# Captek™ - A new capillary casting technology for ceramometal restorations

**Itzhak Shoher, DMD, MS***

**Aharon Whiteman, CDT****

Captek™ (capillary technology) is an advanced metallurgic system that was developed to combine optimal natural esthetics of dental porcelain with the strength of ceramometal , to produce accurate restorations on all types of tooth preparation and provide a biocompatible environment for the oral tissues in simple and affordable procedures. Captek™ restorations include inlays, onlays, crowns, and anterior and prosterior protheses that are based on Captek™ precious-metal understructure veneered with bake-on porcelain (Fig 1).

Captek™ alloys are composed of two major components. The first component, when heated, forms a microscopic three-dimensional network of capillaries; the second, when melted, flows to fill these capillaries. This microscopic process works by the forces of capillary attraction to produce a solid-metal composite alloy. The components of a cast composite metal do not diffuse completely into each other but form a matrix-filler combination similar in concept to the dental composite resins widely used in conservative dentistry. Each component of the metal alloy with a variety of desired properties not possible in a single cast alloy.

Captek™ coping combines oxide-free gold color with high-temperature stability, high abrasion resistance and elastic properties that provide burnishable margins, support for high loads as prosthetic abutments, and resilience for stress control at the ceramometal interface (Fig 2).

The Captek™ system includes three pairs of materials that form composite metals:

1. Captek P™ and Captek G™ are used for crown copings and fixed partial denture abutments.
2. Capcon™ and Capfil™ are used to connect copings and pontics to a prosthetic structure.
3. Captek Repair Paste™ and Capfil™ are used to form extensions and additions on the various Captek™ structures.

---

* Prostheodontist, Tel Aviv, Israel

** Dental Technician, Tel Aviv, Israel

The authors are co-developers of the Captek™ technology.

1

**Fig 1** Captek crown and bridge kit.

2

**Fig 2** Captek copings with different gingival finishing lines: *(left)* metal margin; *(center)* 180-degree porcelain margin on labial surface; *(right)* 360-degree porcelain margin.

**Captek™ Copings**

A Captek™ coping has an overall composition of about 88.2% gold, 9.0% platinum-group metals (including 4.0% pure platinum), and 2.8% silver. It contains particles in which as much as 60% platinum-group metals serve as the filler of the composite metal and the matrix is high-gold-content alloys. These copings have a thickness of 0.25 mm (250 μm) for anterior teeth and premolars, and 0.35 mm (350 μm) for molars. The system provides the ability to make the metal as thick as desired for lingual collars, interproximal extensions, and occlusal surfaces.

Each coping is structured of three layers formed during the heating processes: inner and outer layers 25 μm thick with a bright gold color and fine microgranular texture, and an intermediate layer, with a gold-platinum color, that occupies the remainder of the coping.

Captek™ copings are made on refractory dies by application of Captek P™ and Captek G™ metal impregnated, waxlike elastic strips that are heat processed on the die in a porcelain furnace.

Fig 3 Captek P material placed over the refractory die and adhesive.

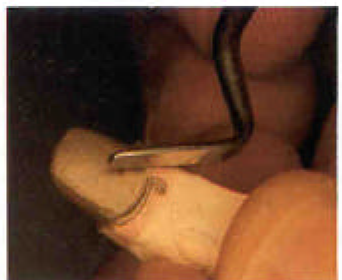
Fig 4 Sections of Captek P joined and unified over the refractory die with a hand instrument.

Fig 5 Trimming Captek P to the margin.

Fig 6 Captek P after processing in the porcelain furnace.

3

4



5

6

Capvest™ refractory die material is used to make a refractory die duplicate of the working master die. The expansion of the Capvest™ can be adjusted by changing the water-Capvest™ liquid ratio to obtain the desired tightness of fit for the final restoration. A layer of Captek™ adhesive is painted over the die and allowed to set before Captek P™ is applied.

**CAPTEK P™**

Captek P™ platinum-colored strips contain metal particles of less than 50 ìm and binders. The strips come in two thicknesses: one for incisors, canines, and premolars, and one for molars.

Sections of Captek P™ are cut and placed over the adhesive (Fig. 3). The pieces are adapted and joined with a hand instrument and light pressure (Fig. 4). Excess material is trimmed from the margins (Fig. 5). To build thicker sections, fresh material can be added or scrap pieces can be pressed into a Captek™ mold to form the desired shape and then added to the coping with light pressure.

The die with Captek P™ is positioned on a firing tray and placed in a porcelain furnace for processing. The firing cycle includes a 2-minute entry time, a starting temperature of 600°C, and a temperature rise of 80°C per minutes to 1,075°C, which is held for 4 minutes, all without vacuum.

During the cycle the adhesive and binders burn out and high-platinum- and high-palladium-content metal particles interconnect to form a stable three-dimensional network of capillaries. There is no apparent dimensional change in Captek P™ during the heat process (Fig. 6).

**CAPTEK G™**

Captek G™ is applied over the processed Captek P™ (Fig. 7). It comes in two thicknesses, for anterior teeth and for molars, corresponding to the Captek P™ materials. Captek G™ contains fine particles with 97% pure-gold content and binders.

Sections of Captek G™ are cut and placed to cover the processed Captek P™ and fired with the same firing cycle in the porcelain furnace (Fig. 8). The molten Captek G™ is drawn by capillary-attraction forces to fill the capillary network and form a solid metal composite. This metal was found in scanning electron microscopy studies to have a density similar to that of conventional castings. Part of the Captek G™ flows through the capillaries to the inside aspect of the coping to form the outer layer. Normally, the inner and outer layers have the same thickness and fine granular appearance (Fig. 9).

The capillary structure formed by the processed Captek P™ material becomes the internal reinforcing skeleton of the intermediate layer (Figs 10 to 12). This skeleton provides the strength, high-temperature stability, abrasion resistance, and high shine of the potential metal surfaces of the finished restorations.

The coping is recovered from the refractory die by aluminum oxide abrasion and seated on the master die (Figs. 13 and 14). The margins are finished with fine paper disks and, when desired, can be burnished onto the die with the provided hand instrument.

The metal composite internal structure of Captek™ allows burnishing of margins with sufficient stability to prevent springing of margins when heated and maintenance of marginal accuracy during porcelain firings. Any metal-ceramic porcelain suitable for use with precious cast ceramic metals may be used with Captek™ metals at the same firing schedule.

The thickness of Captek™ crowns varies from 0.3 mm of metal and ceramic up to a few millimeters (Figs 15 and 16). Any type of tooth preparation can be used, including knife-edged, chamfer chamfer bevel, and shoulder preparations for metal or porcelain margins.

The oxide-free, warm gold color of Captek™ copings make them a highly desirable background for the porcelain. Only a 35-ìm-thickness of opaque porcelain is needed over Captek™ with or without Capbond™ bonder because there are no dark metals or oxides to mask. The opaque porcelain is needed only to bond to the metal and to produce the correct porcelain shade. The use of thin opaque helps to avoid the unpleasant bright, high-value appearance of thicker opaque layers often seen at ceramic margins of cast metal-ceramic crowns.

The microstructure of the intermediate layer of Captek™ copings makes it possible to thin Captek™ copings by grinding down to 50 ìm near the margins without breaking or flecking. Cast metals cannot be successfully thinned to less than 100 ìm because of their grain size and structure.

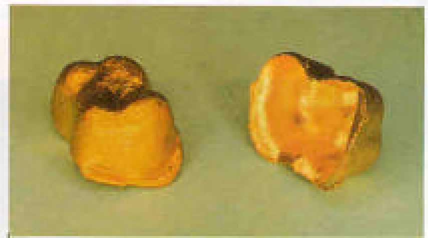
Reduced-thickness Captek™ metal and thin opaque layers make it possible to achieve acceptable esthetics at cervical margins with a total metal and ceramic thickness of 0.3 mm to 0.5 mm. A thickness of 0.5 to 0.7 mm yields pleasing esthetics on the labial aspect of anterior crowns and a thickness of 0.7 to 1.0 mm provides optimal porcelain thickness.

For reasons of strength, crowns may be thinned to 0.3 to 0.5 mm only at the cervical margins of anterior teeth. For best results, premolars and molars should not be thinner than 0.7 mm near the margins.

As recommended for conventional cast metals and porcelain, the occlusal surfaces of premolars and molars should be at least 1.2 mm thick. In cases of limited occlusal space. It is possible to structure a Captek™ metal occlusal surface. It is made during initial coping build up and should be at 0.6 mm thick. The minimal thickness possible with esthetic Captek™ crowns helps prevent overcontouring of the porcelain and enables normal emergence profile with conservative tooth reduction.

7

8



9

**Fig 7** Captek G material placed over the processed Captek P.

**Fig 8** Finished coping after firing of Captek G.

**Fig 9** Captek molar copings with warm gold color and fine granular inner and outer surfaces.

**Fig 10a** Layer of Captek P over the adhesive and the refractory die.

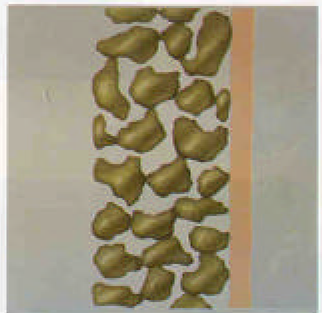
**Fig 10b** Captek P after firing. The metal particles interconnect to form a capillary network.

**Fig 10c** Captek G after firing. Captek G melts over Captek P capillaries and is drawn to fill them by capillary-attraction forces.

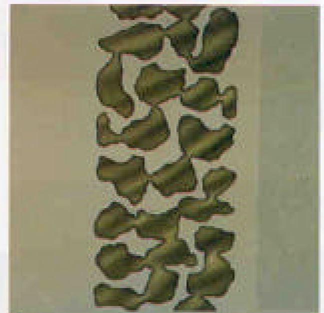
**Fig 10d** Captek composite metal after processing. Captek P become the internal supporting skeleton of the intermediate layer.

**Fig 11** Scanning electron micrograph of Captek P after processing. The open three-dimensional network of capillaries will attract molten Captek G.

**Fig 12** Scanning electron micrograph of the completed Captek coping surface.

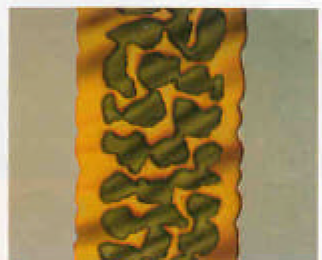


10a

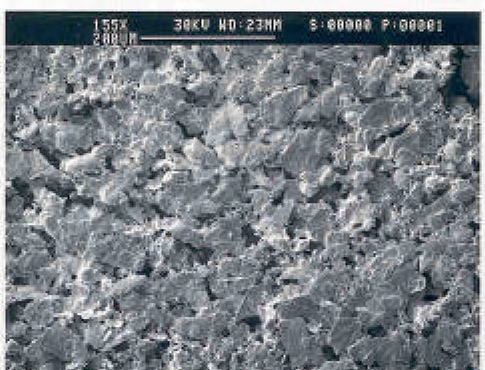


10b

10c



10d




11


12

13

14

15

16

**Fig 13** Captek metal base for two onlays.

**Fig 14** Captek metal base for onlay (interior view).

**Fig 15** Captek premolar crown for knife-edged preparation (interior view).

**Fig 16** Premolar crown shown in Fig 15. The total metal-porcelain thickness of 0.3 mm yields pleasant esthetics.

**Captek™ Fixed Partial Dentures**

Captek™ fixed partial dentures are based on Captek™ copings, used as prosthetic abutments, and Captek™ preformed pontics connected by Capcon™ and Capfil™ (Figs 17 and 18). A selection of 17 prefabricated metal pontics with one, two, or four units in a row are available in palladium-based or gold-based ceramic alloys (Fig 19). The pontics work according to the reinforced-porcelain design that was developed by the authors and has been marketed since 1980 as Inzoma (Ivoclar AG, Schaan, Liechtenstein) and as RPS wax structures (Ivoclar, North America, Amherst, NY).[1]

The pontics are gold plated to control oxide formation during heat cycles for better porcelain esthetics and for better interproximal connections.

The finished Captek™ copings are seated on the master working cast and the selected pontics correctly aligned. The units are joined together with wax and invested in Captek™ soldering investment.

17

18

19

20

**Fig 17** Captek copings for five-unit posterior fixed partial denture (labial view).

**Fig 18** Same copings shown in Fig 17 (palatal view). Lingual color reinforcement was used on all copings.

**Fig 19** Captek prefabricated pontics. The single and multiple pontics for anterior and posterior use are made of palladium-based ceramic alloy and a pure-gold cover.

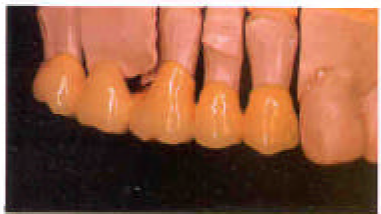
**Fig 20** Metal structure for five-unit Captek prosthesis (same as in Figs 17 and 18). Painting Capcon on the pontic produces a solid-gold base layer for porcelain esthetics.



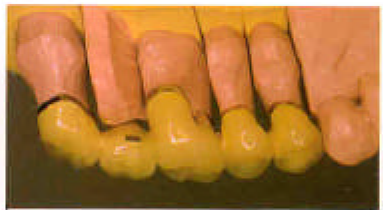
To connect the prosthetic components, a composite metal is formed at the interproximal areas. A powder-liquid mixture of Captek™ is placed with a brush to form the desired shape of the interproximal connections. A section of Capfil™ solid-gold base metal filler is placed over each connection. When a bright gold pontic is desired to improve porcelain esthetics at the pontic, a thin layer of Capcon™ mixture is also painted over the pontic (Fig 20). The prosthesis is placed in the porcelain furnace and fired at the Captek™ thermal cycle to 1,075°C. A two-step process takes place during one heating cycle: a capillary network is formed from Capcon™ and is subsequently filled by Capfil™. A uniform, shiny gold connection indicates a well-structured joint.

The connected prosthetic structure is ready for Capbond™ ceramometal bonder and porcelain (Figs 21 to 23).

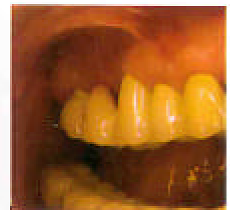
Captek™ units may be post soldered in the same manner, and the same soldering alloy may be used for post solder of precious cast ceramic metals.



21



22



23

24

**Fig 21** Completed Captek prosthesis (same as in Figs 17 to 20), labial view.

**Fig 22** Completed Captek prosthesis (same as in Figs 17 to 21), palatal view.

**Fig 23** Captek prosthesis in situ (same as in Figs 17 to 22).

**Fig 24** Captek-type metal implants in dog's mandible. Bone regenerated into direct contact with the implant in all directions.

**CAPBOND™**

Capbond™ is a gold-based, gold-colored ceramometal bonder. Even though different impact, shear, and bending tests indicate very strong bonds between a Captek™ untreated granular surface and porcelain, the use of Capbond™ is recommended for single units as well as fixed partial dentures, for extra security. Capbond™ is used as a very thin paint-on layer that forms a fine and open gold-colored sponge. Porcelain flows well into this sponge-like surface to form a strong bond.

**CAPTEK™ REPAIR PASTE**

This material allows additions and corrections on Captek™ copings after they are recovered from the refractory die. The additions are processed over a Bunsen burner flame. First, the repair paste is heated in the flame to form the capillary network. Small pieces of Capfil™ are then added and melted in the flame to flow and fill the capillaries and form a solid metal.

**Clinical Testing**

The Captek™ system was developed over 8 years of laboratory and clinical research. During this period, hundreds of metal units derived from capillary technology were tested clinically in combination with Ceplatec coping base material (Ceplatec, Krefeld, Germany). In clinical studies, Setz[2] and Setz and Weber,[3,4] tested 87 crowns and fixed partial dentures and achieved very positive results. Setz[2] also performed corrosion-resistance studies and concluded that the Captek™- type composite metal is as corrosion resistant as cast metal of similar overall metals' content. Studies of tissue cultures and implants in dogs conducted by Binderman[5] revealed excellent tissue response and bone growth around Captek™- type composite metals: " It seems that this metal is very compatible to bone tissues and does not interfere with normal healing process of bone remodeling" (Fig 24).

In 3 years of extensive clinical experimentation by the authors with Captek™ ceramic crowns and fixed partial dentures, there has not been a single crack or fracture, and no units have had to be replaced.

Clinical observations, from a few weeks after insertion to several years later, have indicated good health of the marginal periodontium where Captek™ metal extends to the margin. Larger areas of metal near the margin seemed to produce greater gingival health. Clinical observations suggested that less plaque is retained at Captek™ gingival margins than at the gingival margins of natural dentition.

The favorable periodontal health may be attributed to the high-polish oxide-free precious composition of 88% gold and 4% platinum. However, the early clinical and laboratory results stimulated additional studies that are currently underway to determine whether the internal structure of Captek™ composite metal acts as a contributing factor to the apparently biocompatible environment.

## MECHANICAL TESTING

Consistently accurate crown margins with an opening of 14 to 24 ìm (mean of 21.7 ìm) were maintained by adjusting the water-Capvest™ liquid ratio. Use of correct processing temperature is also important to obtain proper marginal fit.

A series of tests was conducted to evaluate the ultimate fracture resistance of Captek™ crowns to impact, static loading, and cyclic loading. Additional studies evaluated the load-bearing capacity of Captek™ prostheses.

### Impact Tests

A study was performed with an impact apparatus[6,7] that had a weight falling from different heights over a hard metal pin that contacted the surface of the porcelain. Eight Captek™ central incisors with Capbond™ and eight without bonder were tested with 100 g (4 oz) falling from 100 cm (40 inches). All crowns, with and without bonder, suffered only local porcelain flaking at and around the contact site (Fig 25). No major porcelain breakage occurred at or near the ceramometal interface. Successive impacts caused additional crushing without major damage at the interface (Fig 26). The results indicated that Captek™ crowns have a high resistance to impact fracture.

In similar tests of porcelain over cast metal copings, major porcelain breakage occurred with the first impact at or close to the interface.[5]

Effective stress control at the ceramometal interface inhibits breakage and crack propagation at the interface. The stress control in Captek™ crowns results from the outer resilient gold base layer of the copings, the gold component of the intermediate layer, and Capbond when used (Fig 27).

### Static Loading


25


26


27

**Fig 25** Captek ceramometal anterior crowns without bonder after impact testing. All crowns, with or without bonder, suffered only porcelain crushing at the site of impact. There was no damage at or close to the ceramometal interface.

**Fig 26** Captek crown after second impact at the incisal edge. Additional porcelain crushing is present around the site of impact, but there are no cracks or breakage advancing to the interface.

**Fig 27** Scanning electron micrograph of cross section of Captek crown illustrating dense metal layer and complete wetting of metal by the opaque porcelain for good adhesive bond.

**Fig 28** Captek copings used in static loading.

28

change the load required to cause the first crack. Under excessive loads of 265 to 485 lb (120 to 220 kg), the use of Capbond reduced porcelain damage and minimized breakage at the ceramometal interface.

All the results indicated that the resistance of Captek crowns to fracture under pressure is well beyond the maximum loads that exist in the mouth, even under extreme conditions.[8]

The failure load of Captek™ crowns was tested with a hydraulic press testing apparatus (Unikorn, Tel Aviv, Israel). The pressure was applied on a pure-silver palette that contacted the crown. The first crack occurred at an average load of 215 ± 25 lb (98 ± 13 kg) in six central incisors, at 238 ± 31 lb (108 ± 14 kg) in six premolars, and at 258 ± 32 lb (117 ± 15 kg) in six molars (Fig 28). In additional tests, the use of Capbond™ ceramometal bonder did not change the load required to

29a

Fig 29a Captek metal prosthetic structures used in tests of load-bearing capacity.

29b

Fig 29b Captek ceramometal prostheses used in load testing.

cause the first crack. Under excessive loads of 265 to 485 lb (120 to 220 kg), the use of Capbond™ reduced porcelain damage and minimized breakage at the ceramometal interface.

All the results indicated that the resistance of Captek™ crowns to fracture under pressure is well beyond the maximum loads that exist in the mouth, even under extreme conditions.[6]

## SUMMARY

Captek™ capillary casting technology is a new approach to ceramometal restorations. Captek's™ gold-colored, oxide-free precious metal compositions enhance the vitality of bake-on porcelains and yield pleasing esthetic results even with conservative tooth reduction.

Laboratory test results indicate that Captek™ ceramometal restorations have high marginal fidelity and relatively high load-bearing capacity and resistance to impact fracture. Clinical experience and biologic laboratory studies demonstrate good biocompatibility around Captek™ metal composite, predicting good long-term periodontal response.

## REFERENCES


1. Shoher I. Stress analysis in ceramometal units and its application in oral rehabilitation. Aust Prosthodont Soc Bull 1984; 14:21.
2. Setz J. The Use of Powder Metallurgy in Dentistry-Technical, Biological and Clinical Research [thesis; in German]. Tübingen University, Germany.
3. Setz J, Weber H. Ceplatek sintermetal. Part 1. Materials and technique [in German]. Quintessenz 1992;43: 1949-1957.
4. Setz J, Weber H. Ceplatek sintermetal. Part II. Clinical and test results [in German].Quintessenz 1992;43:1763-1769.
5. Binderman I. Renaissance Sintered Metal Implants in Dogs [research report]. Tel Aviv, Israel: Hard Tissues Laboratory, Sourasky Medical Center, 1989.
6. Shoher I, Whiteman A. Reinforced porcelain system: A new concept in ceramo-metal restorations. J Prosthet Dent 1983;50:489-496.
7. Shoher I. Reinforced porcelain system. Dent Clin North Am 1985;29:805-818.
8. Nathanson D, Riis D, Goldstein R. In vitro load capacity of a new bridge system [abstract 1639]. J Dent Res 1991;70.