Comparative Analysis of Zirconium and Lithium Disilicate Restorations in Total Dentures in The Masticatory Areas

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Abstract. *The paper examines the current issue of determining the quality of materials for restorations in total dentures in the chewing areas. Restorative dentistry is concerned with the restoration of the shape, function and aesthetics of teeth damaged by caries, trauma or other diseases. Restoration of chewing teeth ensures the restoration of chewing function, prevents rapid wear of the prosthesis and reduces the load on the remaining teeth and jaw structures. Improving aesthetics is of great importance. Restoration of the color, shape and length of the teeth helps to improve the appearance and increase patient satisfaction. The growing demand for durable and aesthetic dental restorations, especially in total prostheses, highlights the key role of modern ceramic materials. Zirconium dioxide (ZrO2) and lithium disilicate (Li2Si2O5) are the leading options due to their mechanical and optical properties. Despite their widespread use, data on their long-term clinical effectiveness and patient satisfaction in full dentures in the chewing areas are limited. This study aims to comparatively evaluate the properties, aesthetics, durability, and patient satisfaction with these restorations, focusing on the chewing segments. Analysis of available scientific studies and clinical reviews shows that zirconium dioxide demonstrates higher strength and fracture resistance, making it suitable for posterior restorations, with excellent survival rates for monolithic forms. At the same time, lithium disilicate (360 MPa) provides better optical characteristics and significantly higher patient aesthetic satisfaction ($p < 0.05$). The choice of material for full dentures in chewing areas requires a balance between mechanical requirements and aesthetic priorities. Zirconium dioxide is best for loaded areas, while lithium disilicate is chosen when transparency and natural appearance are important. Zirconium and lithium disilicate demonstrate high clinical efficacy, but have different advantages depending on the conditions of use. Zirconium is characterized by the highest mechanical resistance and a lower incidence of chipping, making it optimal for chewing areas. Lithium disilicate, on the other hand, provides better aesthetic characteristics and has a slightly higher survival rate in anterior restorations. The rational choice of material should be based on the clinical situation, the location of the restoration, and the individual needs of the patient.*

Keywords*: zirconium, lithium disilicate, full dentures, chewing areas, dental restoration.*

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Introduction

The relevance of the study on restoration in total dentures in the chewing areas is determined by modern trends in dentistry and high requirements for the quality of restorative procedures. Restorative dentistry aims not only to restore form and functionality, but also to ensure high aesthetics and durability, especially in the complex rehabilitation of patients in need of total dentures.

Nowadays, there is a tendency to gradually replace traditional metal-ceramic restorations. This is due to their opacity and the potential risk of darkening, which can reduce the aesthetic result. Instead, preference is given to metal-free materials that offer improved biocompatibility, natural aesthetics, and high mechanical stability [1; 2; 3].

The latest composite materials, ceramics, and digital technologies allow for more precise, aesthetic, and durable restorations, which is an important aspect of dental practice. The choice of material for the restoration of chewing teeth in total dentures depends on many factors, such as the strength of the composite and the ease of working with it. It is important to take into account both aesthetic and functional aspects, especially when correcting the length and width of the teeth or due to crowding. Chewing areas of the oral cavity are subjected to significant occlusal forces, so the choice of materials that are highly durable, wear-resistant and biocompatible is important for effective restoration and minimization of complications. Zirconium dioxide ($ZrO2$) and lithium disilicate ($Li2Si2O5$) are the leading options due to their mechanical and optical properties and are in great demand in the field of dental restorations [3; 4; 5]. Modern CAD/CAM technologies have significantly improved the accuracy and reproducibility of both materials, which makes it possible to produce all-ceramic dental restorations in a very short period of time [2; 6; 7]. CAD/CAM, allows to get strong and durable restorations that look exactly like other teeth, thanks to the use of digital scanners that create a three-dimensional model of the oral cavity and teeth. This reduces the number of steps in the process of designing, creating, and implanting prostheses; it also reduces manufacturing time and increases the accuracy and quality of the final product. In addition, CAD/CAM technology allows to create dental structures of complex shapes and designs, which increases the flexibility and accuracy of treatment for each patient [2]. As a result, the use of this technology increases the design capabilities and production speed of ceramic elements in dentistry.

Despite significant advances in materials science and in-depth research on both materials, there are a limited number of focused studies comparing zirconia and lithium disilicate in the context of total dentures [7; 8]. Most of the available studies focus on single crowns, without taking into account the complex effects of functional, structural, and symmetrical loads that occur during full mouth contact. This lack of evidence regarding the response of the full arch architecture to cut materials poses a significant challenge to informed choice in the comprehensive rehabilitation of patients.

Analysis of recent research and publications. In recent years, there has been an increase in the number of scientific studies devoted to the study of the effectiveness of zirconia and lithium disilicate restorations, which reflects the constant development of metal-free structures in dental practice. The main focus of the scientific community is on improving the mechanical, optical and biocompatible characteristics of these materials, as well as on analyzing their long-term effectiveness in difficult clinical situations, in particular under masticatory loads.

A comparative analysis of the characteristics and clinical efficacy of zirconia and lithium disilicate restorations is studied in the scientific publications of Zarone et al. (2019) [1], Tafuri et al. (2025) [3], Buser et al. (2025) [4], Baroudi et al. (2025) [5], Bömicke et al. (2024) [6], Manziuc et al. (2023) [9]. The analysis focuses on the material properties, clinical performance in the masticatory area, advantages and aesthetics, as well as indications and limitations of these materials. Pontevedra et al. (2024) [8], Manziuc et al. (2023) [9], Pjetursson et al. (2023) [10], Nazirkar et al. (2020) [11], Soares et al. (2021) [12] study mechanical properties (yield strength, resistance to fractures); Manziuc et al, (2023) [9], Freitas et al. (2023) [13], Gupta et al. (2021) [14] - clinical indicators (survival rate, complication rate); Guillén-Martínez (2024) [15], aesthetic characteristics, transparency and subjective patient assessments (appearance, comfort); Solís Pinargote et al. (2024) [2], Bömicke et al. (2024) [6] - manufacturing features (CAD/CAM technology).

Thus, the study of the main characteristics of materials used for the restoration of chewing teeth in total dentures allows the development of new approaches to improving the durability, functional and aesthetic results of restorations, which is relevant both for practice and for the theoretical foundations of dentistry.

The purpose of the study is to conduct a comparative analysis of zirconium and lithium disilicate restorations based on their material characteristics, clinical efficacy, aesthetic characteristics, advantages, as well as indications and limitations for their use.

Results

The materials used in dentistry for the manufacture of all-ceramic restorations have undergone significant and rapid development over the past two decades. Among the most common ceramic materials in dentistry are materials based on zirconia and lithium disilicate.

Zirconium dioxide (ZrO_2) is a polycrystalline ceramic that demonstrates exceptional flexural strength (900-1200 MPa) and resistance to fracture. These properties make it the optimal choice for posterior crowns and implant components. In addition, zirconia is characterized by excellent biocompatibility and low cytotoxicity compared to other materials. Thanks to recent advances in materials science, it has become possible to create highly transparent zirconia without losing its strength, which expands the range of its application [4; 8]. Clinical studies conducted by Buser et al. (2025) [4] confirm the high 5-year survival rate of monolithic ZrO_2 in masticatory segments. Zirconia had the highest, and lithium disilicate mostly had lower values of fracture load and flexural strength ($p \leq 0.034$). A positive correlation was found between fracture load and flexural strength ($r = 0.997$, $P < 0.001$).

Lithium disilicate ($Li_2Si_2O_5$) is a glass-ceramic whose main advantage is to provide high transparency and the most natural appearance, which makes it an ideal material for anterior restorations. Scientists Manziuc et al. (2023) [9], Soares et al. (2021) [12], Balladares et al. (2024) [16] note that although the bending strength of lithium disilicate (about 360 MPa) is significantly lower than that of zirconia, it is quite sufficient for anterior crowns where high aesthetic quality is a priority.

The comparative analysis of zirconia and lithium disilicate presented in Table 1 demonstrates the significant differences between these two ceramic materials, which are critical for their clinical use in total dentures in the masticatory areas.

Table 1.

Comparative characteristics of zirconia and lithium disilicate materials used in the restoration of total dentures

Characteristics	Zirconium (ZrO_2)	Lithium disilicate ($Li_2Si_2O_5$)
Bending strength (MPa)	>1000 (monolithic ZrO_2)	360-400
Biocompatibility	High	High
Color stability	High (Hi-Trans Zr - less)	High

Transparency	Low transparency	High transparency
Resistance to wear and tear	Resistant to abrasion	Moderate Prone to microcracks
Optimal application	Suitable for implants	Best suited for the anterior area
Features of processing	Needs polishing	Needs crystallization
5-year survival rate (%)	≈96.8 %	91.2 %
Frequency of chipping	1.4 %	5 %
Physical resistance	Highest (monoZr)	Average
Aesthetics	Good (Hi-Trans Zr)	Very high
Comfort/naturalness	High	High
Reliability of color	Stable	Less stable

Source: Built by the author on the basis of [3; 5; 13; 17; 18; 19].

In terms of mechanical strength, zirconia, especially in monolithic form, demonstrates significantly higher bending strength (>1000 MPa) and exceptional wear resistance, which exceeds the similar indicators of lithium disilicate (360-400 MPa) by almost three times [4; 5; 6; 15]. This indicator determines the advantage of zirconia for use in conditions of increased occlusal loads characteristic of masticatory areas. At the same time, Buser et al. (2025) [4], Baroudi et al. (2025) [5], Bömicke et al. (2024) [6] note that although zirconia is characterized by durability, it is inferior in optical properties, especially in the anterior region.

Color stability and transparency also remain important aspects. As noted by Baroudi et al. (2025) [5], Manziuc et al. (2023) [9], both materials demonstrate high biocompatibility and color stability, which is confirmed by low cytotoxicity and favorable interaction with surrounding tissues. This makes them safe for use in long-term orthopedic structures.

It should be noted that zirconia, especially in stabilized forms, demonstrates high color stability to moisture, acids, and thermal stress. Its dense structure reduces the penetration of pigments and prevents shade changes over time. In the case of lithium disilicate, although the initial aesthetic appearance is usually superior, it is slightly prone to discoloration, especially if the polishing protocol is not correct or if the restoration is not tightly sealed.

In terms of optical properties, lithium disilicate has a clear advantage. Soares et al. 2021 [12], Zhang et al. 2023 [19] indicate that lithium disilicate demonstrates high transparency, aesthetics, and better integration with natural teeth, especially in the anterior region. (Hi-Trans Zr) Zirconia, especially in its standard form, has lower transparency, although it has been improved in modified high-transparency versions. Other studies by Manziuc et al. 2023 [20], Kanat-Ertürk B. (2020) [21] found that lithium silicate ceramics reinforced with zirconia have lower color stability compared to lithium disilicate. Freitas et al. (2023) [13] studied the properties of lithium disilicate and found that its translucency level was (28.14) and higher than that of stabilized 4Y-PSZ zirconia (8.62) ($p < 0.05$). Fractures occurred on the cemented surface of the ceramic disks. Lithium ceramics showed a lower surface roughness ($Ra = 0.04$ μm; $Rz = 0.66$ μm). Despite the lower FFL (moisture flow rate) compared to 4Y-PSZ, lithium disilicate has compatible translucency and mechanical fatigue characteristics, which corresponds to its indications for the manufacture of monolithic, anterior and posterior adhesive-cemented single restorations [13].

Another important factor is enamel wear. The results of studies confirm that optimally polished zirconia restorations do not cause significant wear and have higher abrasion resistance, which is critical for chewing surfaces. At the same time, lithium disilicate is prone to microcracks and has lower resistance to fractures, demonstrates moderate abrasiveness, which depends on the methods of finishing [11].

Five-year survival is a critical criterion for assessing the durability of materials. Comparative studies by Gupta et al. (2021) [14] and Prott et al. (2021) [22] on the clinical efficacy of these two materials have revealed their specific advantages. Monolithic zirconia crowns demonstrate a 5-year survival rate of 95-98% in the posterior region, which indicates their exceptional durability under masticatory load. In contrast, lithium disilicate shows stable and highly aesthetic results in the anterior and premolar regions. Zirconia is superior to lithium disilicate in terms of durability under masticatory load, while lithium disilicate provides better aesthetics and higher patient satisfaction [8; 15]. In terms of application, zirconia prevails in masticatory areas and for the manufacture of implant structures due to its mechanical properties. Lithium disilicate is the material of choice for restorations in the anterior part of the dentition due to its high transparency and natural aesthetics [10].

Physical stability is another important parameter that includes resistance to texture, deformation, and wear. According to Baroudi et al. (2025) [5], Gupta et al. (2021) [14], monolithic zirconia demonstrates the highest physical stability among modern ceramic materials, while lithium disilicate and its modifications (ZLS) are characterized by medium stability. This leads to a limitation of their use in distal areas in the presence of pronounced chewing forces.

Antagonist enamel abrasion remains a clinically significant indicator that affects the long-term preservation of occlusion and the condition of natural teeth in contact with the restoration. According to the results of Nazirkar et al. (2020) [11], optimally polished zirconia has a lower potential for antagonist enamel abrasion compared to lithium disilicate, which can cause moderate abrasion. Thus, with an appropriate processing protocol, zirconia is more favorable in terms of biomechanical interaction with antagonists.

The chipping rate reflects the clinical reliability and structural integrity of the material under conditions of prolonged chewing. According to Guess et al. (2021) [17], zirconia shows a significantly lower chipping rate (1.4%) compared to lithium disilicate (5%). This confirms its advantage in conditions of high occlusal loads and justifies the choice in favor of monolithic zirconia restorations in the masticatory segments [9; 17].

Comparison of the aesthetic and subjective properties of restorative materials is one of the key aspects of clinical choice, especially in the context of high aesthetic expectations of patients. In terms of aesthetics, lithium disilicate and its modifications (e.g., ZLS) show an advantage due to high transparency, natural light refraction, and color depth. This makes it the material of choice in the anterior region, especially for veneers, crowns, and aesthetically important bridges [5]. At the same time, improved versions of zirconia, in particular, highly transparent zirconia (Hi-Trans Zr), have come much closer to the aesthetic characteristics of glass ceramics, but are still inferior to them in terms of optical depth.

In the context of subjective comfort and natural feel, both materials show comparable results. For example, patients report a high adaptation to both types of restorations without significant complaints about unnatural perception, which indicates good integration of the materials. An important role in this is played by surface smoothness, thermal inertness, and accuracy of fit.

The results of the data in Table 2 allow us to draw reasonable conclusions about the clinical feasibility of using zirconium and lithium disilicate in the conditions of total dentures in the masticatory areas.

Table 2.

Indications and limitations for the use of zirconium and lithium disilicate restorations in total dentures in the masticatory areas

Aspect	Zirconia	Lithium disilicate/ZLS
Indications	Chewing area, load	Frontal/aesthetic area
Limitations	Lower transparency	Lower strength
Implants	It is used	ZLS as an alternative
Adjustment	After correction - polishing	Before crystallization - grinding

Source: Built by the author according to [5; 16; 17; 18].

The analyses by Pjetursson et al. (2023) [10] and Jurado et al. (2025) [23] showed that zirconium has clearly defined indications for use in areas with a high functional load in implants. Whereas lithium disilicate, although characterized by aesthetic advantages, has limitations in terms of mechanical endurance, which limits its use in the masticatory zone [17].

Zirconia, even in highly transparent modifications, still exhibits lower transparency compared to lithium disilicate, which limits its use in the anterior region. At the same time, lithium disilicate has marginal strength characteristics (360-400 MPa), which makes it less reliable in total structures under multi-point loading. This fact is supported by the data of Baroudi et al. (2025) [5] on more frequent fragmentation and delamination under conditions of significant occlusal pressure.

Along with the development of ceramic materials for dental restorations, the processing technologies for such materials have also undergone rapid and effective development. In dentistry, various methods are used to fabricate all-ceramic restorations. These methods include the traditional technique, the hot pressing technique, the dry pressing method, the slurry casting and glass infiltration method, and CAD/CAM.

CAD/CAM dentistry is a branch of dentistry and prosthodontics that uses computer-aided design (CAD) and computer-aided manufacturing (CAM) technologies to improve the design and creation of dental restorations such as inlays, onlays, veneers, and crowns [6]. CAD/CAM techniques, which are now an important part of dentistry, are methods in which the design and fabrication of ceramic restorations is carried out using computer software [7]. When a tooth is prepared, it is optically scanned and its image is transferred to a computer. Based on this image, the restoration is designed using a special computer program and then processed on a CNC milling machine. The advantages of these methods include reduced clinical time and cross-infections between the clinic and the laboratory, as well as reduced or eliminated patient discomfort, especially when using intraoral scanning (digital impression). Using CAD/CAM systems, the doctor and/or technician can inspect the restoration before the milling process to check its accuracy. Moreover, this technology allows for the manufacture of dental restorations individually in the dentist's office or centrally in a dental laboratory [2].

Consequently, due to the optical properties of lithium disilicate, it is considered the best material in terms of appearance for dental restorations. On the other hand, zirconia-based materials offer high mechanical properties and are often used for the fabrication of all-ceramic restorations that do not have high aesthetic requirements. Particularly noteworthy is the aspect of implant use, where zirconia consistently demonstrates an advantage due to its high structural integrity, biocompatibility, and minimal reactivity in the oral cavity.

The difference in material handling during intraoral corrections is also clinically important. Zirconia requires polishing after each correction, as an inadequately treated surface can cause increased abrasion of antagonistic enamel. In contrast, lithium disilicate shows a dependence on proper grinding before crystallization - which is critical to ensure its final strength. The results indicate that the technological processing of the material has a direct impact on the clinical durability of the structure. The choice of material should take into account not only the localization of the restoration, but also the nature of the load, the patient's aesthetic requirements and the potential reaction to intraoral corrections.

Conclusions

Based on the comparative analysis, it was found that zirconia demonstrates exceptional bending strength and the highest physical stability, which makes it an ideal choice for restorations that are subjected to significant masticatory loads, especially in the masticatory zone. Its low chipping rate and less abrasion of the antagonist enamel (provided optimal polishing) further emphasize its strength and durability advantages. Although the aesthetics of zirconia (especially Hi-Trans Zr) are rated as good, it has less transparency compared to lithium disilicate.

In contrast, lithium disilicate (and its variant ZLS) have very high aesthetics due to better transparency, making it the preferred choice for the front and other aesthetically important areas. It also shows a slightly higher 5-year survival rate in certain clinical studies. However, its lower strength and higher chipping rate require more careful use in areas with a high functional load.

Both materials are characterized by high biocompatibility and provide a high level of comfort and naturalness for patients, the choice between zirconia and lithium disilicate restorations should be based on careful consideration of specific clinical indications, functional requirements, and aesthetic priorities of the patient.

Successful prosthetics depends to a large extent on understanding the unique properties of each material and applying them to the individual needs of the clinical case. The final decision on the choice of material should be made after a comprehensive evaluation of all factors.

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