compare dental posterior fillings from dental amalgam, composites, milled indirect restorations, and 3d printed restorations current and future longevity

Table of Contents

Health and Safety Concerns

Cost Implications

Environmental Impact

Collaborative Decision-Making

Check https://storm.genie.stanford.edu/article/1402702 for more details

Stanford University Open Virtual Assistant Lab

The generated report can make mistakes.
Please consider checking important information.
The generated content does not represent the developer's viewpoint.

summary

Dental posterior fillings are essential components of restorative dentistry, aimed at repairing decayed or damaged teeth, particularly in areas subject to significant stress during chewing. The primary materials used for these fillings include dental amalgam, composite resins, milled indirect restorations, and 3D-printed restorations. Each material possesses unique properties that influence their longevity, aesthetic appeal, and functional performance, making them significant choices for dental professionals and patients alike.

Dental amalgam has been a standard restorative material for over 150 years, known for its durability and longevity, often exceeding 16 years of survival in clinical studies. However, its aesthetic drawbacks and environmental concerns regarding mercury content have prompted a decline in its use in favor of more visually appealing options like composite resins. Composites bond directly to tooth structure and offer a tooth-colored finish, appealing to patients seeking discretion, though they typically have a shorter lifespan compared to amalgam, averaging around 11 years.[1][2]

Recent advancements in technology have led to the development of milled indirect restorations and 3D-printed restorations. Milled restorations, created using CAD/CAM technology, offer improved fit and aesthetics with favorable longevity due to the superior materials employed. In contrast, 3D printing presents an innovative approach that enhances accuracy and efficiency in producing restorations but faces challenges in standardizing performance and material properties across various printing techniques. Both methods are seen as promising alternatives that may redefine longevity and efficacy in dental restorations as technology progresses.[3][4]

The decision-making process regarding filling materials involves a complex interplay of factors, including aesthetic considerations, durability, patient health concerns, cost, and environmental impact. With evolving technologies and materials, dental practitioners must engage in collaborative discussions with patients to navigate these choices, ensuring restorations align with individual preferences and clinical needs.[5][6]

Dental Amalgam

Dental amalgam is a time-tested restorative material used for over 150 years in treating tooth cavities. It consists of a mixture of mercury with other metals such as silver, tin, and copper, providing significant durability and strength, particularly suited for posterior teeth that endure considerable chewing forces[1][2]. Despite its longevity, amalgam's popularity has been declining in cosmetic dentistry due to aesthetic limitations, as it is not tooth-colored and does not bond directly to the tooth structure[1][3].

Longevity and Durability

Amalgam restorations are known for their impressive longevity, with median survival times reported to exceed 16 years, making them a reliable option for many patients[-4][5]. They exhibit a low failure rate, generally ranging from 1% to 3% annually[6]. The material's resistance to wear makes it especially advantageous in areas subject to heavy grinding, such as molars[2]. However, the longevity of amalgam restorations can be influenced by various factors, including the size of the restoration and the individual patient’s oral hygiene practices[7][8].

Safety and Environmental Concerns

While the International Association for Dental Research (IADR) has affirmed the safety of dental amalgam for most individuals without specific allergies or severe renal issues, concerns about the mercury component have prompted discussions about its environmental impact and potential health risks[9][10]. The debate over amalgam's safety has led to increased interest in alternative materials that are both aesthetically pleasing and environmentally sustainable.

Composite Resins

Composite resins are a popular choice for dental fillings, particularly in posterior restorations, due to their aesthetic appeal and functional benefits. They are made from a mixture of plastic and fine glass particles, which allows them to closely mimic the natural color and texture of teeth, making them an ideal option for both visible and occlusal surfaces[11][12].

Strength and Performance

Recent studies have demonstrated that 3D-printed resin composites exhibit strength comparable to that of milled resin composites when adhesively cemented[13][14]. This finding suggests that advancements in 3D printing technology are improving the mechanical properties of composite materials, offering a viable alternative for restorative dentistry. Additionally, composite resins have been shown to possess enhanced mechanical performance, improved resistance to water absorption, and reduced solubility, which are crucial factors influencing their longevity in dental applications[15][16].

Aesthetic and Functional Advantages

One of the key benefits of composite resins is their ability to bond directly to the tooth structure, providing added support and reducing the risk of future fractures. This bonding process typically requires less removal of healthy tooth structure compared to traditional amalgam fillings, making composites a more conservative option for restoration[12][17]. Furthermore, the aesthetic qualities of composite resins allow for a more discreet restoration, which is particularly important for patients concerned about the visibility of dental work[17].

Longevity and Clinical Considerations

The longevity of composite restorations can vary based on several factors, including patient habits, the operator's technique, and the specific materials used. While there is uncertainty regarding the annual failure rates and survival rates of direct and indirect posterior restorations, evidence suggests that with proper placement and maintenance, posterior composite restorations can achieve a long survival rate[3][18]. It is essential for clinicians to consider these factors to maximize the durability and effectiveness of composite fillings in their patients[19][8].

Milled Indirect Restorations

Milled indirect restorations, often produced using CAD/CAM (Computer-Aided Design/Computer-Aided Manufacturing) technology, represent a significant advancement in restorative dentistry. These restorations, which include inlays, onlays, and crowns, are fabricated from materials such as ceramics and composite resins, providing a combination of aesthetic appeal and mechanical strength.

Materials Used

Various ceramic systems are available for milled indirect restorations, including glass ceramics, resin nano ceramics, and zirconia[20]. Notably, lithium disilicate ceramics, such as IPS e.max CAD, have gained popularity due to their high strength and aesthetic properties. This material undergoes a crystallization process post-milling, which enhances its flexural strength significantly, making it suitable for posterior restorations[20][21].

Advantages of Milled Indirect Restorations

Milled indirect restorations offer several advantages over direct restorations. They are generally considered to have superior aesthetic qualities, better restoration of the original tooth morphology, and a lower percentage of polymerization shrinkage. Furthermore, the precision involved in milling contributes to improved fit and marginal integrity, minimizing the risk of secondary caries[19][22]. In addition, the use of advanced materials in CAD/CAM systems allows for the production of restorations that are both durable and biocompatible.

Clinical Outcomes

Clinical studies indicate that milled indirect restorations can exhibit favorable longevity and performance. In a study comparing the failure rates of composite and amalgam restorations, milled indirect restorations demonstrated less failure over an extended period, particularly in posterior teeth[23]. The mechanical properties of CAD/CAM blocks have been shown to improve stress distribution and resistance to fracture, which are critical factors in the longevity of these restorations[21].

CAD/CAM Technology and Its Impact

The introduction of CAD/CAM technology has transformed the workflow of dental restorations. It allows for the scanning, design, and fabrication of restorations in a single appointment, which enhances patient convenience and reduces the need for provisional restorations[20]. Moreover, the integration of advanced software improves the accuracy of the final product and facilitates better collaboration among dental professionals throughout the treatment process[24][25].

Future Prospects

Looking forward, the development of 3D printing technologies alongside CAD/CAM will likely expand the scope and efficiency of milled indirect restorations. Innovations in material science and manufacturing techniques are expected to enhance the mechanical properties and longevity of these restorations, making them an even more viable option for dental professionals and patients alike[23][3]. As research progresses, the combination of these advanced techniques may lead to more customizable and cost-effective solutions in restorative dentistry.

3D Printed Restorations

Three-dimensional (3D) printing has emerged as a transformative technology in the field of restorative dentistry, offering significant advantages over traditional methods for creating dental restorations. This innovative approach leverages advanced printable resin materials to fabricate precise dental models and restorations, providing enhanced accuracy, consistency, and efficiency in the restorative process[26][27].

Advantages of 3D Printing

One of the primary benefits of 3D-printed restorations is their ability to produce conservative indirect restorations, such as inlays and onlays, which represent a substantial upgrade from larger direct resin applications[28][29]. The 3D printing process allows practitioners to achieve superior accuracy and definition compared to traditional milling methods, enhancing predictability in restoration outcomes[30].

Additionally, 3D printing is often faster and more cost-effective, reducing the time patients spend in the dental chair[26].

Material Properties and Performance

3D-printed resin composites have been identified as a promising alternative for indirect restorations, particularly due to their improved adaptation and wear resistance compared to milled counterparts[29][31]. Recent studies suggest that while there is variability in the performance of different materials, 3D-printed restorations can demonstrate competitive longevity when evaluated under clinical conditions[18].

Furthermore, advancements in 3D printing technology have addressed some of the limitations associated with traditional subtractive methods, such as material waste and the mechanical limitations of milling[31]. The additive nature of 3D printing minimizes excess material usage and allows for more complex geometries that can be tailored to individual patient needs.

Challenges and Future Directions

Despite the promising attributes of 3D-printed restorations, challenges remain in standardizing material properties and ensuring consistent clinical performance across different printing techniques and materials[31]. Ongoing research is essential to fully understand the long-term performance of 3D-printed materials in varying clinical scenarios, as well as their potential to replace or complement existing restorative options like dental amalgam and traditional composites.

As dental technology continues to evolve, 3D printing is likely to play a crucial role in shaping the future of restorative dentistry, offering new possibilities for enhanced patient care and outcomes[32][33].

Longevity Comparison

The longevity of dental posterior restorations is influenced by a variety of factors, including the materials used, the type of restorative procedure, and patient-specific parameters. Among direct restorations, amalgam has consistently demonstrated superior longevity, with median survival times exceeding 16 years, while composite restorations typically show median survival times of around 11 years[4][34][35]. In fact, amalgam restorations exhibit an average survival rate of 95% over a decade, and their longevity can reach as high as 22.5 years[35][12].

Factors Influencing Longevity

Material Type

The choice of restorative material plays a critical role in the longevity of dental fillings. Metal alloys, such as amalgam, are noted for their durability and resistance to wear, making them a reliable option for posterior restorations. In contrast, modern materials like composite resins and ceramics offer aesthetic benefits but may have varying mechanical properties that affect their longevity[3][12].

Patient-Related Factors

Several patient-related factors also impact the longevity of restorations. These include age, gender, socio-economic status, caries risk, and oral hygiene practices[36][37][38]. For instance, older patients have been observed to require re-intervention sooner than younger individuals, which highlights the importance of demographic factors in restoration longevity[18].

Post-Operative Sensitivity

Post-operative sensitivity is another consideration, as it can affect patient satisfaction and subsequent dental visits. While this has historically been a concern with composite restorations, improvements in adhesive systems and techniques have made sensitivity less of an issue in contemporary practice[18][37].

Emerging Technologies

Advancements in dental technology, particularly in additive manufacturing, are paving the way for new materials and methods, such as 3D-printed restorations. Initial studies suggest that milled nanohybrid resin composites outperform 3D-printed counterparts in terms of mechanical performance, although 3D printing offers advantages in material preservation and design complexity[31]. As these technologies evolve, they may alter the landscape of restoration longevity, although further research is needed to establish their long-term performance compared to traditional methods[31].

Patient Preferences

When it comes to choosing dental restorations, patients often consider a variety of factors that influence their preferences and decisions. These factors include aesthetics, durability, health implications, cost, and environmental impact associated with different filling materials.

Aesthetic Considerations

Many patients prioritize the appearance of their dental fillings, especially for visible teeth. Composite resins are frequently preferred in these cases due to their ability to match the natural color of teeth, making them an ideal choice for front teeth restorations[39]. On the other hand, amalgam fillings, while known for their durability, are metallic and less aesthetically pleasing, leading some patients to shy away from them when appearance is a concern[2].

Durability and Longevity

Durability is another critical aspect for patients, particularly for those with large cavities or who require fillings in the back teeth, where chewing forces are more significant. Dental amalgam is known for its superior longevity, often lasting over 16 years compared to approximately 11 years for composite fillings[4]. Patients seeking long-lasting solutions may therefore lean towards amalgam, especially if they are unconcerned about the aesthetics[17].

Health and Safety Concerns

Health-related factors also influence patient choices. Some individuals express concerns regarding mercury exposure associated with amalgam fillings, prompting a preference for mercury-free options like composite resins[39]. This health consideration plays a significant role in decision-making, particularly for those who are proactive about their health and wellness.

Cost Implications

Cost is a significant factor in the decision-making process. Dental amalgam fillings are generally more affordable than composite fillings due to their simpler application process and the materials used[17]. Patients on a tighter budget may opt for amalgam, while those willing to invest in higher-quality aesthetics might choose composites despite the increased cost[2].

Environmental Impact

Increasingly, patients are becoming aware of the environmental implications of their choices. Composite resins are considered more environmentally friendly because they do not contain mercury and create less hazardous waste; however, they do come with a plastic-based material footprint[39]. This awareness can influence patients who are environmentally conscious, leading them to consider the sustainability of their chosen restoration material.

Collaborative Decision-Making

Ultimately, the decision between dental amalgam, composites, and newer alternatives like milled indirect or 3D-printed restorations should involve a collaborative discussion with a dental professional. Dentists can guide patients in making informed choices based on individual needs, oral health conditions, and lifestyle preferences[39][2]. By weighing all these factors, patients can select the restoration that best aligns with their priorities and expectations.

References

[1]: Tooth filling materials Dental amalgams & alternative materials

[2]: Metal vs. Composite Fillings: Pros and Cons

[3]: Materials for Indirect Restorations | American Dental Association

[4]: Longevity of Amalgam Versus Composite Resin Restorations in ...
[5]: Properties of Dental Materials: A Comparative Analysis of Amalgam ...
[6]: Longevity of Posterior Composite Restorations: A Systematic ...
[7]: Patient Education on the Longevity of Dental Restorations
[8]: Dental Composites Market | Global Industry Report 2034
[9]: Safety of Dental Amalgam - IADR
[10]: Amalgam | American Dental Association
[11]: The Environmental Impact of Dental Materials
[12]: The Evolution of Dental Fillings: Modern Materials That Last Longer
[13]: (PDF) Comparative Strength Study of Indirect Permanent Restorations
[14]: Comparative Strength Study of Indirect Permanent Restorations: 3D ...
[15]: A review of new generation of dental restorative resin composites ...
[16]: Innovative Dental Fillings For Lasting Smiles - City Dental - Portland
[17]: Dental Amalgam vs Composite Fillings: Pros & Cons
[18]: Longevity of posterior composite restorations: Not only a matter of ...
[19]: The Longevity and Clinical Performance of Direct and Indirect ...
[20]: Two year clinical performance of indirect restorations fabricated from ...
[21]: Survival Rates of Amalgam and Composite Resin Restorations from ...
[22]: Longevity of composite restorations instead of amalgam ones
[23]: The flexural strength of 3D-printed provisional restorations ...
[24]: The Incredible Advancements In 3D Printing For Dental Applications
[25]: Two-year clinical performance of indirect resin composite ...
[26]: Effects of printing orientation and artificial ageing on martens ...
[27]: Advancements in Dental Technology: The Role of 3D Printing in ...
[28]: The Uses of 3D Printed Restorations in a Dental Practice
[29]: 3D-Printed Indirect Restorations for Full-Arch Rehabilitation
[30]: Improving Clinical Efficiency With Single-Appointment 3D Printing of ...
[31]: Evaluation of a 3D-printed nanohybrid resin composite versus a ...
[32]: The Future of Dental Implants: Emerging Trends in Tooth Restoration
[33]: Innovations in Dental Filling Technology: What's New?
[34]: [PDF] A Systematic Review - The Cureus Journal of Medical Science
[35]: (PDF) The longevity of restorations -A literature review - ResearchGate
[36]: Factors influencing the longevity of resin-based composite restorations
[37]: Multifactorial Contributors to the Longevity of Dental Restorations
[38]: Fill The Gap: 6 Factors Affect Composite Fillings
[39]: Composite Fillings vs. Amalgam: What Patients Should Know