Recent advances in composite CAD/CAM blocks

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The introduction of composite CAD/CAM blocks has generated new indirect restorative materials with improved properties when compared to artisanal, light-cured composites. There is, however, some confusion about the different available products, which is exacerbated by incomplete information provided by manufacturers, who sometimes refer to them as "hybrid ceramics," while a recent classification has termed them "resin-matrix ceramics."[1] Advances made in current composite CAD/CAM blocks are associated with: *1)* new microstructures: classic dispersed filler microstructure on one side and resin infiltration of a ceramic network (polymer-infiltrated-ceramic-network or PICN) on the other; *2)* new polymerization modes: with high temperature (HT), or with high temperature/high pressure (HT/HP); *3)* new matrix composition: UDMA as the main component instead of Bis-GMA; *4)* augmented filler content; and *5)* more homogeneous structures with fewer flaws. Consequently, two classes of CAD/CAM blocks must be distinguished: those with dispersed fillers, which are HT polymerized and constitute most of the marketed products (eg, Lava Ultimate, 3M; Cerasmart, GC; Shofu Block HC, Shofu), and PICN materials, which are HT/HP polymerized (Enamic, Vita).[2] PICN ma-

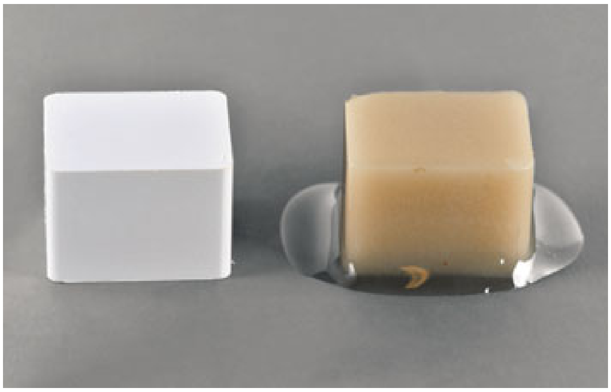

Fig 1 PICNs differ significantly from classic composite materials with dispersed fillers incorporated by mixing in a monomer mixture, in that a PICN material is the result of the infiltration of a pre-sintered glass-ceramic scaffold with a monomer that is secondarily polymerized. This ceramic network forms a real skeleton, with specific mechanical properties.

Fig 2 Example of fillers that are incorporated by mixing in a monomer mixture, thus producing a dispersed filler composite material.

terials are the result of the infiltration of a pre-sintered glass-ceramic scaffold with a monomer, which is secondarily polymerized (Fig 1). They differ significantly from all other composite materials, which contain dispersed fillers incorporated by mixing (Fig 2). It must be noted that the term "hybrid ceramic" is a confusing commercial name, which is used for both dispersed filler and PICN materials.

The ceramic network of PICN materials constitutes a 3D scaffold of interconnected (in contrast to dispersed) particles: It forms a skeleton, which is able to distribute stresses more effectively in all directions and to promote resistance to breakdown phenomena.[3] This microstructure also gives the material a modulus of elasticity between enamel and dentin, while dispersed filler composites show a modulus of elasticity lower than dentin.[4] PICN materials have to be etched prior to bonding, whereas dispersed filler materials have to be sandblasted.

On the other hand, new polymerization modes used for CAD/CAM blocks, especially HT and, most of all, HT/HP, are shown to significantly increase the degree of conversion and to improve many material properties. Recent research outcomes about CAD/CAM composites, especially about experimental PICNs, have shown impressive results in terms of mechanical properties,[3,5-7] as well as low toxicity and monomer release, compared to light-cured composites.[8] Moreover, CAD/CAM composites exhibit a better machinability than glass-ceramics in terms of milling time, damage tolerance,[7,9-11] and the ability to be milled in very low thicknesses.[12] Consequently, high-performance CAD/CAM composites, particularly experimental PICNs, could compete with glass-ceramics such as lithium-disilicate for bonded partial restorations and posterior crowns, notably on implants, due to their property of absorbing masticatory forces.[3,13] These materials could be particularly apt for the development of minimally invasive treatment strategies such as "no-prep" treatment of worn dentition (Fig 3a to u). Current issues are related to the study of the wear, bonding, and cytocompatibility properties of the different varieties of CAD/CAM composites. There is also a crucial need to validate the *in vitro* results of these new products with clinical studies. Finally, manufacturers should provide more complete information regarding their product polymerization process, microstructure, and composition, which significantly influence the properties of CAD/CAM materials.

Fig 3 (From: Mainjot et al,[2] reprinted by permission of SAGE Publications Inc.) "No-prep" pilot clinical case of worn dentition restored with minimally invasive bonded partial restorations (table tops and palatal veneers), milled in Enamic (PICN) with the Cerec MC XL machine (Sirona). **(a to d)** Pre-op clinical situation. **(e)** A wax-up simulating the restoration of the tooth tissues is performed on the duplicate of the models after endodontic retreatments, replacement of amalgams with direct composites, impressions, and analysis of occlusal relationships.

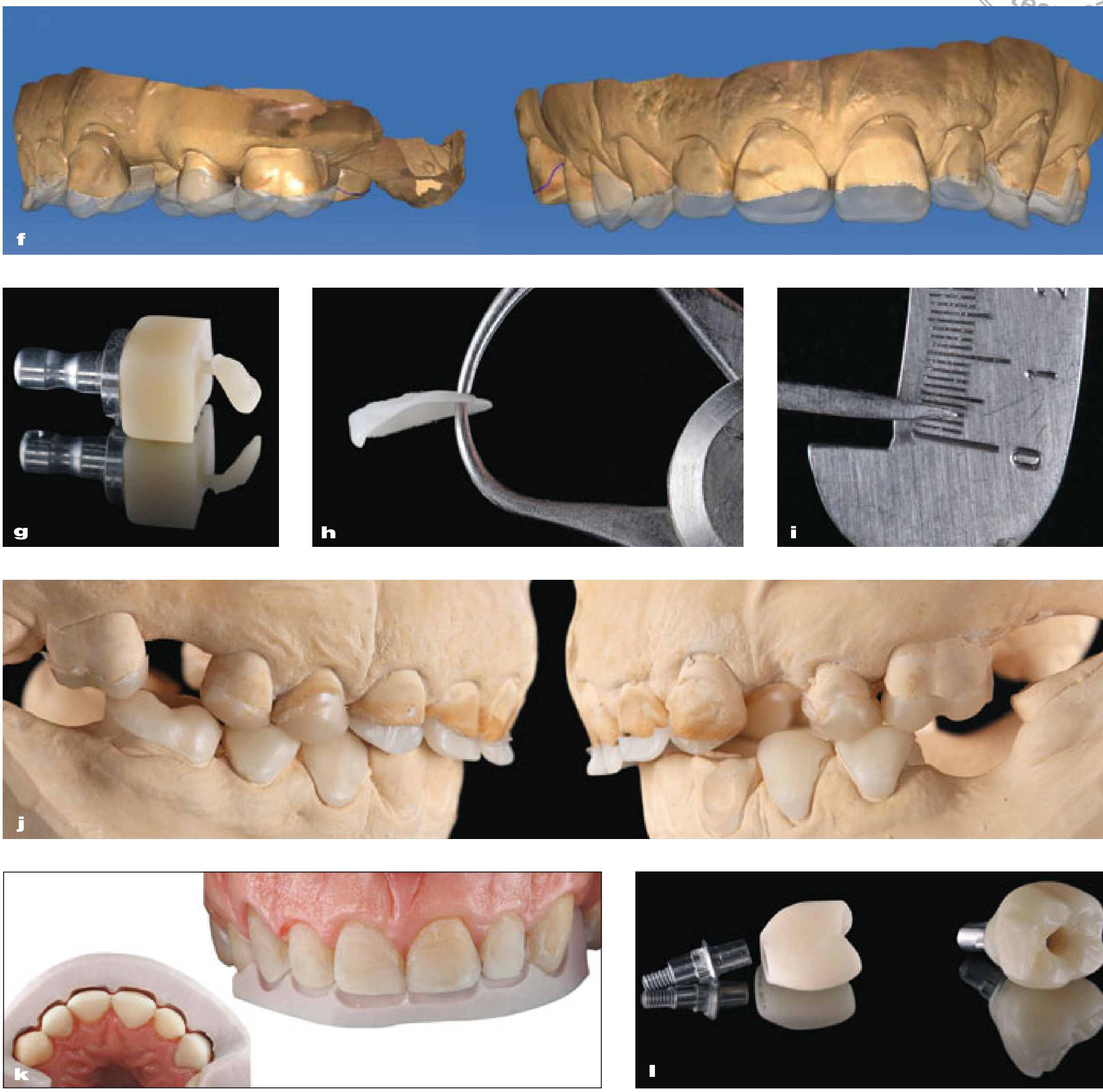

Fig 3 **(f)** The restorations are simulated in the Cerec system after scanning the models and wax-up, respectively. The restoration design corresponds to tissue loss; there is no preparation of teeth. **(g to i)** 0.2-mm thick table top, directly after milling. **(j)** Enamic restorations on models, after slight occlusal adjustments and polishing. If there are no important esthetic issues, restorations are not stained, as in the present case. Indeed, stains are just light-cured composite materials, which are brushed on the restoration surface but which have poor mechanical (notably in terms of wear) and biological properties compared with the PICN material. All restorations are bonded in 2 consecutive half-days (no provisional stage in this case) and direct composite is placed on the buccal faces of the maxillary incisors. **(k)** Minimal preparations of maxillary incisors and canine for the realization of buccal veneers in pressed lithium-disilicate glass-ceramic (IPS e.max press). Ceramic material is preferred for esthetic purposes. Incisal edges of mandibular incisors and canines are restored with direct composite. **(l)** Enamic crowns for implants placed on teeth 16, 24, 36, and 46 (Ceramill Motion 2, Amann Girrbach). These crowns have to be bonded on a titanium abutment.

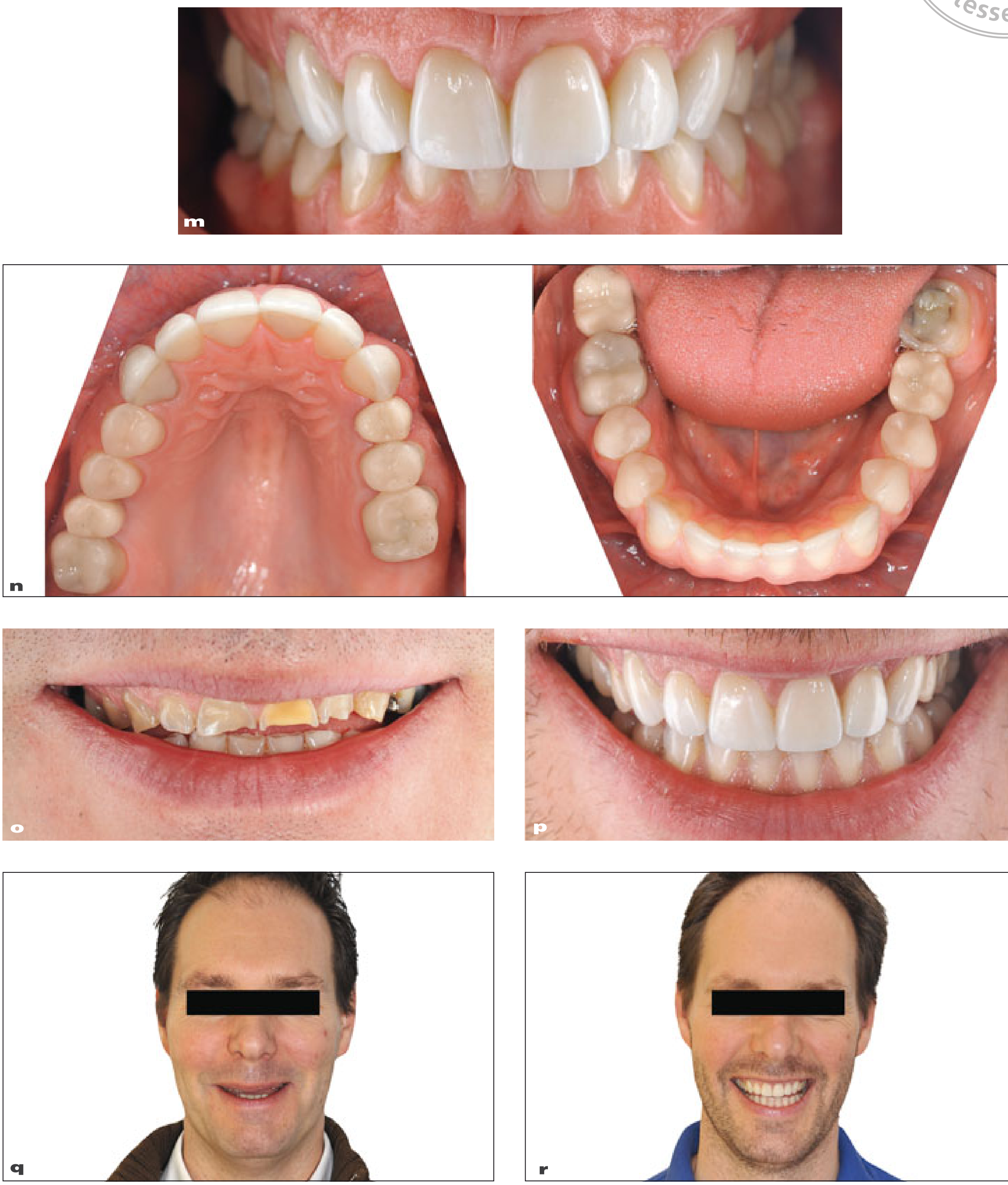

Fig 3 **(m and n)** Final views of treatment, and 9-month follow-up. **(o to r)** Pre- and post-op views.

Fig 3s Pre-op panoramic radiograph.

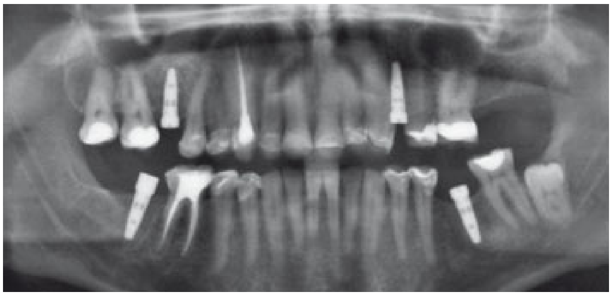

Fig 3t Panoramic radiograph after the completion of the restorations on the teeth and the placement of the implants.

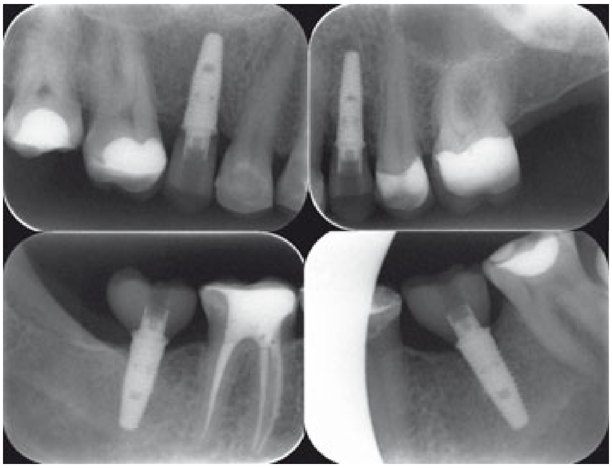

Fig 3u Periapical radiographs of the completed tooth-supported and implant-supported restorations.

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