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The Current Potential of Direct Metal Laser Sintering (DMLS) in Fixed Prosthodontics

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Abstract

CAD/CAM milling and direct metal laser sintering (DMLS) methods, have brought significant advancements to prosthodontics.

In recent years, additive manufacturing techniques have gained popularity for fabricating metal substructures, particularly cobalt-chromium (Co-Cr) components.

These technologies have reduced manufacturing costs and time, while also minimizing human errors such as wax pattern distortion and casting irregularities, leading to improved fitting accuracy compared to traditional casting techniques.

Although milling techniques achieves greater accuracy, its high fabrication costs limit its practicality for daily use. In contrast, DMLS is a more cost-effective and faster technique with a slightly lower precision.

This paper briefly provides an in-depth exploration of the fundamental principles, clinical applications benefits and considerations associated with direct metal laser selective (DMLS) technology in fixed prosthodontics.

Introduction

Metal-ceramic restorations have maintained their status as the gold standard in fixed prosthodontics for several decades [1-3].

However, a persistent challenge within reconstructive dentistry revolves around the issue of veneering ceramic detachment from metal frameworks [Citation3]. Despite concerted efforts to bolster the bond strength between ceramic and metal substrates, instances of ceramic veneer fractures continue to arise intermittently in clinical practice [3-5].

For many years, metal-ceramic restorations have been crafted using the conventional lost-wax technique. Nonetheless, this approach presents various limits, including the numerous technique-sensitive stages and the occurrence of casting imperfections [6].

The alteration of metal-ceramic adhesion during the laboratory steps that may be related to disparities in thermal expansion coefficients (TEC), insufficient anatomical support, suboptimal surface roughness, metal impurities, deficient metal oxide layers on the alloy, and the presence of voids within the ceramic structure may be responsable of failures within the piece's structure [7, 3].

Attaining a precise marginal fit remains a critical prerequisite for the logivity of dental prostheses [8].

An adequate marginal fit reduces the risk of biological complications by minimizing marginal accumulation bacteria, and plaque [9].

Studies have been directed towards the fit and distortion of porcelain fused to metal crowns, with a particular focus on investigating the influence of the manufacturing technologies on marginal and internal fit of metal-ceramic fixed dental prosthesis [10].

Three dimensional metal printing has emerged as a promising additive manufacturing (AM) technique in prosthodontics, offering precision and versatility in prosthetic manufacturing [11, 12].

Direct metal laser sintering DMLS employs a high-powered laser to selectively fuse metallic powder, layer by layer, based on digital CAD models [13, 14].

This process begins with the creation of a detailed digital design, which is then sliced into successive cross-sectional layers [15].

The laser selectively sinters or melts metal powder particles, meticulously building up the desired structure with micron-level precision [16].

Studies have shown that selective laser sintering (SLS)manufactured objects present higher bond strenghts of 24 ± 10 MPa to 54 ± 14 MPa [3, 17].

In fixed prosthodontics, the 3D printing facilitates the use of biocompatible materials such as cobalt-chromium Co-Cr and feldspathic ceramics ensuring optimal compatibility and longevity.

This technology appear to have the capibility of reducing the occurrence of adhesive failures.

Researches suggested that it displays an acceptable internal marginal gap for dental applications within its manufactured products [3, 20].

Other studies have shown that 3D printing exhibited significantly lower buccal and lingual marginal discrepancies when compared to lost-wax method using die spacer [21].

While DMLS offers significant benefits such as rapid prototyping and reduced production time, it also presents limitations such as higher energy consumption [22, 23].

These products strongly depend on the regulation and standardization of the starting powder material [24, 25].

Furthermore, Scanning speed and energy output of the laser influences its physical properties and may be responsable of thermal stresses and the formation of artifacts [26] which requires special skill sets and education for the dental technician [27].

Conclusion

As research and development efforts continue to refine DMLS technology and expand its capabilities, the future of prosthodontics holds immense promise for further innovation and improvement.

References

1. Zarone F, Russo S and Sorrentino R. “From porcelain-fused-to-metal to zirconia: clinical and experimental considerations”. Dent Mater 27.1 (2011): 83-96.
2. Walton TR. “The up to 25-year survival and clinical performance of 2,340 high gold-based metal-ceramic single crowns”. Int J Prosthodont 26.2 (2013): 151-60.
3. Henning Hesse and Mutlu Özcan. “A review on current additive manufacturing technologies and materials used for fabrication of metal-ceramic fixed dental prosthesis”. Journal of Adhesion Science and Technology 35 (2021): 2529-2546.
4. Coornaert J, Adriaens P and De Boever J. “Long-term clinical study of porcelain-fused-to-gold restorations”. J Prosthet Dent 51.3 (1984): 338-42.
5. Ozcan M and Niedermeier W. “Clinical study on the reasons for and location of failures of metal-ceramic restorations and survival of repairs”. Int J Prosthodont 15.3 (2002): 299-302.
6. Willer J, Rossbach A and Weber HP. “Computer-assisted milling of dental restorations using a new CAD/CAM data acquisition system”. J Prosthet Dent 80.3 (1998): 346-53.
7. Ozcan M. “Fracture reasons in ceramic-fused-to-metal restorations”. J Oral Rehabil 30.3 (2003): 265-9.
8. White SN., et al. “Microleakage of new crown and fixed partial denture luting agents”. J Prosthet Dent 67.2 (1992): 156-61.
9. Quante K, Ludwig K and Kern M. “Marginal and internal fit of metal-ceramic crowns fabricated with a new laser melting technology”. Dent Mater 24.10 (2008): 1311-5.
10. Jahangiri L., et al. “Assessment of sensitivity and specificity of clinical evaluation of cast restoration marginal accuracy compared to stereomicroscopy”. J Prosthet Dent 93.2 (2005): 138-42.
11. Hirt L., et al. “Additive manufacturing of metal structures at the micrometer scale”. Adv Mater 29.17 (2017): 1604211.
12. Trevisan F., et al. “Additive manufacturing of titanium alloys in the biomedical field: processes, properties and applications”. J Appl Biomater Funct Mater 16.2 (2018): 57-67.
13. Niemann P. “Laser-Sinterverfahren in der CAD/CAM-Technik”. Quintessenz Zahntechnik 29 (2003): 38-42.
14. Dikova T, Panova N and Simov M. “Application of laser technologies in dental prothetics”. Mach Technol Mater 6 (2011): 32-35.
15. Sing SL., et al. “Laser and electron-beam powder-bed additive manufacturing of metallic implants: a review on processes, materials and designs”. J Orthop Res 34.3 (2016): 369-385.
16. Herzog D., et al. “Additive manufacturing of metals”. Acta Mater 117 (2016): 371-392.
17. Moraru E., et al. “Mechanical and Surface Characteristics of Selective Laser Melting-Manufactured Dental Prostheses in Different Processing Stages”. Materials 16 (2023): 6141.
18. Barucca G., et al. “Structural characterization of biomedical Co-Cr-Mo components produced by direct metal laser sintering”. Mater Sci Eng C Mater Biol Appl 48 (2015): 263-269.
19. Kul E, Aladag LI and Duymus ZY. “Comparison of the metal-ceramic bond after recasting and after laser sintering”. J Prosthet Dent 114.1 (2015): 109-113.
20. Oyague RC., et al. “Evaluation of fit of cement-retained implant-supported 3-unit structures fabricated with direct metal laser sintering and vacuum casting techniques”. Odontology 100.2 (2012): 249-253.
21. Ziaei M., et al. “Evaluating the Marginal and Internal Discrepancy of Nickel-Chrome Copings Made on Fixed Partial Denture Implants with Conventional and 3D Printing Techniques”. J Contemp Dent Pract 24.11 (2023): 826-833.
22. Liu ZY., et al. “Energy consumption in additive manufacturing of metal parts”. Procedia Manuf 26 (2018): 834-845.
23. Verhoef LA., et al. “The effect of additive manufacturing on global energy demand: an assessment using a bottom-up approach”. Energ Policy 112 (2018): 349-360.
24. Ayyildiz S., et al. “Annealing of Co-Cr dental alloy: effects on nanostructure and Rockwell hardness”. J Adv Prosthodont 5.4 (2013): 471-478.
25. Yildiz MT and Babacan N. “Comparison of tensile properties and porcelain bond strength in metal frameworks fabricated by selective laser melting using three different Co-Cr alloy powders”. J Prosthet Dent 131.5 (2024): 936-942.

26. Bae EJ., et al. “Bond and fracture strength of metal-ceramic restorations formed by selective laser sintering”. J Adv Prosthodont 6.4 (2014): 266-271.
27. Despeisse M and Minshall T. “Skills and education for additive manufacturing: a review of emerging issues”. Advances in production management systems. The path to intelligent, collaborative and sustainable manufacturing. Cham: Springer (2017): 289-297.