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Review Article

Recent Advancements in Materials Used in Implant Rehabilitation: A Review

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Abstract

Implant rehabilitation has been made from titanium, gold, alumina, zirconia, and glass materials. The long-term prognosis of an implant restoration depends on meticulous care taken in the diagnosis and the treatment planning for the patient. While titanium abutments are by far the most used and show excellent success rates, their grayish color and the possibility of corrosion and degradation render them less attractive. Before the introduction of zirconia, alumina abutments were used mainly in the anterior zone and for single-tooth replacement, and these were associated with high success rates. Yittria-stabilized zirconia abutments benefit from increased fracture toughness and flexural strength. Hybrid abutment crowns can also be made from lithium disilicate, zirconia-lithium silicate, and hybrid resin-matrix ceramics. High impact polymers have been introduced as dental abutments or framework materials to support single crowns to full-arch reconstructions. Poly-ether-ether-ketone (PEEK) is a sub family of the poly-aryl-ether-ketone. PEEK is a high performance thermoplastic linear homopolymer composed of similar repeating units.

Key words: Hybrid abutment crowns, Implant rehabilitation, Poly-aryl-ether-ketone, Poly-ether-ether-ketone, Yittria stabilized zirconia

INTRODUCTION

Dental implant therapy has dramatically expanded the treatment options available for both the partially and completely edentulous patient.[1] Implant supported overdentures and hybrid prosthesis often provide support for the soft tissues of the face when compared to the traditional fixed prosthesis, with the emergence of computer-aided designs and the development of prosthetic materials.[2] Implant rehabilitation materials have been made from titanium, gold, alumina, zirconia, and glass materials.[3] The long-term prognosis of an implant restoration depends on meticulous care taken in the diagnosis and the treatment planning for the patient.[1]

IDEAL REQUIREMENTS OF IMPLANT REHABILITATION MATERIALS

Requisites of an ideal implant restorative material[4]

- It should be stable in the oral environment and should not undergo rapid corrosion.
- It should fit passively over the various implant abutment.
- It should be esthetic.
- It should not induce undue amount of stresses in the implant or the bone.
- It should be biocompatible and should not induce any allergic reaction.
- It should be easy to fabricate and handle.
- It should be cost-efficient.

RECENT ADVANCEMENTS IN IMPLANT REHAB MATERIAL

PEEK

Poly-ether-ether-ketone (PEEK) is a sub family of the poly-aryl-ether-ketone (PAEK). PEEK is a high performance thermoplastic linear homopolymer composed of similar repeating units. PEEK imparts its stiffness from aromatic benzene rings and its ability to rotate in an axial direction thanks to ether oxygen bonds.[5] PEEK implants rehabilitation materials can be produced using readily available 3D Printers.[6] Modified PEEK materials are also used to construct removable partial denture frameworks, resin-bonded FPDs, conventional bi-layered FPDs, and

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crowns and retentive clips on implant bars. PEEK materials are less prone to surface roughness when compared to composites.[7]

Poly-Ether-Ketone-Ketone (PEKK)

PEKK is a semi-crystalline thermoplastic in the poly-aryl-ether-ketone (PAEK) family, with high heat resistance, chemical resistance, and the ability to withstand high mechanical loads. PEKK's glass transition temperature (Tg) is 162°C. PEKK replaces one of the flexible Ether linkages with a more rigid Ketone group. This increases the glass transition temperature (Tg)– where the material first begins to soften– by about 15°C. PEKK is easier to 3D print than PEEK (i.e., better layer adhesion), all while offering similar strength and resistance properties (i.e., better dimensional accuracy). PEKK was introduced more recently and has an 80% higher compressive strength and better long-term fatigue properties than unreinforced PEEK. The prosthesis design with PEKK framework material may be contraindicated for patients with opposing fixed dental prostheses or natural dentition, a history of bruxism, or unfavorable implant distribution.[8]

DEI® Experience (Microhybid Composite)

It is a micro hybrid composite summing up the knowledge acquired in the years over this important category of composites and taking advantage of its potentialities. DEI® experience is produced using modern manufacturing technologies and has optimal formulation for achieving high resistance and elasticity (respectively, 350 and 130 Mpa) and exceptional esthetics and shine. These features allow its use either at dental practice or at laboratory for preparation of bridges and crowns. It has excellent and esthetic surface smoothing and good stability of the color with particle size from 0.02 micron to 1 micron and a total filler content of 80%.It has a high compressive strength of 350 Mpa and fluorescence.[9]

SR Nexco (Fibre-Reinforced Composite)

SR Nexco paste is a purely light-curing fibre reinforced laboratory composite with micro-opal fillers which allows to achieve a lifelike shade even if space is limited. SR Nexco Paste restorations achieve a durable shade stability and a lasting gloss as a result of the polymerization process. SR Nexco is particularly suitable for restorations supported by metal-based frameworks, framework-free implant supported restorations, and prosthetic gingiva reconstructions. The composition of SR Nexco features a high content of micro-opal fillers. As a result, the optical properties of the restorations are comparable to those of natural teeth: The opalescent and fluorescent characteristics are extremely lifelike. A harmonious shade match is achieved in different restorations and under varying light conditions. Application on zirconium oxide frameworks – SR Nexco also unfolds its well-balanced physical and processing properties on zirconium oxide frameworks. Due to the micro-opal fillers, the restorations are imparted with lifelike translucency, opalescence, and fluorescence. The frameworks are prepared and the materials applied in the same way as in the veneering of metal frameworks.[10]

Telio-Computer-Aided Design (CAD) (Modified Cross-Linked PMMA)

Telio® CAD is CAD/computer-aided manufacturing (CAM)-fabricated implant-supported hybrid abutment crowns for individual and temporary single-tooth reconstructions. The material consists of a cross-linked polymer block (PMMA), enabling the fabrication of individual, monolithic hybrid abutment crowns which are directly cemented to a titanium bonding base. Shape, esthetics, and emergence profile can be easily designed and adjusted any time. The monolithically milled hybrid abutment crown is extraorally cemented to the titanium bonding base by means of multilink hybrid abutment. Then, the restoration is screwed onto the implant. The screw channel is sealed with a composite or a light-curing temporary restorative material. As a result of the industrial polymerization process, the blocks feature a high material homogeneity. Polymerization shrinkage or inhibition layers no longer have to be taken into consideration. Stains and/or layering materials can be used to apply final esthetic optimizations. It has a flexural strength up to 135 Mpa and solubility ranging from 7.5 to 0.0018 $\mu g/mm^3$.[11]

SR Adoro (Nanocomposites)

The advantageous properties of SR Adoro can be attributed to the high proportion of inorganic fillers in the nanoscale range. Furthermore, the matrix is based on a urethane dimethacrylate (UDMA), which has also been newly developed and which is characterized by its toughness, which is higher than that of its predecessors or the frequently used Bis-GMA. The material demonstrates color stability as well as outstanding enamel-like luster and natural opalescence. The range of indications of the SR Adoro veneering composite includes removable denture prosthetics (e.g., telescope crowns and model cast dentures) and fixed dental reconstructions (veneering material for metal or fiber reinforced frameworks).[12]

IPS e.max (Lithium Disilicate)

Lithium disilicate (LS_2) glass-ceramic is ideally suitable for the fabrication of monolithic restorations or veneered restorations in the anterior and posterior region. Due to its natural-looking tooth coloring and excellent light-optical properties, this material produces impressive results. experience. The material is used in the dental laboratory in conjunction with either press or CAD/CAM technology.

Years of clinical experience confirm the high strength of 500 MPa* for IPS e.max lithium disilicate. The outstanding performance of the material is based on a combination of excellent flexural strength and high fracture toughness adjusted to the given dental requirements.[13]

IPS e.max Press

Customized results: Implant-supported hybrid restorations using the press technique.

IPS E. max Press is used to create individual, aesthetic hybrid abutment restorations in combination with Viteo base titanium bonding bases. Two options are available for this purpose:

- Hybrid abutments

The hybrid abutment is an individually pressed lithium disilicate abutment, which is bonded to a titanium bonding base, for example, Viteo Base.

- Hybrid abutment crowns.

A hybrid abutment crown combines the abutment and crown in one. It is monolithically pressed and then securely bonded to the titanium bonding base with the help of Multilink Hybrid Abutment and subsequently screwed in place.[13]

IPS e.max CAD

IPS e.max CAD abutment solutions are designed for the fabrication of implant-supported hybrid structures for single teeth using CAD/CAM technology. The hybrid components are individually milled from lithium disilicate blocks (LS_2) and bonded to a titanium bonding base. This temporary restoration offers many options in terms of soft-tissue management and forms the basis for an aesthetic and functional permanent IPS e.max CAD restoration. The strong bond between the lithium disilicate glass-ceramic (LS_2) and the titanium bonding base is established with the specially formulated luting composite multilink hybrid abutment.[13]

3M Lava Esthetic (5% Yttrium Stabilized Zirconium Oxide)

3M™ Lava™ esthetic fluorescent full-contour zirconia discs are pre-sintered mill blanks used for the fabrication of esthetic, full-contour zirconia restorations. The restorations are designed using dental CAD software, and the data are converted into milling paths by CAM software. Subsequently, the discs are processed in milling units suitable for pre-sintered zirconia. Milled restorations must be finally sintered in a furnace suitable for zirconia, using the cycle designated for Lava esthetic zirconia. The discs are available in various heights and shades based on the VITA classical A1-D4® shade guide. All discs are pre-shaded with a shade gradient set vertically in the blank that becomes visible after sintering. With a flexural strength of 800 MPa and a high translucency, Lava esthetic zirconia is ideal for esthetic full-contour restorations including 3-unit posterior bridges. The material formulation is a composition of "zirconia" (zirconium dioxide, ZrO2) with a small addition of "yttria" (diyttrium trioxide, Y_2O_3). Final sintering at 1500°C for 2 h produces a dense polycrystalline microstructure. The shading elements are distributed and built into the crystals to provide the desired shade gradient and tooth-like fluorescence.[14]

3M LAVA Plus (3% Yttrium Stabilized Zirconium Oxide)

3M™ Lava plus zirconia discs are pre-sintered mill blanks used for the fabrication of esthetic and full-contour zirconia restorations. The material formulation is a composition of "zirconia" (zirconium dioxide, ZrO2) with a small addition of 3% "yttria" (diyttrium trioxide, Y2O3). The yttria content determines the so-called "phase" of the crystals, that is, how the Zr and O atoms are arranged. It has a flexural strength of 1100 Mpa and afracture toughness of 5–10 Mpa.[15]

CERCON® ALL CERAMIC (YTTRIUM – TETRA POLYGONAL ZIRCONIA (TZP) STABILIZED ZIRCONIA)

Cercon ht blanks are made of yttrium oxide- (yttria-) stabilized zirconium oxide (zirconia) (Y-TZP). They are used in fabricating frameworks for fixed prosthetic restorations. In contrast to conventional dental ceramics, Y-TZP is composed of many small particles without any glassy phase at the crystallite border.[16]

Cercon® HT (5% Yttrium TZP Stabilized Zirconia)

Depending on the framework design, cercon ht frameworks can be ceramically veneered or delivered as fully contoured restorations.

Cercon® XT (9% Yttrium TZP Stabilized Zirconia)

Cercon® XT demonstrates extra high translucency and unparalleled shade accuracy with life-like esthetics especially for the anterior region (flexural strength: 750 MPa).

NANOZR (CERIUM – TETRA POLYGONAL ZIRCONIA (TZP) STABILIZED ZIRCONIA)

Ceria-stabilized tetragonal zirconia-based nanocomposite ceramic (nano-zirconia) was a material which was developed by Nawa *et al.* This material inculcates nanosized alumina particles into the crystal grains of tetragonal zirconia (Ce-TZP), which are then stabilized with ceria. NANOZR is usually composed of 10 mol% of CeO_2

stabilized TZP as a matrix and 30 vol% of Al_2O_3 as second phase. The average size of the NANOZR is 0.49 μm. The significant characteristic of its structure is its intragranular-type nanostructure in which several 10–100 nm sized Al_2O_3 particles are trapped within the ZrO_2 grains. The raw material powder of NANOZR mainly consists of zirconium oxide (ZrO2), cerium oxide (CeO_2) as a stabilizer, and also alumina (Al_2O_3). Since alumina is present at 10 wt% or more, there is no translucency, and the color tone is pale yellow due to the effect of cerium oxide. The crystal structure is the eutectic of tetragonal zirconia and alumina. In addition, toughening is achieved by the formation of a nanocomposite structure in which the respective nanoparticles mutually diffuse in zirconia and alumina particles.[17]

VITA IN CERAM YZ CUBES FOR CEREC (ZIRCONIUM OXIDE)

Zirconium oxide is an oxide ceramic material with superior flexural strength among oxide ceramic materials. This results from the possibility of stabilizing ZrO_2 in its denser high temperature phase through the appropriate addition of yttrium oxide. Zirconium oxide is also referred to as "ceramic steel". This property also ensures the high durability of zirconium oxide under permanent load. VITA In-Ceram® YZ Cubes for CEREC® are presintered zirconium oxide blocks partially stabilized with yttrium oxide. In this condition that allows easy processing, they are used to grind enlarged bridge and crown substructures in the CEREC inLab system. Then, these structures are sintered (dense sintering process) in a special high temperature furnace so that they shrink and form highly stable and precision-fit structure which offer all physical benefits of zirconium oxide. The material can only be processed in Cerec 3/inLab, software update version 1.40 R950 (or higher) of Sirona Co.[18]

CONCLUSION

With newer materials being introduced in implant dentistry, it is imperative to acquire knowledge about various materials available and understand the factors, which will contribute to the success or failure of the restorations.[6] A polychromatic feldspathic CAD/CAM ceramic material can yield optical esthetics and a novel CAD/CAM hybrid ceramic material can provide sufficient fracture strength and load capacity for the posterior area. It maintains esthetics and masticatory functions and restores healthy periodontal and peri-implant conditions. Implant dentistry and dentistry in general will witness more applications of PEEK materials in the near future, mainly because of PEEK's ability to be modified using a wide range of materials and techniques. The concept of combining a costabilized zirconia with a dispersion of alumina and/or hexa aluminates provides a variable basis to design composite ceramics with a broad range of properties. Partial substitution of the alumina dispersion by strontium hexa aluminate can improve the strength and preserve toughness, hardness, and low-temperature degradation resistance.[8]

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