METHOD FOR FABRICATING ENDODONTIC, ORTHODONTIC, AND DIRECT RESTORATIONS HAVING INFUSED CERAMIC NETWORK

CROSS REFERENCES TO RELATED APPLICATIONS

This application is a CON of U.S. patent application Ser. No. 09/448,050 filed on Nov. 23, 1999, now abandoned, which is a DIV of U.S. patent application Ser. No. 09/201,455 filed on Nov. 30, 1998, now U.S. Pat. No. 6,159,417, which is a CIP of U.S. patent application Ser. No. 08/854,805 filed on May 12, 1997, now U.S. Pat. No. 5,843,348, which is a CON of U.S. patent application Ser. No. 08/307,455 filed on Sep. 19, 1994, now abandoned.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to ceramic network materials used for restorative material and for various devices such as posts, implant abutments, orthodontic brackets, or blocks.

2. Description of Related Art

Referring to FIG. **1**, natural tooth enamel **10** is a hard, vitreous substance that covers the outer portions on a tooth crown **1**. Hardness is an important enamel property because enamel **10** provides a protective covering for the softer underlying dentin **12**. Enamel **10** also serves as a masticatory surface on which food is crushed, ground, and chewed. Specifically, hardness is a measure of the ability of tooth enamel to withstand deformation by indentation or scraping, or the like, and mature enamel demonstrates a Knoop hardness number (KHN, i.e., the ratio of a given load to an area of indentation expressed in Kg/mm^2) in a range of about 200 to 500 KHN.

Because enamel is semitranslucent, the color of enamel depends in part upon its thickness. For this reason, enamel may assume the various colors of its underlying structures. Thus, when enamel is thicker, and consequently more opaque, it may appear grayish or bluish white reflecting more of its inherent coloration. When enamel is relatively thin, however, it may be yellow-white in appearance, reflecting the underlying generally-yellowish dentin.

As demonstrated by FIG. **1**, dentin **12** may constitute the largest single component of tooth structure, extending almost the entire length of the tooth. Dentin **12** is covered by enamel **10** on the crown **1** and by cementum **14** on the root. The internal surface of dentin **12** forms the walls of a pulp cavity **16** which primarily contains pulpal tissue **18**. Further, the walls of pulp cavity **16** may closely conform to the outline of the external surface of the dentin **12**.

Dentin and bone in general are natural ceramic-composites. Chemically, dentin **12** is composed of organic and inorganic matter. As noted above, the inorganic matter includes calcium phosphate in the form of hydroxyapatite ($Ca_{10}(PO_4)_6(OH_2)$). The organic matter is primarily collagenous material. The hydroxyapatite crystals are bonded to themselves to create tubules through which collagen fibers run and these may be attached to the dentin.

Restorative materials generally are tested on three criteria: sufficient hardness, adequate fit, and acceptable aesthetics, e.g., color match. Of these three, however, aesthetics often are the deciding factor in the choice of restorative materials. Composite resins and ceramics are in widespread use due in part to their ability to match the color of a patient's natural teeth. Composite resins may be composed of a glass in a

polymer matrix. This combination, however, may result in rapid wear of the restoration, as the softer polymer is lost, and the glass filler pulls out of the remaining polymer. High wear rates are associated with rapid loss of restorative strength. Restorative ceramics may also be problematic. Despite relatively high strength and hardness, ceramic materials also are generally brittle, such that they may withstand only minimal deformation without failing. Thus, wear in current composite resin materials and catastrophic fracture of ceramic restorations are significant limitations of currently available restorative materials.

On the other hand, direct filling composite resin restorations are widely used to fill decayed teeth. These materials consist of a glass and/or ceramic particles placed into a resin to create a paste. The paste is placed directly into the tooth and cured.

Orthodontics involves movement of teeth by applying force to the teeth via wires which are tied to brackets mounted on the teeth. Most brackets are fabricated from metal which is not aesthetic. New brackets fabricated from alumina are more aesthetic but tend to fracture prematurely and also wear the opposing teeth. Alumina brackets also have high friction with the archwires which slows the tooth movement and prolongs treatment time. Plastic brackets deform and thus decrease the force transmitted to the teeth, prolonging treatment.

SUMMARY OF THE INVENTION

A process for preparing a ceramic network for fabricating stronger, more aesthetic, and better wearing restorative materials. A restorative material may be based on monomer, glass, or metal infusion or a ceramic network, or monomer infusion of a partially, glass infused ceramic network may present advantages over currently available restorations, such as composite resin and ceramic restorations, with respect to wear resistance and strength. It is a technical advantage that such a restorative material may have improved wear resistance and flexibility with respect to conventional composite resins and ceramics. It is a further technical advantage that in restorative materials made according to this invention, the masticatory surface, e.g., the coronal portion, may be glass infused to provide a bard, wear resistant restoration. For example, a glass layer may have a hardness in a range of about 300 to 600 KHN and an elastic modulus in a range of about 70 to 80 GPa. In addition, it may have a flexural strength of about 200–500 MPa, and the polymer infused interior may have a flexural strength of about 150–80 MPa and an elastic modulus of 15–25 GPa.

One embodiment of the invention includes producing implant abutment parts which may be machined directly from resin infused ceramic or the ceramic mixed with a binder which may be directly molded to form the part. The binder is burned out and the ceramic is sintered, infused and then cured.

Additionally, endodontically treated teeth often require crown restorations. Polymer infused ceramic may be used to fabricate posts, or post and cores may be milled directly from a block or can be molded into custom or prefabricated parts. Advantages of this material include its increased strength, improved translucency and cementing ability.

Furthermore, orthodontic brackets which are polymer infused have the advantages of improved fracture toughness, aesthetics and decreased enamel wear. They also have decreased friction with orthodontic arch wires which eases tooth movement and decreases treatment time. These brackets may be fabricated by machining a block of polymer