1) blend incisally.

Discussion

The "workhorse" of dentistry today is the porcelain-fused-to-metal restoration. Its advantages are its strength and its frictional retention form. When desired, the restoration can be designed to contact the axial walls before full seating, creating tensile forces on the casting and compressive forces on the dentin.5

The all-porcelain veneer crown suffers two main shortcomings. First, tight frictional retention form may cause fractures in the porcelain. Also, the preparation design, which utilizes a rounded shoulder or a 130-degree chamfer (usually at a level equal to the crest of the tissue), creates a short axial wall. As a result, the retention form is usually in the middle third of the tooth preparation. There is no tight collar of metal encircling the tooth below the crest of the gingiva to add to the axial length available to the clinician.

Because the all-porcelain veneer crown should seat passively upon insertion, the cementing medium becomes very important relative to dental adhesion. The more distally placed crown restoration has less axial retention and less resistance to dislodgement when relying solely on dentinal bonding mechanisms. The cementation requires more time and meticulous attention to detail.

Supragingival or equigingival margin placement can be an advantage. It is easier to develop than a restoration which requires intracrevicular margin placement. Elongated teeth in an environment that has been changed due to periodontal surgery or recession are a greater challenge for the clinician. Although the clinician must take into consideration supragingival and equigingival margin placement, it is much easier to fabricate a crown with a supragingival/equigingival margin than one with a margin in the intracrevicular zone.

The clinician has to be keenly aware of the requirements of tooth preparation,
such as embrasure form, tooth reduction, occlusal morphology, supragingival coronal crown contours, presence or absence of erosion, abrasion, caries, or previously existing restorations. Root anatomy and root sensitivity are also concerns. The operator must also take into consideration the surgically created architectural form of the soft tissues and hard tissues, if the case has been treated with periodontal surgery.6

There are numerous articles in the literature7-14 that allude to the desirability of placing the margin at or above the gingival margin. From a biologic standpoint, crown margins located subgingivally can promote inflammatory changes in the gingival sulcus. Marcum in 196715 found more favorable periodontal response if margins were located at the gingival margin as compared to the subgingival and supragingival position. Valderhaug's18 10-year study noted higher Gingival Inflammation (GI) scores, a small increased pocket depth, and a slightly greater loss of attachment when crown margins had been located in the subgingival zone compared to the supragingival position.

There is an advantage to supragingival and equigingival margin placement as compared to subgingival placement relative to the periodontal microflora and gingival health. The literature has a number of articles that compare the microbiology of a supragingival margin with that of a subgingival margin; most notably those by Lange and Flores-de-Jacoby et al.16 When crowns were placed subgingivally and overhangs or open margins were present but not clinically detectable, there was a higher incidence of caries and plaque retention, with probable changes in the gingival flora associated with the open margin and overhanging margin. In these studies, it was found to be very difficult to detect an overhanging or open margin (Lange K, personal communication, 1990).

A high level of oral hygiene cannot ensure the health and stability of the periodontium when subgingival crown margins are placed. When crown margins are placed supragingivally, there is less loss of attachment and secondary caries as compared to subgingival margin placement. Subgingival margin placement is clearly implicated in the etiology of periodontal disease. Flores-de-Jacoby and coworkers16 indicated unequivocally that the subgingival margin location provided the highest scores of the assessed clinical parameters (Gingival index, probing depth, and sulcular fluid rate). There not only was an increased bacterial accumulation, but a worsening of the composition of the bacterial flora; the numbers of filaments, motile rods and spirochetes increase with time when the margins were placed subgingivally.16 Microroughness of the subgingival margin may favor plaque accumulation and retention with adverse microbiological sequela.

Another advantage of supragingival margin placement is the easier management of the soft tissue; for instance, a lack of attached gingiva may not be as critical. A supragingival margin away from the crevicular epithelium probably decreases the chance of damage to the periodontium. With intracrevicular margin placement, special care must be taken when the gingiva is thin and where a minimal width of attached keratinized tissue is present. In fact, the latter often requires surgical intervention (gingival enhancement).

When crown placement is planned with intracrevicular margins, a 2.5- to 3-month wait is required before final impressions can be taken—the time necessary for tissue maturation and development of the biologic width.17-21 With a supragingival margin of approximately 1 to 2 mm coronal to the gingival crest, the waiting period for making the final impression can be reduced.
Case Reports

Case 1

This case demonstrates the shadowing or darkening effect that some metal ceramic crowns have in the anterior dentition (Figs 11a to 11e). Preoperatively, the porcelain-fused-to-metal crown had overclosed the distal embrasure, had a supererupted appearance, and generally was too opaque to blend in with the other teeth. A long chamfer margin was established with a bullet-shaped diamond (see Fig 2a).

Postoperatively, the margin is slightly supragingival on the distofacial aspect, yet the optical blend is gradual and esthetic. It was felt a slightly exaggerated mesial emergence angle was necessary to close the diastema between the central incisors. Note the absence of the blue shadowing effect with the more translucent porcelain crown. The overall result is an acceptable esthetic blend.
Case 2

This case illustrates restoration of the maxillary premolars with the all-ceramic crown (Figs 12a to 12g). Preoperatively, there is a facial recession on the first premolar; a long chamfer was used on this tooth. The second premolar had less recession and, hence, had more of a rounded shoulder on the facial aspect.

Provisional restorations were made and placed with the facial finish lines at the crest of the tissue. The final crowns are shown immediately after luting and approximately 2 years postoperatively. Note the preoperative and postoperative radiographs.
Case 3

In this case, four all-ceramic crowns were placed on teeth 11, 12, 21, and 22 (Figs 13a to 13i). The patient had a high smile line. The ceramometal crowns on teeth 11 and 21 were unnecessarily splinted. The interproximal tissue was impinged and the patient particularly disliked the bluish tissue at the margins.

The patient required endodontic treatment on teeth 21 and 22. Tooth 11 was not retreated, because removal of the cast post was not possible: an apicoectomy may be necessary in the future. Parallel-sided posts of a minimal diameter were employed on teeth 21 and 22, along with buildups using tooth-colored composites to minimize any effect on translucency. Tooth 11 required some additional die spacing on the facial aspect to allow an opaque layer to be placed over the gold post at the delivery appointment.

Provisional restorations were placed using a translucent material to test how improved translucency would affect the gingival area and to see if the cast post would be a significant cosmetic liability.

Final appearance of the crowns demonstrate reduced shadowing, a slight open embrasure between teeth 11 and 21, and an overall nice esthetic blend.
**Fig 13e**  Provisional restoration in place.

**Fig 13f**  Final restorations on teeth 11, 12, 21, and 22.

**Figs 13g to 13i**  Postoperative radiographs.
Conclusion

The all-ceramic Optec crown provides a biologically acceptable and esthetic restoration. It is an alternative to the porcelain-fused-to-metal crown in cases where a high level of translucency is required, because translucency is a distinct advantage of this restorative material. The data presented in this article can be compared to data presented by McLean on the strength and success of the platinum-bonded aluminous core porcelain crown. McLean reported a 7-year study where failure rates of 15.2% for molar crowns, 6.4% for premolar crowns, and 2.1% for incisor crowns were noted.

In this 5-year study, the failure rate of Optec crowns, due to fracture, was 24% for molars, 2.3% for premolars, and 0% for anterior teeth. Based on this experience, Optec can be used successfully on anterior teeth, and on selected premolars, where a translucent, vital-appearing restoration is desired. Additionally, because of margin design and translucency, this restoration can be placed equigingivally or even slightly supragingivally and have an esthetic appearance.

References


