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Current Trends and Innovations in Oral and Maxillofacial Reconstruction

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This review examines the latest advancements in maxillofacial reconstruction, focusing on transformative innovations in dentistry. Traditional surgical techniques, although effective, are accompanied by challenges such as inherent risks, complications, and inconsistent outcomes that can be influenced by variations in surgeon skill. To address these drawbacks, cutting-edge technologies have emerged, emphasizing enhanced precision, safety, and efficiency in treatment modalities.

Key innovations in this field include 3-dimensional printing (additive manufacturing), virtual surgical planning, computer-aided design/computer-aided manufacturing (CAD/CAM) technology, and tissue engineering. These advancements not only revolutionize diagnostics but also streamline workflow processes, offering sustainable, timely treatments while improving therapeutic results and aesthetic outcomes. The integration of CAD/CAM technology enhances workflow efficiency by simplifying complex processes in dental prosthetic design. Simultaneously, additive manufacturing facilitates the creation of intricate dental implants with superior accuracy. Virtual surgical planning provides clinicians with valuable preoperative insights, enabling tailored surgical interventions, while tissue engineering presents regenerative solutions to complex reconstructive challenges.

Despite these technological breakthroughs, the adoption of these innovations requires significant initial investments and extensive training for healthcare professionals. While logistical and financial obstacles can arise, the long-term benefits, such as enhanced patient care and superior aesthetic results, are considerable.

In conclusion, this article aims to evaluate the transformative impact of digital and additive manufacturing technologies on maxillofacial reconstruction and to underscore their crucial role in advancing modern dentistry.

Keywords: **Surgery, Oral • Computer-Aided Design • Tissue Engineering • Digital Technology • Bone Regeneration • Printing, Three-Dimensional**

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Introduction

Oral maxillofacial reconstruction includes orthognathic surgery and addressing the treatment of diseases and injuries related to aesthetic and functional aspects of the soft and hard tissues [1]. The procedures performed on the oral and maxillofacial region range from the removal of affected teeth and performing complex facial reconstructions, to treating cleft lip, oral cancer, chronic facial pain disorders, and the palate [2]. The maxillofacial area has a core role in how an individual defines themselves and relates with others [3]. In particular, facial appearance is a significant aspect of one's identity and capacity to show emotion, converse, and eat.

Oral maxillofacial reconstruction has traditionally relied on comprehensive preoperative planning, which includes developing physical models and using different imaging approaches [4]. Other standard practices include dental casts, 2-dimensional (2D) imaging, computed topology scans, panoramic radiography, and cephalograms [2]. Conversely, the standard practices are associated with limitations. For instance, 2D imaging does not offer the comprehensive details that 3-dimensional (3D) imaging offers [2].

The standard techniques applied in oral maxillofacial reconstruction are made up of a range of bone grafting methods and surgical osteotomies [2]. While the standard strategies have been reported to be effective, they are characterized by invasiveness, prolonged recovery times, and postoperative complications, such as nerve damage, infections, and bleeding [5]. In some instances, complications can result in secondary surgical interventions. The traditional oral maxillofacial reconstruction techniques significantly depend on surgeons' experiences and skills, which results in variations in outcomes [2]. Another factor that can result in a variation in outcomes is the unpredictability of how human tissue responds after surgery, which can cause unprecedented results. The unpredictability can result in patient dissatisfaction and an adverse outcome, which has supported the need for advancements in standard practices. The delivery of comprehensive patient care requires opening the mind to novel diagnostic techniques and therapeutic interventions. Consequently, in this review, the focus was discussing the advancements that have been made in facial bone reconstruction.

Oral Maxillofacial Reconstruction Advancements

The dental profession has undergone significant evolution over the years and continues to advance as new technologies and methodologies emerge [6]. A key driver of this progress is the necessity to address illnesses stemming from infectious agents and cellular-level changes effectively. When selecting reconstructive approaches, various factors are considered, including the defect size, vascularization patterns, types of tissues affected, surgeon and patient preferences, and availability of donor tissues for transfer [3]. For small hard tissue defects, the preferred method remains non-vascularized autologous tissue transfers. Current options for reconstruction encompass autologous block bone grafts, local and regional rotational flaps, free flaps, autologous nerve grafts, allografts, xenografts, and prosthetic solutions [3]. However, dental and medical professionals face considerable challenges in reconstructing maxillofacial defects caused by trauma, congenital anomalies, or malignant pathologies [3]. The primary objectives of reconstructive surgery should extend beyond restoring preoperative form and function, to include minimizing intraoperative time and reducing patient morbidity [6].

Key Innovations in Maxillofacial Reconstruction

Significant technological advancements in maxillofacial reconstruction have revolutionized the field. Among these innovations, additive manufacturing (3D printing), virtual surgical planning (VSP), computer-aided design/computer-aided manufacturing (CAD/CAM), and tissue engineering have emerged as critical tools in surgical planning and execution. These technologies have enabled improvements in precision, reduced operative times, and enhanced patient outcomes. Key methods such as VSP and 3D printing allow for more personalized and detailed surgical planning, thereby improving surgical precision and predictability. The use of CAD/CAM technologies further enhances customization and the quality of prosthetic restorations [3,7].

Digital Technology

A contemporary trend in dentistry is the shift toward photopolymerization and powder-based 3D printing, which offer several advantages, including cost-effectiveness, adaptability, and swift fabrication processes [8,9]. Ensuring precision and validity while minimizing risks is essential and drives innovations in oral and maxillofacial reconstruction. Key advancements in digital technology for this field include 3D printing, VSP, and CAD/CAM. The present study highlights advancements in tissue engineering as a critical area of progress.

VSP and 3D Printing

The digital workflow in modern dentistry encompasses image acquisition, post-processing data, and 3D printing [10]. In oral and maxillofacial reconstruction, VSP is invaluable by leveraging patient-specific imaging data acquired through computed

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Table 1. Applications, benefits, and challenges of additive manufacturing in dentistry.

Applications	Benefits	Challenges
Orthodontic models	High precision and accuracy	High initial costs
Dental crowns and implants	Customization of complex designs	Requires specialized training
Surgical guides	Reduced surgical time and complications	Time-intensive for complex designs
Maxillofacial implants	Biocompatible materials	Limited material availability

tomography or cone-beam computed tomography scans. These scans are then converted into 3D digital models, enabling visualization of intricate anatomical structures and simulation of various surgical outcomes [2,11].

Post-processing data transforms the imaging into digital files compatible with 3D printers. Using CAD, virtual 3D representations of anatomical structures are rendered, allowing for segmentation to develop models for advanced evaluation, planning, customization, and printing. VSP facilitates the creation of surgical tools, such as occlusal splints, drilling and cutting guides, custom plates, and skeletal prostheses, which provide detailed preoperative insights [7]. When paired with 3D printing, VSP enhances efficiency from presurgical planning to postsurgical outcomes [12]. This approach allows virtual visualization of procedures, improving surgical precision, predictability, and customization to address individual patient needs [2]. The ability of VSP to simulate outcomes enhances procedural understanding, manages patient expectations, and fosters patient satisfaction [2,13,14].

Sahim and El Quars highlight that VSP aids orthodontists in planning tooth movements and predicting hard and soft tissue changes during surgery [12]. Additionally, it promotes communication between patients and surgeons, reducing operative time and complications while improving precision [13]. VSP enables visualization of interosseous relationships, bony interferences, and segment overlaps, although its success depends on addressing potential sources of error [15].

The integration of 3D printing complements perioperative planning by enabling detailed visualization and simulation of surgical procedures [2,7]. VSP and 3D-printed surgical guides minimize angular and linear deviations, enhancing dental implant accuracy [11]. 3D technology offers precise surgical visualization, improving accuracy and reducing uncertainties [5].

Three-dimensional printing has revolutionized the production of custom dental implants, bridges, crowns, and orthodontic appliances, using CAD data [16,17]. This technique builds physical 3D models layer by layer, using methods such as stereolithography, selective laser sintering, and fused deposition modeling [17]. Combining additive manufacturing with VSP offers promising solutions for reconstructing complex maxillary defects and minimizing soft tissue reconstruction needs [18].

Applications of 3D printing in dentistry include creating 3D templates for missing teeth replacements, designing digital teeth models with CAD, producing surgical guides, printing orthodontic aligners, and fabricating crowns, tools, and custom prosthetics [17]. Its benefits include cost efficiency, precise customization, and rapid production [17].

Three-dimensional printing also improves surgical outcomes, including preoperative planning, intraoperative execution, and postoperative rehabilitation [7,19]. For maxillofacial trauma, it aids in planning osteotomies, repositioning bones, and prebending osteosynthesis plates [10]. Three-dimensional-printed anatomical models based on patient data support surgical training and navigation, producing dental implants from materials such as ceramics, titanium, and titanium alloys [10]. For example, selective laser melting creates 3D-printed jaws by fusing metal powders layer by layer [20]. Commonly used 3D printing materials include polypropylene, acrylics, polyethylene, and polylactic acid, the latter valued for its low melting point, strength, and biocompatibility [10].

Postoperatively, 3D printing has introduced custom prosthetics and implants that expedite recovery and enhance rehabilitation outcomes. It also enhances patient communication through tangible models that clarify surgical procedures, improving informed consent [21]. Furthermore, 3D-printed surgical guides reduce surgical time, enhance precision, and minimize complications [22]. Anatomical models produced via 3D printing allow accurate analysis of defects, restoration of symmetry, and understanding of complex structures, like the maxilla, orbit, and mandible. These models aid preoperative evaluation and patient motivation [7]. **Table 1** summarizes the key applications, benefits, and challenges of 3D printing in dentistry.

CAD/CAM Technology

The implementation of CAD/CAM technology has significantly advanced the field of dentistry, offering innovative solutions across various domains. Restorations using CAD/CAM can be classified into 3 categories: chairside, laboratory, and

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Table 2. Comparison of traditional methods and computer-aided designing/computer-aided machining (CAD/CAM) technology in terms of efficiency, cost, and precision.

Parameter	Traditional methods	CAD/CAM technology
Efficiency	Time-consuming	Rapid production
Cost	Lower initial cost	Higher initial investment
Precision	Variable, operator-dependent	Consistently high
Customization	Limited	High customization

centralized production. Chairside restorations involve taking an impression and fabricating the restoration in a single patient visit, without laboratory involvement, providing time efficiency but at a higher cost. Laboratory production follows a more traditional approach, in which impressions are sent to laboratory technicians for processing. Centralized production involves digitizing the impression in a laboratory and outsourcing fabrication to an external facility before returning the final restoration to the dentist [23].

CAD/CAM is applied across a broad spectrum of dental procedures, including single-unit restorations and complex surgeries. This technology enhances the quality of prostheses by reducing manufacturing time and enabling accurate error detection [24,25]. Additionally, CAD/CAM supports craniofacial reconstruction, offering improved patient comfort, aesthetic outcomes, and surgical predictability. Its use in developing patient-specific surgical guides and implants facilitates the transition from VSP to actual surgical procedures [26].

The primary advantages of CAD/CAM include its precision, customization capabilities, and ability to produce aesthetic restorations. It allows for the use of diverse materials, such as metals, composites, and ceramics, thereby broadening the scope of prosthetic restoration options [23,27]. In clinical practice, CAD/CAM has demonstrated efficacy in various applications, including direct metal laser sintering for metal restorations, 3D-printed prototypes for alloy casting, and milling of fiber-reinforced composites and lithium disilicate ceramics. These techniques provide a balance of precise fitting, stability, and individualized restoration shapes [27].

Furthermore, CAD/CAM enhances the efficiency of dental diagnostics, including implant impressions, pulp exposure management, caries assessment, and temporomandibular disorder diagnoses [28]. While the cost and limited availability of CAD/CAM remain challenges, the ability of CAD/CAM to improve accuracy, reduce errors, and deliver high-quality outcomes has established it as a transformative technology in modern dentistry [23,26]. **Table 2** shows the comparison of traditional methods and CAD/CAM technology in terms of efficiency, cost, and precision.

Tissue Engineering

Regenerating large maxillofacial defects presents significant challenges, particularly in cases involving the loss of biocritical bone segments [10,12]. However, advancements in 3D printing have opened new avenues for personalized tissue regeneration therapies [29]. The development of patient-specific 3D-printed bioactive scaffolds underpins the application of tissue engineering in tailored treatments. Tissue engineering integrates stem cells, growth factors, and biomaterials, to restore the structure and functionality of damaged tissues. These components work in tandem to create a complex microenvironment that includes the vascular system, which is crucial for nutrient delivery, waste removal, pulp regeneration, and inflammatory response regulation [30-32].

Tissue engineering therapies leveraging stem cells have been identified as promising avenues for enhancing current maxillofacial and oral reconstructive practices [3]. Advances in tissue engineering and biomaterial sciences have shown the potential of stem cell-based therapies in maxillofacial reconstruction [33]. Nonetheless, a significant limitation remains the lack of clinically implemented stem cell-based devices or products to replace microsurgical free tissue transfer, which continues to be the criterion standard. Despite this, stem cell therapy offers an emerging alternative with the potential to improve reconstruction outcomes [33].

This innovative field shows promise as a substitute for autologous bone grafts in bone defect reconstruction, as it enhances tissue regeneration through the use of cytokines, growth factors, and stem cells [3,33,34]. For example, advanced platelet-rich fibrin has demonstrated efficacy in accelerating bone regeneration in allografts and reducing healing times after maxillary sinus augmentation. Combining serum albumin-coated bone allografts with advanced platelet-rich fibrin can facilitate implantation after 3 months, achieving outcomes comparable to the standard 6-month healing period [35].

While tissue engineering holds great promise for the future of reconstructive surgery, facilitating regeneration in tissues compromised by various dental pathologies [34], restoring complex

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Table 3. Key components of tissue engineering in maxillofacial reconstruction.

Component	Role
Scaffolds	Provide structural support for tissue growth
Growth factors	Stimulate cellular processes and regeneration
Stem cells	Promote tissue repair and regeneration

tissue structures with full functionality remains a significant challenge that requires continued research and innovation. **Table 3** highlights the key components of tissue engineering, including scaffolds, growth factors, and stem cells, and their roles in maxillofacial reconstruction.

Conclusions

The ongoing advancements in oral and maxillofacial surgery have ushered in a transformative era characterized by the adoption and refinement of various technologies, techniques, and innovative approaches. These developments have played a pivotal role in reshaping traditional surgical methodologies, enabling enhanced precision, optimizing efficiency, and significantly improving patient outcomes. The integration of digital technologies into oral and maxillofacial reconstruction represents a cornerstone of this progress, revolutionizing the field by providing clinicians with tools to achieve unprecedented levels of accuracy and reliability.

The benefits of 3D-based technologies in dentistry are extensively documented, showcasing their impact on improving clinical outcomes, while streamlining procedural workflows. These technologies have proven instrumental in increasing diagnostic accuracy, reducing surgical errors, and enhancing treatment predictability. Tools such as cone beam computed tomography and 3D imaging have become integral components in the assessment and planning stages of oral and maxillofacial reconstruction. By offering detailed anatomical visualizations, these tools enable personalized treatment plans tailored to the specific needs of each patient. Furthermore, 3D printing has emerged as a transformative tool, allowing for the fabrication of anatomical models, surgical splints, patient-specific implants, and prostheses. This capability not only reduces manufacturing times but also fosters more efficient and precise surgical interventions.

Parallel to these advancements, the field of tissue engineering has made remarkable strides. The application of stem cell therapies in regenerative medicine introduces a groundbreaking dimension to oral and maxillofacial surgery. Tissue engineering leverages the body's natural healing mechanisms by integrating biomaterials, growth factors, and stem cells to regenerate and restore damaged tissues. This approach has shown immense promise in addressing challenges such as bone and soft tissue defects, particularly in complex reconstructive scenarios. As a result, tissue engineering represents a forward-looking strategy with the potential to augment or even replace traditional methods, such as autologous grafting and microsurgical tissue transfer.

Looking ahead, the continued evolution of these technologies is expected to drive further innovations in oral and maxillofacial surgery. The synergistic application of advanced imaging modalities, 3D printing, and tissue engineering will likely redefine the standards of care, offering patients safer, faster, and more effective solutions. However, alongside these advancements, ongoing research and development are essential to address challenges such as material biocompatibility, cost-effectiveness, and regulatory considerations. As the field progresses, it is poised to not only improve clinical outcomes but to also enhance the overall patient experience, solidifying its role as a critical domain in contemporary medicine.

Future Directions

Advancements in oral and maxillofacial restorations have revolutionized dentistry; however, digital technologies often entail substantial initial investment costs [25]. This section delves into the challenges and future directions in this evolving field.

The application of VPS and 3D technology has demonstrated improved clinical outcomes [35], but integrating 3D technology into routine practice poses financial challenges [7]. However, ongoing advancements in software and manufacturing processes have the potential to reduce these costs over time. Another hurdle with 3D printing is the time-intensive nature of manufacturing. While simple anatomical models can be printed in healthcare facilities, complex implants require specialized manufacturing units, adding to time and costs [7]. Additionally, complications, such as implant rejection, infection, or loosening, can occur, emphasizing the need for randomized controlled trials to establish causality [7].

Post-processing measures, such as mitigating unfavorable responses to metallic residues and surface topologies, are essential to improve 3D-printed implant outcomes [36]. Future advancements should focus on developing materials with enhanced biocompatibility to reduce graft rejection and infection risks [7]. The stiffness and flexibility of materials should mimic natural bone properties, and further clinical evidence is necessary to validate the long-term benefits of 3D-printed dental

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implants [10]. Challenges including insufficient legal regulations, randomized controlled trials, and standardized procedures, particularly for vascularization in scaffolds, need to be addressed before widespread clinical application can occur.

Additive manufacturing technologies offer numerous advantages but also face challenges that require resolution to maximize their potential [16]. For instance, magnetic resonance imaging data cannot be directly used in additive manufacturing, and certain materials, such as some polymers, composites, and high-strength metals, are incompatible with the process [16]. Future efforts should align the rapid evolution of additive manufacturing with the development of biocompatible materials to enable cost-effective prosthodontic model production [17]. Enhancing collaboration between laboratory technicians and clinicians could foster solutions for producing custom dental models [17]. Nevertheless, optimizing printing parameters and improving the printability of biocompatible materials remain critical research areas [36].

The use of CAD/CAM technology in diagnostics has proven valuable but is not without challenges. High costs and significant time investments are primary obstacles [37]. Procedures using CAD/CAM can be twice as expensive as traditional laboratory services and demand extensive training, with a steep learning curve spanning months. Additionally, achieving aesthetically pleasing veneers with durable frameworks and cores presents technical difficulties [37]. The variability in the survival rates of CAD/CAM restorations based on material selection underscores the need for more clinical studies to assess material durability [38].

Tissue engineering, while promising, faces limitations in maxillofacial reconstruction, especially for complex soft tissue constructs [3]. Continued research is essential to evaluate the durability of tissue-engineered constructs and optimize procedures. Standardization and integration of stem cell therapy into clinical practice necessitate further investigation to advance its routine application.

In conclusion, while significant strides have been made in oral and maxillofacial restoration technologies, overcoming existing challenges through research and development will be crucial for achieving their full potential.

References:

1. Hartmann A, Schmohl J, Cascant Ortolano L, et al. Therapy of neurophysiological changes after oral and maxillofacial surgery – a systematic review. Appl Sci. 2022;12(3):1-17
2. Kim J-Y, Lee Y-C, Kim S-G, Garagiola U. Advancements in oral maxillofacial surgery: A comprehensive review on 3D printing and virtual surgical planning. Appl Sci. 2023;13(17):9907
3. McGue CM, Mañón VA, Viet CT. Advances in tissue engineering and implications for oral and maxillofacial reconstruction. J Calif Dent Assoc. 2021;49(11):685-94
4. Lee YC, Sohn HB, Park YW, Oh JH. Evaluation of postoperative changes in condylar positions after orthognathic surgery using balanced orthognathic surgery system. Maxillofac Plast Reconstr Surg. 2022;44(1):11
5. Sugahara K, Koyachi M, Odaka K, et al. A safe, stable, and convenient three-dimensional device for high Le Fort I osteotomy. Maxillofac Plast Reconstr Surg. 2020;42(1):32
6. Song D. Oral and maxillofacial reconstruction: Thinking beyond the dental complex in diagnosis and treatment. J Calif Dent Assoc. 2021;49(3):123-24
7. Dadhich A, Nilesh K, Shah S, Saluja H. Three-dimensional printing in maxillofacial surgery: A quantum leap in future. Natl J Maxillofac Surg. 2022;13(Suppl. 1):S203-S11
8. Assari A. Usability of three-dimensional printing in maxillofacial surgery: A narrative review. Open J Implant Dent. 2023;17(1):1-10
9. Touri M, Kabirian F, Saadati M, et al. Additive manufacturing of biomaterials – the evolution of rapid prototyping. Adv Eng Mater. 2019;21(2):Article 1800511
10. Hadad H, Boos Lima FB, Shirinbak I, et al. The impact of 3D printing on oral and maxillofacial surgery. J 3D Print Med. 2023;7(2):1-13
11. Park SY, Hwang DS, Song JM, Kim UK. Comparison of time and cost between conventional surgical planning and virtual surgical planning in orthognathic surgery in Korea. Maxillofac Plast Reconstr Surg. 2019;41(1):35 [Erratum in: Maxillofac Plast Reconstr Surg. 2023;45(1):37]
12. Sahim S, El Quars F. Virtual planning versus traditional planning in orthodontic-surgical treatment: A review. OALibJ. 2023;10(7):1-9
13. Oh HJ, Son IS, Lee SJ, et al. Effect of maxillary impaction on mandibular surgical accuracy in virtually-planned orthognathic surgery: A retrospective study. J Craniomaxillofac Surg. 2023;51(6):387-92
14. Trevisiol L, Bersani M, Martinez Garza A, et al. Accuracy of virtual surgical planning in bimaxillary orthognathic surgery with mandible first sequence: A retrospective study. J Craniomaxillofac Surg. 2023;51(5):280-87
15. Kwon TG, Lee ST, Choi SY, Kim JW. Considerations for virtual surgical planning and simulation in orthognathic surgery – a narrative review. Front Oral Maxillofac Med. 2020;2:1-10
16. Celik HK, Koc S, Kustarci A, et al. The state of additive manufacturing in dental research – a systematic scoping review of 2012-2022. Heliyon. 2023;9(6):e17462
17. Javaid M, Haleem A. Current status and applications of additive manufacturing in dentistry: A literature-based review. J Oral Biol Craniofac Res. 2019;9(3):179-85
18. Kudva A, Srikanth G, Singh A, et al. Reconstruction of maxillary defects using virtual surgical planning and additive manufacturing technology: A tertiary care centre experience. J Maxillofac Oral Surg. 2024;23(3):644-52
19. Dod G, Jibhakate R, Walke P. A review on 3D printing maxillofacial surgery: Present work and future prospects. Mater Today. 2023;1(1):1-10
20. Nikhil K, Ranjan R, Pandey R. Additive manufacturing application in dentistry: A systematic literature review. Conference: Second International Conference on Design and Materials, 2023;1(1):1-10
21. Nesic D, Schaefer BM, Sun Y, et al. 3D printing approach in dentistry: The future for personalized oral soft tissue regeneration. J Clin Med. 2020;9(7):2238
22. May MM, Howe BM, O'Byrne TJ, et al. Short and long-term outcomes of three-dimensional printed surgical guides and virtual surgical planning versus conventional methods for fibula free flap reconstruction of the mandible: Decreased nonunion and complication rates. Head Neck. 2021;43(8):2342-52
23. Aslam K, Nadim R. A review on cad cam in dentistry. J Pak Dent Assoc. 2015;24(03):112-16
24. Suganna M, Kausher H, Tarek Ahmed S, et al. Contemporary evidence of CAD-CAM in dentistry: A systematic review. Cureus. 2022;14(11):e31687
25. AlShaibani R, Akhtar TM, Gentle M, et al. Digital applications of maxillofacial reconstruction – a systematic review. J Adv Dent. 2021;1(1):21-27
26. Probst FA, Liokatis P, Mast G, Ehrenfeld M. Virtual planning for mandible resection and reconstruction. Innov Surg Sci. 2023;8(3):137-48
27. Tomova Z, Zhekov Y, Alexandrov G, et al. Application of CAD/CAM technologies and materials for prosthetic restoration of severely damaged teeth-clinical cases. Aust Dent J. 2023;68(4):294-302

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS]

28. Ardila CM, González-Arroyave D. Efficacy of CAD/CAM technology in dental procedures performed by students: A systematic scoping review of randomized clinical trials. Heliyon. 2023;9(4):e15322
29. Matheus HR, Hadad H, Guastaldi FP. The state of 3D Printing of bioengineered customized maxillofacial bone scaffolds: A narrative review. Front Oral Maxillofac Med. 2024;6:1-10
30. Sugiaman VK, Jeffrey, Naliani S, et al. Polymeric scaffolds used in dental pulp regeneration by tissue engineering approach. Polymers (Basel). 2023;15(5):1082
31. Kulebyakin KY, Nimiritsky PP, Makarevich PI. Growth factors in regeneration and regenerative medicine: "The cure and the cause". Front Endocrinol. 2020;11:384
32. Xie Z, Shen Z, Zhan P, et al. Functional dental pulp regeneration: Basic research and clinical translation. Int J Mol Sci. 2021;22(16):8991
33. He P, Zhang Q, Motiwala FI, et al. Potential application of dental stem cells in regenerative reconstruction of oral and maxillofacial tissues: A narrative review. Front Oral Maxillofac Med. 2022;4:14
34. Shetty SS, Shetty S, Venkatesh SB. Tissue engineering in oral and maxillofacial rehabilitation – current status and future prospects. Curr Oral Health Rep. 2024;1(1):1-7
35. Zoabi A, Redenski I, Oren D, et al. 3D printing and virtual surgical planning in oral and maxillofacial surgery. J Clin Med. 2022;11(9):2385
36. Cristache CM. Aditive manufacturing in maxillofacial prosthodontics. Appl Sci. 2023;13(17):9972
37. Abdulla MA, Ali H, Jamel RS. CAD-CAM technology: A literature review. Rafidain Sent J. 2020;20(1):95-113
38. Rexhepi I, Santilli M, D'Addazio G, et al. Clinical applications and mechanical properties of CAD-CAM materials in restorative and prosthetic dentistry: A systematic review. J Funct Biomater. 2023;14(8):431

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