Forward to the Past: A Renaissance in Ceramometal Technology

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Increased patient demands for esthetics have led to widespread use of porcelains for both ceramometal and all-ceramic restorations.[1-3] Over the last decade, the interest in dental esthetics has expanded rapidly. The public is demanding more natural-looking restorations, whether full coverage or partial coverage, that are indistinguishable from natural teeth.

Ceramometal restorations are still the most widely used type of indirect restorative system, and have been used with great success for nearly 40 years. Conventional ceramometal restorations have been problematic esthetically, primarily because of the opaque dark metal-oxide layers created on conventional alloys. The dark oxide can cause shadowing in the adjacent soft tissue because of lack of light transmission, and the oxide can corrode and invest the surrounding tissue, creating a tattoo.

New Developments in Ceramometal Materials

Recent advances in material science have led to development of a new class of ceramometal materials[4] and alternate alloy systems that have significantly overcome some of the inherent esthetic problems with conventional ceramometal materials.[5] With the use of these alternate alloy systems and one of the newer generation veneering porcelains, it is possible to fabricate restorations that rival all-ceramic restorations in appearance (Figures 1 and 2).

This article will discuss new developments in ceramometal materials for the esthetic restoration of teeth and cover some of the clinical and laboratory guidelines in using these materials.

High-Gold Alloys

Because of the high demand for esthetics, it is desirable to use ceramometal restorations with a high gold content, which gives the final restoration a warmer appearance. High-gold alloys have the added benefit of having greatly reduced amounts of nonprecious elements, which easily oxidize and increase the likelihood of corrosion. Corrosion products can invest the surrounding tissues, causing local toxic reactions and unsightly discolorations.[6] One recently introduced high-gold alloy system, **CAPTEK™ (CAPTEK)**, has no nonprecious metals in the alloy, which eliminates the possibility of nonprecious metal toxicity.[3]

CAPTEK™

CAPTEK™ employs advanced metallurgic principles of capillary casting technology to create metal frameworks for the subsequent veneering of porcelain. The final framework is a high-gold, oxide-free alloy. This alloy is unique to dentistry because it is a composite alloy composed of two distinct alloy phases. Traditional alloys used in dentistry are single-phase materials.[7] Composite alloys can be fabricated to have better physical properties than single-phase materials. A complete discussion of the microstructural aspects of the CAPTEK™ composite alloy can be found elsewhere.[7]

CAPTEK™ is fabricated by a special process that does not use centrifugal casting, vacuum, or pressure as with conventional alloys. CAPTEK™ is fabricated on a refractory die in two separate steps. The first step is to apply CAPTEK™ "P" material, which is a gold, platinum,

Figure 1—Ceramometal crown with CAPTEK™ framework, demonstrating warm, natural appearance.

Figure 2—Ceramometal crowns cemented on teeth Nos. 2 and 3 with CAPTEK™ framework. Note the excellent blend with the natural dentition.

Figure 3A—Layering of CAPTEK™ "P" on the refractory die.

Figure 3B—CAPTEK™ "P" after firing.

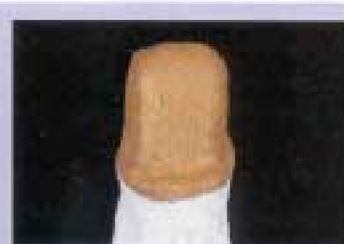

Figure 4—Completed layering of CAPTEK™ "G" over the already fired layer of CAPTEK™ "P".

Figure 5—Finished single coping. Note the warm gold color and diffuse reflection surface.

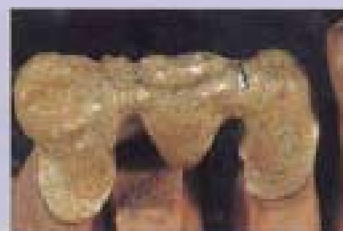

Figure 6—A three-unit bridge framework ready for porcelain application.

Figure 7—Diagram of the diffuse reflection nature of a CAPTEK™ coping. This type of reflection more closely matches the reflection of natural teeth than conventional alloys.

Figure 8—Technique case with thin areas of porcelain over the opaqued CAPTEK™ framework. Note that even in the areas where the porcelain is very thin, it still has a very natural, nonopaque appearance.

Figure 9—SEM of Vita® Omega 900. The average leucite crystal size is 3 µm with a more homogeneous distribution than conventional porcelains. No apparent tensile cracks are present.

Figure 10—Two anterior three-unit FPDs at try-in with bright-edge CAPTEK™ margins. Because of the warm reflectance of CAPTEK™ frameworks, there is no shadowing at the soft tissue. There is a slight increase in opacity as a result of the thin porcelain at the margin. Note: The author only performed the lab work for this patient.

and palladium material in a thermoplastic binder. The CAPTEK™ "P" comes in sheets (strips) of material that is similar in handling to **ALUWAX (ALUWAX Dental Products)**. These sheets are manually molded to the refractory die (Figure 3A) and built to the desired coping dimensions. The die is then placed in a porcelain furnace and fired to 1,075° F for 4 minutes (Figure 3B). The thermoplastic binder is burned out and the gold, platinum, and palladium particles interconnect, leaving a stable, three-dimensional (3D) network of capillaries. This capillary structure becomes the internal reinforcing skeleton that provides strength, high-temperature stability, abrasion resistance, and high shine of the polished metal surfaces of the finished restorations.[7]

The next step is to apply CAPTEK™ "G" material, which contains fine particles of 97% pure gold content in a thermoplastic binder. The CAPTEK™ "G" is applied in the same manner as the CAPTEK™ "P" (Figure 4). This is then fired with the same firing cycle as the CAPTEK™ "P." The molten CAPTEK™ "G" is drawn into the capillary spaces of the CAPTEK™ "P" by capillary attraction.

As soon as both components have been fired, the surface produces a warm gold color (Figures 5 and 6). Conventional alloys are often gold plated, which gives a similar gold color, but with one distinct difference—the surface of a CAPTEK™ coping is very granular in nature, whereas a gold-plated coping is very smooth. The granular surface of the CAPTEK™ coping gives a more diffuse (scattered) reflection (Figure 7), whereas the plated coping gives a more specular (mirror) reflection. A diffuse reflection more closely mimics the optics of natural teeth.

As a result of this diffuse reflection of light, even thin areas of porcelain will not exhibit the opaque "headlight" effect seen in conventional alloys with the same thickness of porcelain (Figure 8).

The coping is then divested and is ready for porcelain application. Several studies have demonstrated the mechanical properties and marginal fidelity of CAPTEK™ crowns to be equal and even exceed that of conventional ceramometal crowns.[5-10]

As a result of CAPTEK™'s composite microstructure, the material exhibits high temperature sag resistance. Single-phase alloys of similar noble metal content undergo sag at the firing temperatures of conventional ceramometal porcelains. Thus, CAPTEK™ can be used with existing ceramometal porcelains with standard building techniques, and excellent esthetic results can be achieved with conventional ceramometal porcelains. Newer generation porcelains with improved optical and physical properties have been found to work ideally with these alternate alloy systems.

New-Generation Ceramometal Porcelains

Recent developments in ceramic science have led to the realization that improved physical properties could be obtained in dental ceramics by manipulation of the leucite crystalline phase. The leucite crystals in conventional ceramometal systems are arranged in clusters, leaving large areas of the amorphous glass crystal free. Because of this irregular arrangement of crystals and mismatches in CTEs, tensile cracks are more likely to form in the glass phase. Relatively low flexural strengths for conventional ceramometal porcelains have been reported to lie between 60 MPa and 80 MPa.[11]

Ceramic material developers focused on creating ceramics with a finer and more evenly dispersed crystalline phase within the glassy matrix. Two all-ceramic systems, **IPS Empress® (Ivoclar Williams)** and **Optimal™ Pressable Ceramic (OPC) (Jeneric®/Pentron®, Inc.)** incorporate this optimized leucite phase, which results in much higher flexural strengths.[12] More recently, continued development has led to the evolution of ceramometal materials that take advantage of this optimized leucite phase. This technology was adopted in the development of state-of-the-art materials including **Vita® Omega 900 (Vita Zahnfabrik, Germany, distributed in US by Vident™)**, and **Ducera Gold® (Degussa/NDI)**.[3]

In contrast to conventional ceramometal porcelains, the leucite crystals are more evenly dispersed and much smaller. This more homogeneous nature of the crystalline phase not only raises the CTE of the material to match that of the casting alloys, but the absolute tensile stresses between the crystals and the glass matrix are so negligible that no tensile cracks occur (Figure 9). This homogeneous nature of the crystalline phase greatly improves the physical properties of this class of ceramic, and flexural strengths twice that of conventional ceramometal porcelains have been reported.[3]

One of the most significant problems with conventional ceramometal porcelains has been their abrasion potential. This is most likely a result of the rather large (30 µm) average particle size of the leucite crystals. One of the main benefits of the fine crystalline structure is the decreased potential for abrasion, which can be attributed to a significantly smaller particle size of about 3 µm.[3] The size and shape of particles on the surface of the dental ceramic, rather than the hardness of the material, appear to be the critical factors for abrasion of the opposing dentition.[13,14]

Clinical Procedures

Preparations for these new ceramometal combinations are the same as for conventional ceramometal systems. Teeth can be prepared with any margin design that has traditionally been taught.

Posterior Teeth

Typically, a moderate chamfer is best for posterior teeth. Axial reduction of 1 mm and occlusal reduction of 1.5 mm are necessary for good porcelain esthetics. For optimum esthetics, the author found 1.5-mm axial and 2-mm occlusal reduction to be ideal.

Anterior Teeth

For anterior teeth, the traditional shoulder/bevel or light chamfer can be used if a metal collar of CAPTEK™ is used. CAPTEK™ metal margins do not display the typical dark margin of conventional ceramometals because of the warm reflective color of the CAPTEK™ copings. Thus, in situations where it is not possible to prepare a definitive shoulder for a porcelain butt margin, CAPTEK™ is ideally suited (Figures 10 and 11).

For optimally esthetic anterior ceramometal restorations, a shoulder preparation that allows for the creation of a 1-mm porcelain margin is preferred.[15] Ideally, a minimum of a 270-degree or 360-degree shoulder preparation on teeth in the anterior region facilitates optimal esthetics (Figure 12). Facial reduction of 1.5 mm (as in conventional ceramometal restorations) is the standard for these new materials in esthetically demanding regions. Accepted tissue management and impression-making procedures should be followed. The author prefers a new vinyl polysiloxane impression material that uses synthetic fillers (**3M™ Imprint™ II Impression Material System, 3M Dental Products**) because of its improved rheological properties.

Provisionals are then fabricated by a direct or indirect technique. Ideally, provisional materials that match the shade guide should be used. This will facilitate the shade-taking and communication process. One such material, **Vita® Zeta Cold Cure (Vita Zahnfabrik, Germany distributed in US by Vident™)**, which matches Vita™'s newly developed shade-taking system, the 3-D Master, works well for this purpose.

Laboratory Procedures

The procedures for the fabrication of CAPTEK™ copings have been discussed earlier. For a more detailed technique for copings and fixed partial dentures (FPDs), the reader is referred to previously published techniques.[2]

CAPTEK™ can be routinely used for three-unit posterior FPDs and four-unit FPDs with adequate connector design (Figures 13A and 13B). For FPDs larger than four units, especially in the posterior regions, lower-gold conventional casting alloys should be used. Standard laboratory techniques for fabricating metal frameworks using the lost wax technique are best for these larger frameworks. Manufacturer's directions for the alloy to be used specify investing and casting parameters. Only the Degunorm alloy can be used with the Ducera Gold® system because of its high CTE.[16]

> True mastery takes into account not only esthetic success, but the long-term functional and biologic requirements of our patients.

Framework Design

Framework design should allow for maximum thickness of porcelain within accepted limits to minimize susceptibility to fracture. After casting, frameworks can be safely thinned to 0.15 mm in esthetic areas for single teeth with no increased potential for ceramic fracture.[17] This would be catastrophic for all-ceramic restoration frameworks.

Margin design can be a conventional metal margin (collar), or the metal framework can be cut back to create a porcelain butt margin. State-of-the-art ceramometal restorations can rival all-ceramic restorations in appearance by using a vertically reduced metal framework as described by Geller and Winter.[18]

The framework is reduced up the axial wall a minimum of 2 mm

Figure 11—Three CAPTEK™ frameworks with thin metal margins (resulting from knife-edge preparations) cemented with Omega on teeth Nos. 5, 9, and 10. Because of the patient's low lip line, the margin is not visible with the patient smiling. Note: The author only performed the lab work for this patient.

Figure 12—Ideal anterior preparations that allow for a 360-degree shoulder and a vertically reduced framework for optimum esthetics.

Figure 13A—Three-unit CAPTEK™ framework.

Figure 13B—Three-unit FPD cemented with Omega 900 in situ.

Figure 14—Anterior coping demonstrating a vertically reduced metal framework.

Figures 15A and 15B—Opaqued coping with fluorescent powders used on the shoulder and as a thin wash over the coping. This is the coping under fluorescent light.

Figure 15B—Coping under reflected light.

Figure 16—Second set of provisionals used as a 3D blueprint for final restorations. Used here during the porcelain build-up.

Figure 17—Enamel/translucent porcelains added as a correction to duplicate the form of the provisionals as closely as possible.

(Figure 14). This allows for more translucent porcelains to be used in the marginal area, thereby improving optics in this region. As long as the margin design is a shoulder with a 90-degree exit angle, this amount of cutback does not affect the strength of the cemented system.[19]

Opaquing

One of the benefits of using the CAPTEK™ system is that it generally only requires one coat of opaque porcelain, which saves vital space for the more translucent dentin and incisal porcelains.

It is recommended to place one extremely thin coat of opaque before the main opaque layer and fire it 20°C to 30°C higher than the listed firing temperature. This will create better surface wetting of the CAPTEK™ and thus promote better porcelain bonding. The use of spray opaque systems with one coat of opaquing can keep this layer to a thickness of less than 50 μm.

After opaquing, special fluorescent porcelain materials can be used as a shoulder material, built up as a thin wash over the opaque layer, and fired (Figures 15A and 15B). These special powders can increase the value and chroma without negatively affecting the apparent translucency.[20]

Control of the individual layers of opacious dentin, dentin, enamel, and translucent porcelains is critical for the proper 3D expression of color in the final restoration. Also vitally important is the duplication of the form and arrangement of the teeth dictated during the provisional phase of treatment. The author has found it extremely beneficial for esthetically critical cases to fabricate two sets of provisionals—one that gets temporarily cemented and one that goes with the case that can be used as a 3D blueprint for the final restoration (Figure 16).

Figure 18—Finished case on cast ready for delivery.

Figure 19A—Frontal preoperative view.

Figure 19B—Maxillary occlusal preoperative view.

Figure 20A—Postoperative full arch frontal view of full mouth reconstruction with CAPTEK™.

Figure 20B—Close-up of finished anterior teeth.

Figure 20C—Maxillary occlusal view.

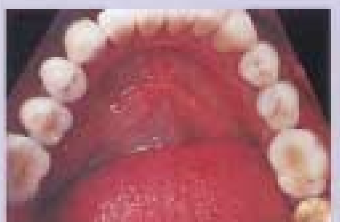

Figure 20D—Mandibular occlusal view.

Figure 20E—Smiling view.

Figure 20F—Left sagittal view of cemented reconstruction.

Building Individual Layers

Maximum control of the individual porcelain layers can be achieved by individually building and firing each layer. The opacious dentin layer is built and then fired, and adjustments can be easily made before proceeding to the next layer.

Dentin powders are then modified and fired, then incisal framing and internal effects are built and fired. The last step is to place the enamel and translucent layers (Figure 17). This individual layering and separate firing allows maximum control of the color and translucency of the final result. This technique, developed by the author, has been named the "Skeleton Build-Up Technique" and is discussed in greater detail elsewhere.

Contouring, staining, and glazing are accomplished by the same techniques as for conventional ceramometal materials (Figure 18). The clinical case in Figures 19A through 20F demonstrates the esthetic potential of the new generation of ceramometal materials.

Cementation

Because these new alloy and porcelain systems behave mechanically similarly to conventional ceramometal combinations, standard cements can be used. However, experience has shown that more opaque cements (such as zinc phosphate) limit the esthetic result with a vertically reduced metal framework. In the critical anterior areas where esthetics are paramount, more translucent cements are preferred. **3M™ Vitremer™ Luting Cement (3M Dental Products)**, which is in the so-called compomer class of cements, has moderate translucency and works well in these regions because of its ease of use. For maximum translucency, the author prefers **Panavia 21® TC (J. Morita USA, Inc.)**. As with all resin cements, Panavia 21® TC is significantly more technique-sensitive and requires the use of dentin bonding agents.

Summary

Because of the short clinical history and technique difficulty of all-ceramic restorations, ceramometal restorations are the restoration of choice for full-coverage esthetic posterior applications (Figure 21), and especially for bridge applications (Figures 22A and 22B). With the concomitant development of alternative alloy systems and optically and physi-

Figure 21—Posterior CAPTEK™ crown.

Figure 22A—Occlusal view of three-unit CAPTEK™ FPD.

Figure 22B—Buccal view of Figure 22A. Note the excellent match and comparable translucency to the natural dentition.

cally improved porcelains, PFM restorations can rival all-ceramic restorations in esthetics without some of their disadvantages.

The author's preference is to use a new-generation porcelain, but the CAPTEK™ alloy is ideally suited for conventional ceramometal porcelains.

One potential benefit of the CAPTEK™ alloy, soon to be published,[22] demonstrated significantly less plaque adherence to the CAPTEK™ alloy than the contralateral natural tooth. This could have potential benefits in treating periodontally involved cases.

True mastery takes into account not only esthetic success, but the long-term functional and biologic requirements of our patients. The decreased potential for abrasion and plaque adherence, coupled with the ability to use long-established clinical and laboratory techniques, make these materials an ideal choice for esthetic ceramometal indications.

Note

All clinical and all-ceramic work was performed by the author, except where noted. The author would like to thank Chris Lawthrop for the fabrication of the CAPTEK™ copings presented in this article.

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Product References

Product: ALLOWAX
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Fax: 616.895.5060

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Manufacturer: CAPTEK
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Product: Duceragold®
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Product: IPS Empress®
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Address: 175 Pineview Drive, Amherst, NY 14228
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Product: Optimal™ Pressable Ceramic (OPC)
Manufacturer: Jeneric®/Pentron®, Inc.
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Product: Pontor 21™ TC
Manufacturer: J. Morita USA, Inc.
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Product: 3M™ Imprint™ II Impression Material System; 3M™ Vitremer™ Luting Cement
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