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Research Article

Masking Ability Of Implant Abutment Substrates By Using Different Ceramic Restorative Systems

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Abstract
Background: The restoration of missing teeth through implant reconstructions represents a reliable treatment modality. The survival rates for fixed dental prostheses (FDPs) are reported to be between 89% and 94% over a ten-year period. Hence; the present systematic review was conducted for assessing masking ability of implant abutment substrates by using different ceramic restorative systems.
Materials & methods: The present review analyzed the masking ability of implant abutment substrates by using different ceramic restorative systems. This literature review has revised the literature search and data extraction processes of an earlier systematic review concerning the masking properties of implant abutment substrates, incorporating relevant studies published subsequently. All the results were summarized and tabulated.
Results: Monolithic ceramics must be employed judiciously in the presence of discolored implant abutments. The use of bilayer systems, specifically Zirconia combined with Polymer ceramics, has proven to be the most reliable method for effectively concealing discolored substrates, including PEEK and titanium. Additionally, an increase in the thickness of the restoration enhances the masking capability across all restorative materials evaluated.
Conclusion: The variety of modern materials and techniques accessible for production of implant-supported, all-ceramic restorations complicates the selection of the most suitable treatment approach. The market is continuously evolving, with new products being introduced alongside an extensive array of existing options. Ongoing research is focused on the development of zirconia-alumina composites that are resistant to degradation at low temperatures, particularly for use in dental implant abutments. Future advancements are expected to facilitate the production of more resilient abutments and restorations, characterized by superior quality and reduced fabrication time and costs.

Key words: Implant, Ceramics, Restorative

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INTRODUCTION

The restoration of missing teeth through implant reconstructions represents a reliable treatment modality. The survival rates for fixed dental prostheses (FDPs) are reported to be between 89% and 94% over a ten-year period. These implant reconstructions are consistently subjected to functional forces, which can affect their longevity and the occurrence of complications. Various materials, including titanium, gold, alumina, and zirconia, have demonstrated biocompatibility and promote healthy mucosal attachment. As a result, clinicians are able to choose an appropriate abutment material for a specific case. Metal abutments are more likely to be visible through thin mucosa, potentially compromising aesthetic results compared to zirconia abutments. For this reason, ceramic abutments, particularly those made of zirconia, have gained popularity and are increasingly utilized in clinical practice.[1-3] Ceramics are recognized for their biocompatibility and inertness, exhibiting a significant level of stability within the oral environment. Consequently, they are deemed safe for application in the oral cavity. Nonetheless, ceramics possess a brittle nature, rendering them susceptible to fractures. Ceramics are frequently enhanced to address their intrinsic brittleness through the incorporation of particulate materials, the utilization of metal frameworks for support, or the complete fabrication from polycrystalline materials.[4] When aesthetic considerations are paramount, dental ceramics emerge as the preferred material due to their capability to closely resemble the look of natural tooth. Numerous investigations have explored the masking capabilities of various ceramic restorative materials.[3-5] Hence; the present systematic review was conducted for assessing masking ability of implant abutment substrates by using different ceramic restorative systems.

MATERIALS & METHODS

The present review analyzed the masking ability of implant abutment substrates by using different ceramic restorative systems. This literature review has revised the literature search and data extraction processes of an earlier systematic review concerning the masking properties of implant abutment substrates, incorporating relevant studies published subsequently.

General search strategy

The focused question for the current review had been assessed as per the well-developed PICO strategy (Population, Intervention, Comparison, and Outcome) (Sackett 2000, Akobeng 2005).

Population: Partially edentulous subjects

Intervention: Implant-supported fixed reconstructions based on different ceramic abutments with internal implant-abutment connection

Comparison: Implant-supported fixed reconstructions based on ceramic/metal abutments with external implant-abutment connection

Outcome: Survival as well as complication rates of the abutments as well as reconstructions.

A comprehensive search of electronic databases (PubMed, Scopus, and Web of Science) will be carried out using the following keywords:

- Ceramic restorative systems
- Implant abutment substrates
- Clinical outcomes
- Complications
- Dental implants

Inclusion criteria:

- Clinical trials and observational studies published in English
- Studies evaluating ceramic restorative systems for implant abutment substrates
- Studies reporting clinical outcomes and complications

Exclusion criteria:

- Case reports and reviews
- Studies evaluating other types of restorative materials
- Studies without clinical outcomes or complications data

RESULTS AND DISCUSSION

The advancement of technology within the ceramic sector has resulted in significant rise of usage of ceramic materials for dental restoration purposes. These materials provide numerous merits over traditional alloy options, comprising good optical characteristics, biocompatibility, reduced thermal conductivity, color stability as well as remarkable mechanical strength. Consequently, there has been a progressive transition in dental restoration practices from alloys to various ceramics. Ceramics occur to be well-suited for various manufacturing techniques, including subtractive manufacturing, additive manufacturing, and hybrid manufacturing. Additionally, ceramic-based restorations have demonstrated long-term clinical efficacy.[6-8]

Authors	Aim	Systems used	Conclusion
Jirajariyavej B et al[9]	evaluated the impact of abutment material as well as ceramic width on final color of several ceramic systems.	4 experimental as well as control ceramic samples in shade A3 had been cut from IPS e.max CAD, IPS Empress CAD, as well as VITA Suprinity PC block.	More ceramic width over the abutment minimized the color mismatch. Raising the width of ceramic on a yellow-shaded zirconia abutment instead of on titanium or white zirconia delivered an aesthetic color for entire restoration.
Soares PM et al[10]	Masking ability of several monolithic or bilayer ceramics with various widths over substrates advised for implant restorations by employing opaque as	Bilayer system [yttria-stabilized zirconia infrastructure+porcelain veneer: Zir+Pc] and monolithic systems [lithium disilicate under low, medium, or high translucency: LtLD, MtLD, or HtLD, accordingly, and a high-translucent yttria-stabilized zirconia: HtZir])	Monolithic ceramics must be handled with care over discolored abutments. Bilayer systems (Zir+Pc) had been the most anticipated technique to sufficiently mask discolored substrates like PEEK or Ti.

	well as translucent evaluation pastes		
Bacchi A et al[11]	To assess the substrate masking ability of various ceramics.	11 ceramic cohorts had been investigated (n=10). Bilayer cohorts were: ZrPc - zirconia+porcelain; CAD-onHT - zirconia+high translucent lithium disilitace; CAD-onLT - zirconia+low translucent lithium disilicate; LDPc - high opaque lithium disilicate+porcelain. Monolithic groups were: TZ - high translucent zirconia; TLS - translucent, zirconia-reinforced lithium silicate; HTLS - high translucent, zirconia-reinforced lithium silicate; LTLD - low translucent lithium disilicate; HTLD - high translucent lithium disilitace; LGC - leucite-reinforced glass ceramic; FC - feldsphatic ceramic.	Zirconia cohorts displayed reduced ΔE_{00} as well as TP_{00}. Each discolored substrate tested is appropriately masked with veneered zirconia or with LDPc .
Fachinetto E et al[12]	Assessed the color variations when discolored substrates had been managed with CAD/CAM monolithic ceramics.	6 ceramic types had been evaluated: high-translucent lithium disilicate (LD-HT); medium-translucent lithium disilicate (LD-MT); low-translucent lithium disilicate (LD-LT); low-translucent leucite (LC-LT); feldspathic ceramic (FC); and BL1 low-translucent lithium disilicate, stained to A1 shade (LD-BL1-LT).	The utilization of low-translucent glass-ceramics as well as Opaque White try-in paste are aid in diminishing color variations.
Soares PM et al[13]	The influence of resin composite layering on discolored substrates to achieve masking ability with monolithic ceramic	4 cohorts (n = 8) of CAD/CAM monolithic ceramics, shade A1, with widths of 1.0 as well as 1.5 mm, had been evaluated: feldspathic (FC), leucite-reinforced (LC), lithium disilicate-reinforced (LD), as well as translucent zirconia (5YSZ).	Layering severely discolored substrates with selected opaque resin composites assures masking ability for restoration with CAD/CAM monolithic ceramics.
Bidaki A, et al[14]	Masking ability of computer-aided design as well as manufacturing () bleach shade ceramics in various widths on titanium abutments.	Celtra Duo (CD), Vita Suprinity (VS), and zirconia Luxen	Besides VS ceramic in widths of 1 mm, the rest of the bleach shade ceramics in all three widths of 1, 1.5, as well as 2 mm have sufficient capability to mask the titanium background as well as their usage in line with the masking ability of titanium background has led to suitable esthetic outcomes.
Passos L et al[15]	masking ability of CAD/CAM zirconia-reinforced lithium silicate (ZLS) glass-ceramic	90 high-translucency (HT) as well as low-translucency (LT) ZLS glass-ceramic discs of various widths (1.0, 1.5, as well as 2.0 mm) had been assesed as a monolithic structure	To attain ideal masking, the least width of CAD/CAM ZLS glass-ceramic must be 1.5 mm over a gold background, while two millimeters over a C2 background.
Tomm AGF et al[16]	fatigue resistance of monolithic zirconia (Yz) as well as multilayer ceramic structures employing the CAD-on strategy in multiple widths.	fiberglass-reinforced epoxy resin (NEMA grade G10), digitalized, as well as restorations were machined in CAD-CAM, constituting five cohorts: Control: 1.5 mm (milled zirconia framework + manual layered porcelain); Yz monolithic 1.5 mm; Yz monolithic 1.0 mm; CAD-on 1.5 mm; and CAD-on 1.0 mm.	The Weibull modulus of CAD-on 1.5 mm had been greater compare to the control whilst being similar to other conditions. Both the monolithic systems as well as the CAD-on strategy presented high as well as identical fatigue fracture behavior as well as survival rates, which were also greater as compare to the control bilayer system.

Tabatabaian F et al[17]	Determined the color masking ability of a zirconia ceramic on substrates with numerous values.	Zirconia disk specimens,0.5 mm in width as well as ten millimeters in diameter, had been manufactured by a CAD/CAM system. 4 substrates with distinct values had been constructed, including: white (control), light grey, dark grey, as well as black	Tested zirconia ceramic did not show adequate color masking ability to hide the grey as well as black substrates.

In vitro research indicates that the biocompatibility of zirconia (Zir) surpasses that of titanium oxide as well as is comparable to that of alumina. Zirconia is favored for implant-supported restorations due to its superior toughness as well as less elastic modulus. Such abutments are known for their tooth-like color, good tissue compatibility, as well as minimal plaque formation. A study having a 4-year follow-up revealed a one hundred percent survival rate for fifty three implants. However, an instance had been reported where a subject having more than one implant-supported crowns underwent metal sensitivity. Osseointegration had been successful in the two scenarios. Nonetheless, Zirconia remains a dependable material for abutments in implant-supported crowns as well as fixed dental prostheses. Concerns have been raised regarding the long-term clinical efficacy of Zirconia in fixed implant prosthodontics, particularly due to problems related to veneering ceramic fractures as well as Zir's susceptibility to aging. Restorations utilizing 3Y-TZP have been proposed as alternatives to titanium abutments as well as implants, owing to their favorable optical characteristics, enhanced corrosion as well as wear resistance, improved biocompatibility, along with lower tendency for plaque buildup as well as peri-implantitis. nevertheless, clinical studies have indicated a higher likelihood of early fractures in Zirconia implants opposed to their titanium counterparts highlighting mechanical integrity as a critical concern.[18-23]

Implant-abutment connection at SCs

A total of ten investigations examined implant-supported single crowns (SCs) featuring an internal implant-abutment connection, while six investigations focused on those with an external connection. The five-year failure rates for abutments supporting SCs had been recorded at 2.3 percent for internal connections as well as 1.3 percent for external connections. Correspondingly, the failure rates for implant-supported SCs had been 2.4 percent for internal connections as well as 4.3 percent for external connections. However, the variations in failure rates amongst the two connection types didn't achieve numerical significance. The overall incidence of technical issues had been comparable for both types, with a five-year complication rate of 10.1 percent for internal connections as well as 12.4 percent for external connections. Notably, there was a considerably greater rate of screw loosening associated with external implant-abutment connections. Conversely, a greater occurrence of ceramic chipping was observed in implant-supported SCs utilizing internal connections compared to those with external connections. The five-year rate of all complications had been 6.7 percent for internal connection, in contrast to 4.3 percent for external connection, with this variation also failing to achieve statistical significance.[8-17]

Implant-abutment connection at FDPs

A total of eleven investigations were analyzed regarding implant-supported FDPs, with five focusing solely on those utilizing internal implant-abutment connections and another five on those with external connections. The failure rates over a five-year period for both abutments as well as FDPs varied from 0.7 percent to 4.2 percent. However, the comparison among internal as well as external connections didn't yield statistically significant differences for either abutments or FDPs. The overall complication rate for technical issues was recorded at 9.4% for internal connections and 12.2% for external connections. In terms of biological issues associated with these FDPs after five years, the rate was 5.6%. The technical complication rates were 9.4 percent for internal connections as well as 4.8 percent as well as 12.2 percent for external connections, respectively, with no statistically significant differences observed. Notably, the incidence of abutment or occlusal screw fractures had been considerably greater in FDPs with external connections (1.8 percent) compared to those with internal connections. Additionally, a greater proportion of implants having internal connections (5.6%) showed significant bone loss compared to those with external connections (0%), although this outcome was derived from a limited number of implant-supported FDPs.[12-17]

CONCLUSION

The variety of modern materials and techniques accessible for production of implant-supported, all-ceramic restorations complicates the selection of the most suitable treatment approach. The market is continuously evolving, with new products being introduced alongside an extensive array of existing options. Ongoing research is focused on the development of zirconia-alumina composites that are resistant to degradation at low temperatures, particularly for use in dental implant abutments. Initial short-term results appear to be encouraging. Beyond accurate diagnosis and treatment planning, it is vital to comprehend the properties, long-term performance, indications, and contraindications associated with each material utilized, as this knowledge is essential for ensuring the lasting clinical success of restorations. Both in vitro and in vivo studies suggest that ceramic abutments are predominantly suitable for single-tooth, implant-supported all-ceramic restorations. Enhancing the durability of these abutments could potentially broaden their application to include implant-supported, all-ceramic fixed partial dentures and restorations in the posterior region. Zirconia ceramics and abutments are currently the subject of extensive research and are gaining popularity. Future developments in ceramic materials are expected to focus on enhancing color and long-term stability. There are ongoing efforts to integrate coloring oxides into zirconia ceramics before the sintering process, which would modify its natural whitish appearance and enhance aesthetic outcomes. However, it is crucial to assess the effectiveness of any proposed techniques prior to their endorsement. Furthermore, advancements in computer-aided design and computer-aided manufacturing technologies have greatly optimized the fabrication processes for ceramic abutments and implant-supported, all-ceramic restorations, rendering them more rapid, straightforward, and efficient. These innovations are instrumental in the rising adoption of ceramic abutments. Future advancements are expected to facilitate the production of more resilient abutments and restorations, characterized by superior quality and reduced fabrication time and costs.

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