



RESEARCH ARTICLE – DENTISTRY (MISCELLANEOUS)

Polymer Infiltrated Ceramic Network in Dentistry: A Narrative ReviewNisreen Manaa Khalaf^{1*}, Zahra N Alwahab¹, Nihad AlFurajji¹, Syed Qasim²¹Middle Technical University, College of Health and Medical Techniques, Prosthodontic Dental Techniques Department²Kuwait University, Safat 13110, Kuwait, Department of Bio Clinical Sciences, Faculty of Dentistry*Corresponding author E-mail: nisreenmanaa3@gmail.com

Article Info.	Abstract
<i>Article history:</i>	
Received 13 Apr. 2025	Background: The excellent mechanical compatibility of polymer-infiltrated ceramic network materials (PICN) with human enamel has contributed to their exploration as a crown restoration material. PICNs were produced by polymerizing a resin monomer that has been soaked into porous ceramics.
Revised 13 May 2025	Objective of study: Analyze effect PICN materials that have many characteristics with dentin and enamel. PICNs have properties that are transitional between those of resins and ceramics due to their unusual microstructure, which consists of a dual-network consisting of the ceramic framework and polymer phases.
Accepted 20 May 2025	Materials and Methods: The scientific literature on this topic was searched through both an electronic systematic review (using Science Direct, PubMed, the Web of Science, and Google Scholar) and a manual search. This review was a compilation, analysis, and selection of articles published between 2013 and 2023. Studies of ceramic networks infused with polymers for use in dentistry were described. This evaluation includes over 38 papers that were selected for their potential relevance to the topic at hand.
Publishing 10 Nov. 2025	Results: The results demonstrate that the information at issue was adequate for characterising the microstructure and determining some mechanical features of the commercially available polymer-infiltrated ceramic-network (PICN) material (Vita Enamic, Vita Zahnfabrik). PICN may be a good option for in-office dental procedures because it does not need to be sintered or burned after milling. The manufacturer recommends PICN for use in both the anterior as well as posterior crowns (including implant-supported crowns), inlays, onlays, partial crowns and veneers for single teeth. Conclusion: Researchers have shown that PICN materials have many characteristics with dentin and enamel; it reduces abrasion on opposing tooth surfaces more than other dental ceramics; and it is harder than composites, making it more wear-resistant.

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Keywords: Polymer Infiltrated Ceramic Network; Hybrid Ceramic; PICN; VITA Enamic; Microstructure**1. Introduction**

Prosthetic dentistry aims to replace lost teeth or dental tissues with artificial replacements that function and look much like the real thing [1]. The superior biocompatibility and good aesthetic performance of veneering porcelain fused on ceramic substrates have made all-ceramic restorations a viable option for metal restorations [2, 3]. Dental ceramics are parts of a dental prosthesis, that can be used to replace missing or damaged teeth, and have been successfully used in full crown and bridge restorations to preserve the appearance and function of damaged natural teeth [4]. In addition to being chemically stable, the mechanical, optical, and biocompatibility qualities of ceramics were all highly regarded. However, if repairs were needed after being inserted into the mouth, it can be difficult. In contrast, ceramic has superior wear, biocompatibility, and mechanical qualities, whereas composites are easier to operate and repair. Composites have an elastic modulus similar to dentin, which has motivated some authors to suggest combining the two., with feldspathic ceramic, which is analogous to enamel and would offer long-term aesthetics, to create the ultimate restorative material. To make this simpler to accomplish, researchers have developed a novel material called polymers-infiltrated-ceramic-network (PICN) that seeks to mimic the qualities of a genuine tooth. A sinterized feldspathic ceramic forms the porous phase of PICN, and a polymer infiltrates it (usually methacrylates in the dentistry field) [5]. Dental restorations made of resin composites or ceramics were currently the preferred and most popular option. In resin composites, a polymeric organic matrix is combined with inorganic filler particles, creating a material with unique features. The matrix's constituent monomers influence polymerization shrinkage, while the filler particles translate directly into the material's Young's modulus and hardness. Ethoxylated bisphenol A glycol dimethacrylate (Bis-EMA), bisphenol A-glycidyl methacrylate (Bis-GMA), urethane dimethacrylate (UDMA), urethane

tetramethacrylate (UTMA), and urethane tetramethacrylate (UTMA) are all popular forms of methacrylate [6]. The initial dental application of hybrid ceramic CAD/CAM material was resin nanoceramic, which was developed in 2012. The building blocks of this substance were zirconia-silica clusters and nanoparticles of zirconia and silica, that were randomly dispersed in a polymer matrix [1]. In 2013, VITA Zahnfabrik presented to the dentistry market CAD/CAM hybrid ceramic blocks (Vita Enamic) built from polymer infiltrated ceramic networks. Vita enamic was thought to have mechanical qualities similar to those of human teeth [7].

Nodes made of polymer (UDMA and TEGDMA) and a regulating ceramic matrix (Feldspar) penetrate each other in the dual network design. An acrylate-based polymer mesh supports a feldspathic ceramic crystal network structure in this material. This material had a stronger wear resistance than standard composites and a far lower fracture rate when compared to ceramics. Materials with a lower fracture toughness grind more successfully and show improved marginal Better visual adaption was achieved with VITA enamic due to its superior adaptability, stress resistance, and light conductivity [8]. The surface properties of a material can be affected by its microstructure. Plaque retention, restoration life span, and the restoration's appearance were only a few of the clinical aspects that can be affected by the surface roughness of dental restorations [1].

The PICN (Vita Enamic) material is made from two different matrix structures, one of sintered ceramic and the other of polymeric material. Investigations into its microstructure, composition, mechanical characteristics, and adhesive behaviour were conducted. The mechanical properties of PICN were intermediate when compared to those of nanoceramic resins, feldspathic porcelain, and lithium disilicate glass ceramic [9]. VITA enamic's structure is built on two overlapping networks: a ceramic mesh (86% of the material) and a polymer (14%) as shown in Table 1 below. As was previously indicated, the hybrid material's structure enables us to take advantage of the benefits of both ceramics and composites. The ceramic additive may significantly boost the material's strength, making it superior to composite resins in performance [10]. Crowns in the posterior segment, aesthetic segments, and restorations with reduced wall thickness can all benefit from VITA enamic (VITA Zahnfabrik). The ability to design restorations around implant frames becomes a reality as a result. With a polymer reinforcement layer and a mostly ceramic mesh (86%), VITA Enamic's structure is built on two interpenetrating networks. We can combine the advantageous qualities of ceramics and composites thanks to the hybrid material's structure, as previously stated. For superior visual adaptation, go no further than VITA enamic, thanks to its ideal flexibility, stress resistance, and light conductivity [8].

2. Materials and Methods

"Polymer infiltrated ceramic network," "resin infiltrated ceramic," and "hybrid ceramic" were the search terms used." "VITA Enamic," "Microstructure," and "Mechanical properties" in Google Scholar, PubMed, Science Direct, and Z-library. Between 2013 and 2023, researchers published numerous studies on the chemical composition, physical characteristics, and other aspects of PICN. Other studies focused on the microstructure of PICN and its applications in dentistry and biomaterials. In addition to reviewing previous work on Polymer infiltrated ceramic networks, the current work aims to offer research problems and future objectives. The findings from the current Polymer infiltrated ceramic network study can be applied to the practise of dentistry in any area where there is interest in conducting additional research.

Monolithic dental restorations made today, for example PICN hybrid ceramic, have been the subject of substantial research into their microstructure and mechanical properties. The good mechanical characteristics and binding strength of PICN have been highlighted in recent review studies, and this has led to optimism about the material's potential clinical application for indirect permanent restorations like crowns. Vita Enamic, a commercial PICN, has been extensively utilized in both clinical practice and basic research for more than ten years. As a result of its widespread use, Enamic is the PICN that dentists typically recommend. To build a new CAD/CAM block that was technically appropriate for usage with human teeth, an experimental PICN (EXP) was created [11].

Table 1. Materials used in this study [7]

Materials (Commercial names)	Type/description	Chemical composition (In wt%)	Manufacturer	
Vita Enamic CAD/CAM blocks	Innovative hybrid ceramic size: EM-14 shade: 2 M2-T	86% fine-structure feldspathic ceramic (58-63)		VITA Zahnfabrik, Spitalgasse 3. Germany
		SiO2		
		AL2O3	20-23	
		NaO2	9-11	
		K2O,	4-6	
		ZrO2	0-1	
		14 polymer: (urethane dimethacrylate) UDMA, (triethylene glycol dimethacrylate) (TEGDMA)		

3. Results

New dental restorative material termed resin-matrix ceramics has been developed and introduced to the market because of its high physical, chemical, and cosmetic quality standards. They were simple to deal with in processing and further treatment, and their use can lessen brittleness and improve machinability [10]. The material is new to the market, but its supporters believe it has desirable properties for use in dental prostheses. Resin matrix ceramics were distinguished from silica-based ceramics by their superior milling properties, load capacity, and modulus of elasticity. The aesthetic appeal extends to the visual properties that resin matrix ceramics share with natural teeth [8]. An organic matrix is densely packed with ceramic particles to form resin-matrix ceramics. Even though there might be a small amount of organic

phase (polymer), the refractory inorganic chemicals make up the vast majority of their composition (> 50% by weight). The ceramic particles in resin-matrix materials are distributed throughout an organic matrix.

Even if there was a smaller organic phase (polymer), refractory inorganic compounds make up more than half of their mass. There was a wide range of inorganic compositions in resin- matrix ceramics. As an example, the Lava Ultimate "Resin Nano Ceramic" from 3M ESPE contains a matrix of urethane dimethacrylate (UDMA) and zirconia-silica nano-fillers in the form of aggregated or dispersed particles, accounting for 79% of the weight. Composite materials have recently emerged as a result of advancements in computer-aided design and manufacture (CAD/CAM). These materials offer several advantages over ceramics, such as being millable, resistant to chipping, repairable within the mouth, and reducing wear on opposing teeth [12]. To achieve optimum infiltration, resin mixture ratios were modified. The resulting PICN composites were comprehensively characterized, including their flexural characteristics, Vickers hardness, wear resistance, etc.

This involved the infiltration of resin combinations into the ceramic networks as well as their viscosity and the degree of porosity and shrink of prefabricated ceramic-networks [13]. RMCs are considered to be superior to conventional ceramics because they may be applied immediately following milling; conventional ceramics require additional processing stages like burning, sintering, and glazing before they can be used. These materials aim to achieve the same or similar flexural strengths and elastic moduli as real teeth. Ceramic and resin are among the materials utilized in their production. Materials with polymer-infiltrated ceramic networks (PICNs) are created using a polymer combination of UDMA and TEGDMA is injected into porous ceramic scaffolds [14].

Resins-based ceramics (RBC) and polymer infiltrated ceramic network (PICN) resins are two types of hybrid polymer ceramics (HPC) and resin matrix ceramics (RMC). Hybrid materials (HPC, RMC, RBC, and PICN) are starting to gain favor because of their high flexibility and structural resilience [15]. Ceramics that combine elements of several materials known as hybrids., and nano ceramics, have shown promise because they integrate the aesthetic trends of modern dentistry with the least invasive procedures of modern clinical workflows [16]. Resin networks were polymer networks formed when organic monomers were polymerized in the presence of starting materials [17]. This matrix can then be used to encase inorganic fillers. The goal of developing hybrid materials was to take advantage of the best features of both ceramics and composites [18]. By piercing the filler's porous structure, the resin matrix creates micromechanical interlocking at the filler/resin matrix interface as shown in Fig. 1, which improves the composites' elastic modulus and ageing stability. This phenomenon demonstrated the strength of the physical micromechanical interlocking against the harsh conditions of the mouth Fig.1 [17].

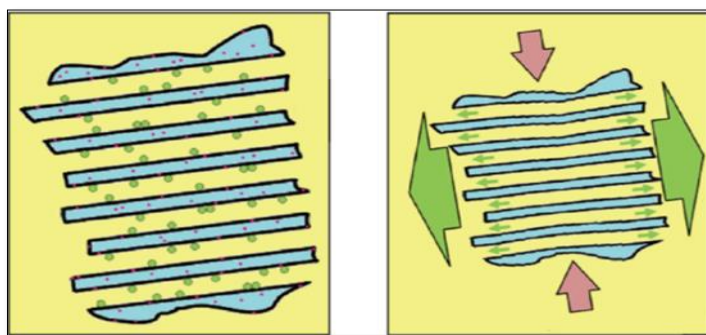


Fig.1. Schematic diagram of mechanism for optimizing the linked porous structure (high deformation, insertion of bioactive particles, and improved interfacial interactions

3.1. Resin-based ceramics (RBC)

This is a novel material in the market, however it has been found to have some desirable qualities for dentures. In comparison to silica-based ceramics, resin-based ceramics have superior milling performance, a larger load capacity, and a higher elastic modulus [10]. Differentiating between resin-based ceramics (like 3M-ESPE's Lava Ultimate) and hybrid ceramics (like VITA-Zahnfabrik's VITAEnamic and GC's Cerasmart, The polymer matrix in the former makes it feasible to make the latter (both of which were manufactured utilising polymer-infiltrated ceramic network (PICN) technology). There was a clear distinction between resin-based ceramics (such as 3M-ESPE's Lava Ultimate in Seefeld, Germany) and hybrid ceramics as shown in Fig 2, both of which were composed of a polymer matrix with at least 80% nanosized ceramic filler particles. (e.g., VITA enamic by VITA-Zahnfabrik, Bad Säckingen, Germany and Cerasmart by GC, Leuven, Belgium) made of a ceramic network infiltrated with a polymer using polymer-infiltrated ceramic network (PICN) technology [8].

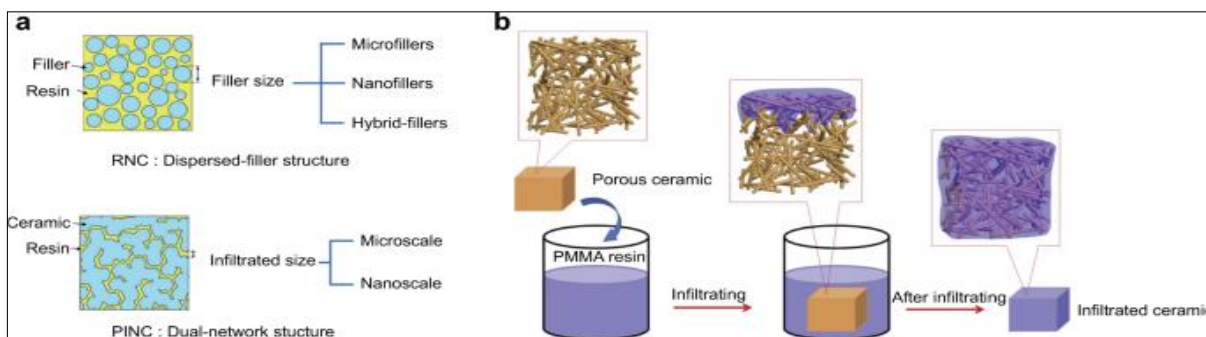


Fig. 2. Porous scaffolds. **a** Schematic diagram of RNC and PINC[19]. **b** Schematic diagram of polymer infiltrating porous scaffold [20] Figures adapted with permission from refs. [19, 20]

3.2. Polymer infiltrated ceramic network (PICN)

Product VITA "Polymer Infiltrated Ceramic Network" (PICN) The interpenetrating phases in enamic are novel . A polymer network strengthens the main fine-structure feldspar ceramic network (86 percent by weight or 75 percent by volume) [21], creating a dual-network structure in three dimensions. The Enamic (VITA, Bad Säckingen, Germany) material was created using a cutting-edge method for creating PICNs. This material was made by partially sintering ceramic particles, followed by infiltrating them with a polymer of low viscosity by capillary action. Polymer-ceramic interconnected networks (PICNs) have two separate networks instead of only one, like resin composites [22]. The advantages of both ceramic and polymer materials were brought together in PICN. It has a double mesh structure, making it a ceramic-polymer hybrid. Polymerization by capillary infiltration into a presintered porous ceramic network (PICN) describes a specific technique. High flexural strength and flexibility, similar to dentin, distinguish PICN from composite resins in terms of wear resistance. The intermixing of ceramic and polymer stops cracks from spreading, and the material's dominant ceramic network proves to be wear-resistant. As a relatively novel material, PICN restorations lack long-term follow-up investigations. The material is only available in a few shades, and its long-term effects on cervical regions and discolorations have not been adequately studied. Veneers, inlays/onlays, single crowns in the anterior and posterior, and implant prostheses are all good candidates for the PICN. A reduced aesthetic result makes this material more suitable for posterior reconstructions [13, 23]. There have been several studies, both theoretical and experimental, that have made use of a commercially available PICN composite termed VITA ENAMIC [24]. Indirect tooth replacement using CAD/CAM building components was a reality. For instance, PICN composites have been proven in prior studies to effectively mimic human enamel from a mechanical standpoint. Unlike conventional DF composites, this design does not involve dispersing filler across a resin matrix. Indirect tooth restoration using the commercially available PICN composite VITA ENAMIC (composed of a silicate glass ceramic skeleton with infiltrated acrylic resin) has been the subject of numerous basic and clinical studies [25]. The mechanical properties of PICN composites are very similar to those of human enamel [26]. There is still potential for improvement due to the discrepancies in the mechanical characteristics of PICN composites and teeth [23].

VITA enamic's production method provides a lower fracture tendency and better CAD/CAM processing performance than that of pure ceramics. Furthermore, their optical characteristics were similar to that of real teeth, and they exhibit less tooth wear than ceramics [27]. When compared to more traditional restorative materials nano-ceramic resins and polymer-infiltrated ceramics are considered to have many advantages. Resin composites were versatile, but polymer infiltrated ceramic networks (PICN) were durable and long-lasting in appearance as well. Previous research has looked into the mechanical characteristics of PICN and similar resin-ceramic composites. PICN approaches current glass ceramics in its hardness, flexural durability, and modulus of elastic modulus, whereas CAD/CAM resin-ceramic composites excel over traditional direct resin composites [28].

Vita Enamic, a type of PICN, is a multiphase structure made up of a feldspathic ceramic inorganic phase (86 wt.% or 75 vol.%) and a dimethacrylate polymer organic phase (UDMA and TEGDMA; 14 wt.% or 25 vol.%). The two phases of the PICN were linked together, allowing each to contribute its properties and so optimizing the bulk material's overall characteristics. The PICN's true value lies in how well it mimics real teeth. In preliminary testing, Vita enamic was shown to have a Young's Modulus similar to dentin and a hardness intermediate between enamel and dentin. Enamic's physical structure was quite similar to that of interlocking prisms of natural teeth. Because of this, PICN has shown an increased resistance to crack development, which is similar to the strengthening effect found in human enamel [29]. The physical and mechanical similarities between PICN and natural dentition make it an ideal material for dental restorations. Although PICN has these desirable qualities, it lacks the strength of other ceramics utilized in CAD-Milling veneers or crowns, such as LDS based glass ceramics (IPS e.max CAD) [29]. Computer-aided design and computer-aided manufacturing (CAD/CAM) might facilitate the effective processing of the hybrid ceramic Vita enamic. After the polymer has been ground up and mixed with the sintered feldspar ceramic block, it is no longer essential to use a ceramic furnace as shown in Fig.3 . Instead, it just needs some finishing touches to make it perfect. Now can offer in-chair, once-and-done treatment [24]. The VITA Zahnfabrik in Bad Säckingen, Germany, created and distributed the first PICN, known as VITA Enamic®. The monomer and polymer that were synthesised from the inorganic feldspathic ceramic matrix make up the remaining 14% wt. The organic polymeric component, consisting of urethane dimethacrylate (UDMA) and triethynel glycol dimethacrylate (TEGDMA), contributes to around 14% of the overall mass [30].

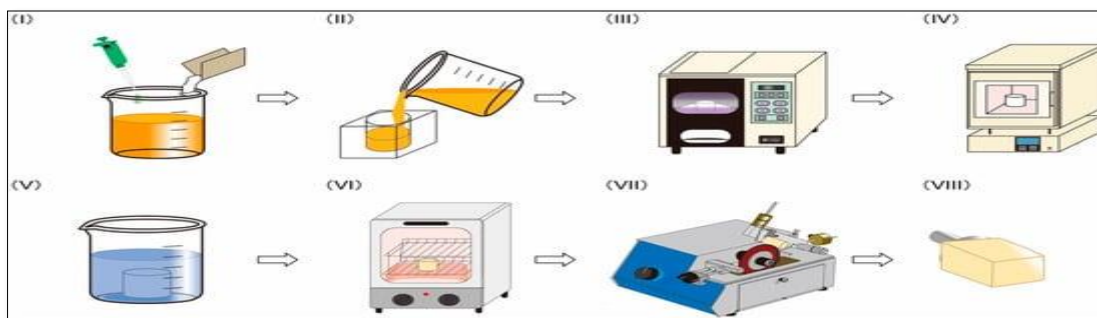


Fig. 3. Computer-aided design and manufacture (CAD/CAM) building blocks made from a polymer infiltrated ceramic network (PICN) composite: First, a light-curable precursor solution is made, then the precursor is moulded, then the precursor is cured with light to form a green body, then the green body is sintered to create a porous body, then the resin monomer is infiltrated into the porous body, then the body is heated to polymerize the resin, and finally the PICN composite is cut into CAD/CAM blocks [23]

3.3. Nano-ceramic resins (NCR)

Different parts of nanoceramics share the same resin composite microstructure. About 80% of their weight comes from ceramic nanoparticles (size less than 100 nm), which were dispersed within a polymeric matrix. These fillers could be made of a polycrystalline ceramic (zirconia) or regular ceramic. The properties of nanoceramics mimic those of healthy teeth. Their flexural strength was typically around 200 MPa [31]. Nano-ceramic resins (NCR) are a composite material consisting of a resin matrix, a silane coupling agent, nanocluster particles (0.6-10 m),

silica nanomers (20 nm), zirconia nanomers (4-11 nm), and a silica nanocluster particle. enclosed within an extremely dense matrix of cross-linked resin (80% by weight) [30]. include nanoceramic particles made of zirconia and silica (Lava Ultimate®, 3M ESPE, St. Paul, MN, USA). Lava Ultimate (3M ESPE, USA) is a nanoceramic material that can be used in CAD/CAM processes [32]. The strong chemical bonds formed between the nanoceramic structure and the resin are responsible for the material's outstanding fracture strength. This substance also boasts a tensile strength of two hundred megapascals [26].

4. Discussion

There has been a rise in the usage of hybrid materials for dental restorations, such as resin-based composites (RBC) and polymer-infiltrated ceramic network materials (PICN). Traditionally, silicate ceramics have been used for restorations, but RBCs and PICNs were preferable due to their lack of heating and the ease with which they might be processed in the lab and the dental office. Compared to ceramic restorations, the flexural modulus and strength of these hybrid materials were similar to those of real teeth, and they are easier to repair in the mouth. Researchers have also noted that restorations made from these materials had a smaller impact on opposing teeth. PICN's enhanced marginal stability allows for smaller margins than those possible with silicate ceramics, allowing for more conservative restorations [33]. Made by VITA Zahnfabrik in Bad Säckingen, Germany, Vita Enamic was a hybrid ceramic that features a ceramic network supported by an acrylic polymer network resin. It was believed that its load-bearing capacity was enhanced in a way similar to teeth by combining a low flexural modulus with a high flexural strength (150-160 MPa), as the latter will allow for greater elastic deformation before failure.

The Vita Enamic's unique double-network microstructure was essential to the micromechanical bonding and performance of the adhesive interface because of its ability to limit the spread of cracks [34]. Polymers had been injected into the ceramic matrix, turning "glass-ceramic in a resin interpenetrating matrix" into a "hybrid ceramic" with a bi-layered network. Feldspathic ceramic's essential network (weight: 86%) was strengthened with the polymer "UDMA, TEGDMA" (14% by weight). "Polymer-infiltrated ceramics" were more robust and have a higher fatigue strength than glass ceramics [35]. To retain the benefits of ceramic and composite materials, hybrid ceramics were developed to mimic the mechanical and visual properties of native tooth tissues. Resin nanoceramics (RNC) and polymer-infiltrated ceramic-network materials (PICN) are two types of hybrid ceramics. VITA ENAMIC, manufactured by VITA Zahnfabrik in Bad Säckingen, Germany, has been the only PICN on the market since its introduction in 2013.

The remaining fourteen percent of its mass was comprised of a polymer that has been infiltrated into a sintered ceramic matrix and polymerized at high temperatures and pressures during manufacture [36]. CAD/CAM (computer-aided design/computer-aided manufacturing) technology has been a boon to the field of restorative dentistry by facilitating the development of more visually acceptable materials for use in the dental chair. Some examples of such materials include Vita Enamic (Vita Zahnfabrik, Bad Säckingen, Germany), which consists of a fine glass ceramic three-dimensional network infiltrated with a mixture of urethane dimethacrylate (UDMA) and triethylene glycol dimethacrylate (TEGDMA) monomers. This material has ceramic-like qualities due to its exceptional visual quality and exquisite surface structure. Improvements in milling performance and resistance to loading pressures are two other outcomes of increasing fracture toughness in restorative manufacturing. The polymer structure also allows for the production of smoother, thinner margins with fewer faults, which serves two purposes: on the one hand, it helps to preserve tooth structure, and on the other, it improves the accuracy of the restoration's marginal region. Fitting dental restorations snugly increases their longevity [37].

The mechanical compatibility of polymer-infiltrated ceramic network (PICN) materials with human enamel has prompted their study as a crown restoration material. PICNs are manufactured by polymerizing a solution of a resin monomer and porous ceramics that have already been pre-sintered. PICNs have a dual-network of the ceramic backbone and polymer phases, giving them properties that are an in-between state between resins and ceramics. PICNs were analysed mechanically to see how closely their flexural strength, surface hardness, and elastic modulus resembled those of human teeth, specifically enamel and dentin. When compared to modern dental materials, PICNs have properties more akin to actual teeth, namely in terms of Vickers hardness and elastic modulus. Extensive work has gone into developing new PICNs that mimic teeth in appearance. Thus, theoretically, PICN materials are very successful tooth-restoration materials [11].

5. Conclusion

Hybrid ceramics have many applications in dentistry. Milling hybrid materials was straightforward and no sintering was needed. The processing time has decreased as a result. Even after final cementation, the restoration might be characterised and ground or polished. Hybrid ceramics' modulus of elasticity was lower than porcelain's and more similar to dentin's. This means it protects both sets of teeth from wear.

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Nomenclature & Symbols

PICN	Polymer-infiltrated ceramic network	UDMA	urethane dimethacrylate
Bis-GMA	Bisphenol A-glycidyl methacrylate	UTMA	urethane tetramethacrylate
Bis-EMA	ethoxylated bisphenol A glycol dimethacrylate	TEGDMA	triethylene glycol dimethacrylate
ZrO ₂	Zirconium dioxide	HPC	Hybrid-polymer ceramic

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