MECHANICAL PROPERTIES OF VARIOUS TYPES OF MONOLITHIC CROWNS ON CUSTOMIZED IMPLANT ABUTMENTS WITH A VERTICAL MARGINAL DESIGN

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Abstract

Dental implant treatment is an integral part of modern dentistry. The success of implant therapy is closely linked to the proper prosthetic rehabilitation of the placed implants. To date, no universal material or standardized approach has been established for implant prosthetics. This article aims to compare contemporary methods and materials used in prosthetic treatment on implants and to highlight unresolved questions in this field that require further clarification.

Key words: dentistry, implant, custom abutments, prosthetic treatment

Introduction:

In modern dentistry, implant treatment has become a routine part of daily practice for most dental professionals. Successful implant therapy requires proper prosthetic rehabilitation. Many authors [1,2,3,4] have focused their efforts on identifying the most effective materials and methods for implant prosthetics to establish reliable and predictable clinical protocols that ensure favorable treatment outcomes. However, no universal material has yet been developed, nor is there a definitive answer as to which material possesses optimal mechanical and biological properties. Furthermore, a standardized approach to implant prosthetics has not been established.

The aim of this review article is to compare contemporary methods and materials used in prosthetic rehabilitation on dental implants. According to the literature, the most commonly used materials for implant crowns are two types of ceramics: zirconium dioxide and lithium disilicate, both of which are cemented onto implant abutments. Studies indicate that most dental practitioners utilize prefabricated implant abutments and follow various clinical protocols, which remain the primary focus of research on implant prosthetics. However, there is a lack of sufficient studies on customized implant abutments with horizontal and vertical marginal designs.

The Role of Implant Abutments in Prosthetic Stability and Tissue Health

Implant abutments play a crucial role in ensuring the functional stability of the prosthetic structure and in creating an optimal emergence profile that maintains healthy soft tissues [1,5]. It has been established that a properly contoured emergence profile of the abutment harmoniously supports the free gingival margin and papilla while providing adequate space for the biological width [6].

Many researchers focus on designing the most stable emergence profile through the use of provisional crowns, which can later be replicated in the final restoration [7,8,9].

Customized abutments used in provisional restorations demonstrate satisfactory results in shaping soft tissues and have a positive impact on the aesthetic appearance of the final restoration [4]. One of their key advantages is the ability to create a personalized emergence profile that guides the marginal gingival edge into the correct contour [10,11].

The initial developments of customized abutments were reported by Marchack [2]. The author presented a clinical case involving a custom titanium alloy abutment for the restoration of a single implant in the anterior region. He highlighted several advantages of customized abutments over standard implant abutments, emphasizing that standardized implant abutments cannot meet the individual needs and requirements of every patient [2]. According to Blatz et al., a change in the colour of soft tissues becomes visible at a thickness of 2 mm, while discoloration is not discernible to the naked eye at a thickness of 3 mm. The thickness of peri-implant tissues is critical for achieving aesthetic outcomes, as it conceals the greying of the metallic abutment [12]. In cases of thin soft tissues, any metallic abutment becomes visible, compromising the aesthetic result [2].

Many authors suggest that customized abutments can prevent a range of complications commonly observed in prosthetic treatments using prefabricated abutments, particularly in cases with anatomical constraints. These challenges most often include insufficient vertical space with opposing dentition, large interproximal spaces, and non-parallel implant positioning, among others [1,13,14].

Other researchers also identify customized abutments as one of the key elements in modern dentistry, as they provide precise and personalized solutions for each clinical case. The use of CAD/CAM technologies enables the precise and highly accurate fabrication of customized abutments. These technologies allow for the simultaneous design of the future prosthetic structure and its substructures, facilitating better adaptation and passive fit of the prosthetic restoration [15,16]. It has been established that CAD/CAM-fabricated abutments exhibit superior survival rates compared to conventional superstructures [1,2,17,18].

In recent years, a new tooth preparation technique has been proposed—the Biologically Oriented Preparation Technique (BOPT) [3,19,20]. The concept of margin-free preparation can also be successfully applied to implant abutments. Many implant systems offer components with or without a margin. Studies in the literature primarily focus on the mechanical properties of prefabricated abutments; however, data on the mechanical characteristics of customized abutments remain scarce [21,22,23,24].

Cocchetto et al. established that, in implant prosthetics, the Biologically Oriented Preparation Technique (BOPT) offers several advantages, the main one being better marginal adaptation of the crown after cementation and minimal microleakage compared to traditional margin preparation techniques, such as bevel or horizontal preparations. Furthermore, the emergence profile of the crown supports and shapes the buccal soft tissue, which adapts to the contour of the tooth [4]. In a study by Canullo, L. et al., the durability and biological stability of margin-free zirconia and metal-ceramic restorations cemented onto conical titanium abutments were compared. All prosthetic crowns followed the BOPT technique and were margin-free. No statistically significant difference was found between the two materials, with overall survival rates of 98.2% for zirconia and 97.5% for metal-ceramic crowns. The authors concluded that zirconia implant restorations without margins are a good alternative for prosthetic treatment on implants [3].

Kaweewongprasert et al. compared the fatigue resistance of three different designs of lithium disilicate crown restorations on implant abutments, finding that lithium disilicate crowns cemented onto prefabricated titanium abutments exhibited higher fatigue resistance compared to the same crowns cemented onto customized abutments or two-piece abutments made of lithium disilicate coping and prefabricated titanium base. The lowest results were observed in the two-piece abutment group, although all groups were tested with forces higher than those encountered in normal chewing load [25].

On the other hand, in an in vitro study, Elsaid A. et al. compared five different types of implant abutments, all custom-designed and computer-fabricated, including ceramic abutments both as standalone and bonded to titanium bases. The best results for fracture resistance were observed in the two-component abutments [26].

Hjerppe et al. investigated a new design for the fabrication of a fully customized monolithic zirconia CAD/CAM implant crown without an abutment, comparing it to the standard method involving a pre-made prefabricated abutment for CAD/CAM zirconia crowns. They found no significant difference in the mechanical strength between the two types of zirconia implant restorations, suggesting that this innovative method will simplify and enhance the efficiency of creating zirconia implant crowns while maintaining the same durability as conventional methods [27].

Contemporary Materials Used in Implant Prosthetics

The primary contemporary materials for prosthetic restorations on implants are zirconium dioxide and lithium disilicate [28,29,30].

In his review article, Seiji provides a comprehensive overview of the use of zirconium dioxide in dental implantology. He concludes that zirconia has the highest mechanical durability among materials used in restorative dentistry. The article concludes that properly selected zirconia is an ideal material for both implant abutments and restorative crowns due to its mechanical, aesthetic, and biological properties [31].

Price et al. conducted an in vitro study on the fatigue strength and fracture resistance of various ceramic implant crowns. They found that monolithic zirconia crowns exhibited significantly higher resistance values under thermal and mechanical loading, as well as considerably greater fracture resistance compared to other ceramic materials [32]. Their findings support Spitznagel's assertion that monolithic zirconia crowns supported by implant abutments demonstrate the same or greater fracture resistance compared to lithium disilicate crowns [33].

On the other hand, in a study comparing the fracture strength of single crowns made of lithium disilicate ceramic on two-piece implant abutments, with different materials such as ceramic-reinforced PEEK, zirconia, and lithium disilicate, Kaneploy et al. found no statistically significant difference in compressive strength between zirconium dioxide and lithium disilicate ceramics [34]. This finding is corroborated by research conducted by Ali et al., who compared the fracture resistance of different ceramic materials and concluded that there was no significant difference between zirconia and lithium disilicate ceramics [35].

Monolithic lithium disilicate crowns cemented to titanium prefabricated abutments demonstrate higher fracture resistance compared to those cemented to customized ceramic abutments [36].

Conclusion:

Based on the literature from the past 10 years, it has been established that the standard method for prosthetic restoration on implants remains the use of prefabricated titanium bases, onto which digitally designed and fabricated (CAD/CAM) zirconia or lithium disilicate crowns are cemented. Another preferred option is the use of customized zirconia abutments, also entirely digitally created, cemented onto titanium abutments, and carrying zirconia or lithium disilicate crowns. Both ceramic materials exhibit similar aesthetic and mechanical properties.

The literature contains numerous studies on the mechanical characteristics of prefabricated titanium or ceramic abutments; however, customized implant abutments remain under-researched. Customized implant abutments without a preparation margin are not sufficiently well-studied, and there is a lack of adequate research on this topic. No definitive conclusion has been drawn regarding which ceramic material is most suitable for implant prosthetics.

Further in vivo and in vitro studies are needed to address issues related to the types of abutments, margins, and restorative materials. This will lead to the creation of an optimal working protocol and facilitate prosthetic treatment on implants.

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