# Orthognathic Surgery and Oral and Maxillofacial Surgery: A Survey

www.surveyx.cn


## Abstract

Orthognathic, oral surgery, and oral and maxillofacial surgeries are pivotal in correcting jaw and facial irregularities, significantly enhancing patients' functional and aesthetic outcomes. This survey examines the integration of advanced technologies, including computer-aided design and computer-assisted surgery, which have revolutionized surgical precision and patient care. The transition from 2D to 3D imaging technologies, such as cone-beam computed tomography, has improved diagnostic accuracy and surgical planning. Additionally, innovations like virtual and augmented reality, along with robotic platforms, have further enhanced surgical precision and training. The role of telemedicine and digital health is emphasized, particularly in remote patient care, facilitating postoperative monitoring and consultations. Nursing informatics is highlighted for its contribution to data management and improved healthcare delivery. Despite these advancements, challenges in telemedicine implementation and educational gaps in oral and maxillofacial surgery training persist. Future directions include optimizing reverse engineering and rapid prototyping technologies, developing autonomous robotic systems, and enhancing augmented reality applications. Addressing these challenges will require collaborative efforts to ensure the successful integration of these technologies, ultimately improving patient outcomes and expanding access to care in the digital age.


## 1 Introduction

### 1.1 Importance of Orthognathic and Oral Maxillofacial Surgery

Orthognathic and oral maxillofacial surgeries are vital for correcting dento-facial deformities, significantly improving patients' quality of life by addressing both functional and aesthetic concerns [1]. These interventions not only restore occlusal function and achieve facial harmony but also enhance soft tissue aesthetics, ultimately contributing to psychosocial well-being and oral functionality [2, 3].

Reconstructing the mandible remains a challenge for maxillofacial surgeons. Recent advancements in simulation techniques have improved reconstructive outcomes, as traditional methods relying on 2D radiographs and manual model surgery are increasingly seen as inadequate [4, 5]. The integration of 3D technology in orthognathic surgery has proven essential for enhancing surgical precision and outcomes [6].

Moreover, effective planning tools for cranial 3D implant design are crucial for customizing implants and improving patient outcomes [7]. The limitations of earlier methods in observing speech biophysics during surgery underscore the need for innovative approaches that can simultaneously capture speech and anatomical data, facilitating better surgical planning [8].

Understanding postoperative complications is vital for informing patients and improving surgical outcomes, guiding practitioners towards optimal results [9]. Additionally, during the COVID-19 pandemic, managing patients in oral and maxillofacial surgery required careful strategies due to the

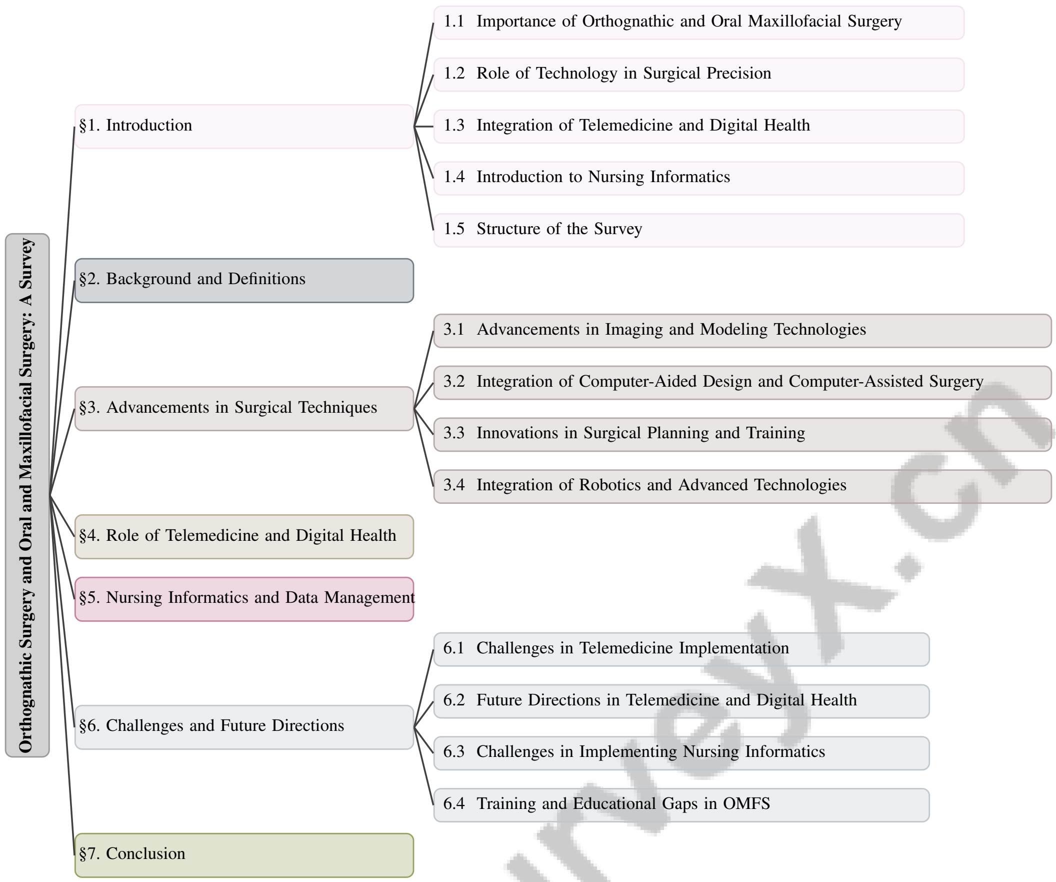


Figure 1: chapter structure

high risk of SARS-CoV-2 transmission [10]. Thus, orthognathic and oral maxillofacial surgeries are indispensable, profoundly affecting both functional and aesthetic aspects of patient health [3].

### 1.2 Role of Technology in Surgical Precision

Technological advancements have revolutionized orthognathic and oral maxillofacial surgeries, markedly enhancing surgical precision and patient outcomes. The shift from two-dimensional to three-dimensional imaging technologies has enabled comprehensive evaluations and precise surgical planning. For instance, structured light scanning has improved assessments of post-surgical changes in nasolabial soft tissues [2]. Computer-aided simulation benchmarks have further refined surgical planning, leading to better patient outcomes by enhancing the accuracy of orthognathic surgery [5].

The development of computerized registration systems for maxillofacial cone-beam computed tomography (CT) images and scanned dental models exemplifies how technology streamlines surgical procedures, improving alignment between preoperative and intraoperative data [11]. Furthermore, 3D technology addresses the limitations of conventional 2D methods, providing valuable insights that enhance surgical outcomes [6].

Innovations like SurgTrack, which utilizes signed distance function (SDF) modeling for registration, have improved robustness against occlusions and weak textures, thereby enhancing surgical precision [12]. The integration of virtual and augmented reality technologies has also transformed surgical planning and training, facilitating interactive modifications to cranial implant designs and improving procedural accuracy.

Robotic platforms combined with ultrasound technology represent another frontier in enhancing surgical capabilities, emphasizing robotics' role in increasing precision and minimizing human error [13]. Additionally, a digital platform integrating 3D jaw-teeth-face models supports applications in



AI-generated, for reference only.

treatment planning and orthognathic surgery, offering a comprehensive approach to surgical precision [14].

Recent advancements in 3D technology, virtual and augmented reality, and artificial intelligence have significantly transformed surgical precision in orthognathic and oral maxillofacial surgery. These innovations improve preoperative diagnosis, surgical planning, execution, and postoperative evaluation, ultimately leading to enhanced patient care and outcomes. Notably, the integration of 3D imaging, computer-aided design, and virtual planning has decreased operative time and hospital stays while increasing surgical accuracy, playing a crucial role in addressing complex dental and facial deformities [15, 5, 16, 6, 1].

### 1.3 Integration of Telemedicine and Digital Health

Telemedicine and digital health have become pivotal in transforming remote patient care, addressing challenges posed by an aging population and rising healthcare costs [17]. Their integration into healthcare systems has fostered financially viable models that expand access to medical services while enhancing patient satisfaction and alleviating the burdens of traditional healthcare delivery [18].

In oral and maxillofacial surgery, telemedicine has proven essential for postoperative care, enabling timely access to healthcare professionals without the need for physical visits. This approach enhances patient satisfaction by offering convenience and reducing travel-related stress, while also yielding cost savings for both providers and patients [18]. The use of telemedicine for surgical prioritization and educational adaptations during the COVID-19 pandemic further underscores its importance in maintaining healthcare continuity and safety [19].

The advent of 3D printing technology in telemedicine exemplifies the potential of digital health tools in remote patient care, allowing for the production of customized medical devices and anatomical models that support personalized treatment plans [20]. These advancements highlight the transformative role of telemedicine and digital health in modern healthcare, demonstrating their capacity to improve patient outcomes and streamline service delivery in orthognathic and oral maxillofacial surgery.

### 1.4 Introduction to Nursing Informatics

Nursing informatics represents a critical intersection of nursing practice and information technology, aiming to enhance healthcare delivery through improved data management and technological integration. Utilizing advanced technologies such as augmented reality (AR), nursing informatics significantly enhances patient care and operational efficiency, providing innovative solutions to contemporary healthcare challenges [21]. The integration of artificial intelligence (AI) within nursing informatics further exemplifies its transformative potential, particularly in dental diagnostics, where AI technologies are revolutionizing patient care and diagnostic accuracy [22].

The role of nursing informatics extends beyond technological adoption; it encompasses continuous adaptation and refinement of healthcare practices, especially in response to emerging challenges such as the COVID-19 pandemic. The ongoing evolution of guidelines and practices in light of new information about the virus underscores the importance of nursing informatics in maintaining healthcare resilience [10]. By focusing on the seamless integration of technology within nursing practice, nursing informatics serves as a pivotal tool in optimizing healthcare delivery, ultimately improving patient outcomes and enhancing healthcare systems [23].

### 1.5 Structure of the Survey

This survey is meticulously organized to provide a comprehensive exploration of orthognathic surgery, oral surgery, and oral and maxillofacial surgery, focusing on integrating advanced technologies that enhance surgical precision, patient care, and healthcare delivery. The introduction highlights the critical role of orthognathic surgery in correcting jaw and facial irregularities, emphasizing its applications beyond aesthetic improvements to include treatments for conditions such as obstructive sleep apnea. It also discusses the transformative impact of advanced technologies, particularly three-dimensional (3D) imaging and virtual reality, on surgical planning, execution, and postoperative evaluation, collectively enhancing outcomes and reducing operative times [16, 15, 6, 9].

The survey is structured into several key sections. The first section, "Background and Definitions," provides detailed explanations of core concepts relevant to the field, establishing a foundational understanding for readers. This is followed by "Advancements in Surgical Techniques," which explores recent technological innovations, including computer-aided design and computer-assisted surgery, and their role in enhancing surgical precision.

Subsequently, the section on "Role of Telemedicine and Digital Health" examines the impact of these technologies on patient care, providing examples of successful implementations. The paper then transitions to "Nursing Informatics and Data Management," discussing how nursing informatics efficiently manages patient data and integrates data management technologies in surgical care.

The survey concludes with "Challenges and Future Directions," identifying current challenges in integrating advanced technologies and potential future innovations. This section also addresses training and educational gaps in oral and maxillofacial surgery, offering insights into future research directions.

Each section is carefully crafted to build upon the previous one, ensuring a logical flow of information that guides the reader through the complexities of the subject matter, reinforcing the survey's overarching theme of technological integration in surgical and healthcare practices.The following sections are organized as shown in Figure 1.

## 2 Background and Definitions

### 2.1 Core Concepts and Definitions

Understanding the foundational concepts in orthognathic and oral maxillofacial surgery is essential for appreciating the advancements in this field. Computer-aided design (CAD) is pivotal in enhancing surgical precision, particularly when integrated with Reverse Engineering (RE) and Rapid Prototyping (RP), improving reconstructive outcomes [4]. The synergy between CAD and computer-assisted surgery emphasizes the role of advanced imaging and modeling in achieving surgical accuracy [24].

Cone-beam computed tomography (CBCT) is crucial for providing detailed imaging across dental specialties, supporting precise alignment of preoperative and intraoperative data [11]. The application of 3D technology in orthognathic surgery surpasses traditional methods, offering comprehensive insights for diagnosis, planning, and evaluation [6].

Artificial Intelligence (AI) is reshaping diagnostic accuracy and treatment planning, offering sophisticated tools for assessing nasolabial soft tissue changes post-surgery through structured light scanning [16, 2, 1, 22]. Telemedicine and digital health expand healthcare access, enabling remote consultations and continuous care, while nursing informatics leverages data management technologies to enhance healthcare delivery [22].

The integration of ultrasound-based robotic systems and automated navigation systems signifies significant advancements in surgical practices, addressing challenges and enhancing precision [13]. These developments in orthognathic surgery highlight the evolving landscape, focusing on aesthetic outcomes and technological integration [15].

A comprehensive understanding of telemedicine, augmented reality, and nursing informatics is essential for recognizing technological advancements that enhance precision in surgical practices. These innovations improve patient care, increase accessibility, and reduce costs, thereby transforming modern healthcare [23, 18, 21].

### 2.2 Historical Development and Evolution

The evolution of orthognathic and oral maxillofacial surgery (OMFS) reflects significant advancements in surgical methods and technology. Initially limited by two-dimensional imaging, the field progressed with the advent of three-dimensional imaging, particularly cone-beam computed tomography (CBCT), which enhanced diagnostic accuracy and surgical planning [25, 26].

OMFS training programs have adapted to the increasing complexity of procedures, balancing theoretical knowledge with practical skills. This evolution includes adaptations during the COVID-19 pandemic, emphasizing safety measures like PPE and screening [27]. Procedures are now categorized by urgency, prioritizing based on clinical necessity and resources [10].

Technological innovations, such as CAD and computer-assisted surgery, have revolutionized the field, enabling precise modeling for complex reconstructions and addressing historical challenges in anatomical clarity [4]. Despite these advancements, there remains a need for comprehensive frameworks capturing the complexities of 3D facial structures, categorized into stages from diagnosis to postoperative evaluation.

AI is an emerging frontier, enhancing diagnostic precision and optimizing treatment plans, though literature in this area is still developing [1]. Understanding wound healing phases is crucial for informing surgical practices and postoperative care [28].

The historical development of orthognathic surgery and OMFS illustrates a trajectory of sophistication and precision, driven by 3D technology advancements and a deeper understanding of anatomical complexities. These innovations have expanded applications beyond traditional corrections to include treatments for obstructive sleep apnea and cosmetic enhancements. The integration of AI and 3D imaging into surgical planning and execution has reduced operative times and improved outcomes, marking a comprehensive transformation in the field [15, 6, 1].

In recent years, the field of oral and maxillofacial surgery has witnessed significant advancements, particularly in the realm of imaging and modeling technologies. These innovations are crucial as they not only enhance the precision of surgical procedures but also improve patient outcomes. Figure 2 illustrates the hierarchical structure of these advancements, detailing the integration of computer-aided design and computer-assisted surgery, as well as innovations in surgical planning and training. Each section of the figure delves into the specific technologies, methods, and applications that contribute to increased efficiency and effectiveness in surgical practices. By examining these developments, we can better understand the transformative impact of advanced technologies in the surgical domain.

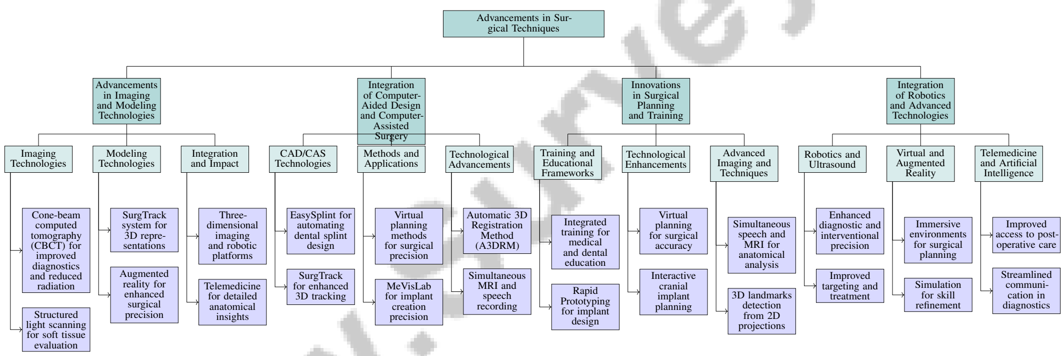


Figure 2: This figure illustrates the hierarchical structure of advancements in surgical techniques, focusing on imaging and modeling technologies, integration of computer-aided design and computer-assisted surgery, innovations in surgical planning and training, and the integration of robotics and advanced technologies. Each section explores the technologies, methods, and applications that enhance precision, efficiency, and outcomes in oral and maxillofacial surgery.

# 3 Advancements in Surgical Techniques

## 3.1 Advancements in Imaging and Modeling Technologies

| Method Name | Technological Advancements | Imaging Techniques | Modeling Innovations |
|---|---|---|---|
| SLS[2] | 3D Imaging | Structured Light Scanning | Structured Light Scanning |
| ST[12] | Surgtrack System | Rgb-D Video | Sdf Modeling |
| OPP[29] | Diminished Reality | Medical Video Inpainting | Dual-domain Propagation |

Table 1: Overview of recent advancements in imaging and modeling technologies relevant to orthognathic and oral maxillofacial surgery. This table highlights specific methods, their technological advancements, imaging techniques, and modeling innovations, illustrating the integration of these advancements in enhancing surgical precision and outcomes.

Imaging and modeling technologies have significantly enhanced orthognathic and oral maxillofacial surgery by providing detailed anatomical insights and improving precision. Table 1 provides a comprehensive summary of the latest methods in imaging and modeling technologies, emphasizing their contributions to improving surgical precision and outcomes in orthognathic and oral maxillofacial surgery. The transition from traditional imaging to advanced modalities like cone-beam computed tomography (CBCT) has improved diagnostic capabilities and reduced radiation exposure, establishing CBCT as a cornerstone in dental radiography and surgical planning [26]. Its comprehensive three-dimensional visualizations enable precise assessments of complex craniofacial structures, optimizing surgical outcomes.

Structured light scanning offers high-resolution evaluations of soft tissue changes, enhancing the predictability of surgical results by accurately assessing nasolabial soft tissues, crucial for achieving desired aesthetic and functional outcomes [2]. The integration of high-fidelity imaging techniques in preoperative planning is vital for successful surgical interventions.

Innovative modeling technologies, such as the SurgTrack system, generate reliable three-dimensional representations without traditional CAD models, using historical tracking data to address challenges from occlusions and weak textures, thereby improving the accuracy of surgical navigation [12]. Augmented reality (AR) technology enhances patient outcomes and operational efficiencies by providing interactive experiences that improve surgeons' visualization and manipulation of anatomical structures during procedures, leading to more precise surgical execution [21].

The Optimised ProPainter method, incorporating advanced propagation mechanisms and transformer architectures, enhances clarity and continuity in surgical videos, supplying critical visual information that aids complex surgical decision-making [29]. These advancements underscore the pivotal role of imaging and modeling technologies in enhancing surgical planning and execution. By integrating three-dimensional imaging, robotic platforms, and telemedicine into surgical practices, healthcare providers achieve detailed anatomical insights and perform precise interventions, improving patient outcomes and fostering ongoing innovations in surgery [18, 13, 6].

### 3.2 Integration of Computer-Aided Design and Computer-Assisted Surgery

The integration of computer-aided design (CAD) and computer-assisted surgery (CAS) has greatly enhanced precision and efficiency in orthognathic and oral maxillofacial procedures. These technologies utilize advanced imaging and modeling techniques to improve surgical planning and execution. For instance, specialized software like EasySplint automates dental splint design for orthognathic surgery, streamlining the process and increasing operational efficiency [30].

A systematic review of virtual planning methods highlights their role in improving surgical precision and establishing benchmarks for accuracy [5]. The SurgTrack system employs a two-stage 3D tracking method, enhancing tracking robustness and accuracy [12]. CAD/CAM technologies and 3D printed models enhance surgical accuracy by providing precise anatomical guidance for complex surgeries [6]. MeVisLab's customized data-flow network improves implant creation precision, demonstrating the transformative impact of these technologies in reconstructive surgeries [7].

Advanced methods like the Automatic 3D Registration Method (A3DRM) enhance integration of 3D images by detecting corresponding landmarks in 2D projections, improving alignment between preoperative and intraoperative data [14]. This integration is augmented by simultaneous MRI and speech recording, creating comprehensive datasets that enhance understanding of anatomical changes and surgical outcomes [8].

Recent advancements in CAD and CAS underscore their essential contributions to contemporary surgical practices, facilitating innovative solutions that enhance surgical precision and improve patient outcomes. These technologies streamline postoperative care through telemedicine and integrate augmented reality and artificial intelligence, optimizing surgical planning and execution [15, 21, 16, 18, 22]. By adopting these technologies, practitioners achieve greater accuracy and efficiency, ultimately enhancing patient care quality.

### 3.3 Innovations in Surgical Planning and Training

Advancements in surgical planning and training have significantly improved precision and educational outcomes in oral and maxillofacial surgery (OMFS). Integrated training approaches emphasizing comprehensive education in both medical and dental fields are essential for effective OMFS practice



AI-generated, for reference only.

[31]. These educational frameworks are enhanced by technological innovations that facilitate detailed surgical planning and execution.

Rapid Prototyping captures patient data to create precise 3D models, aiding in implant design and the production of final medical models, improving surgical outcome accuracy and providing invaluable training tools [4]. The two-step process for generating dental splints using specialized software exemplifies technology's role in improving operational efficiency and training methodologies [30].

Virtual planning methods have been shown to enhance surgical accuracy, with outcome differences generally accepted to be less than 2 mm [5]. These methods set benchmarks for precision in surgical planning, underscoring digital technologies' transformative impact on educational outcomes and surgical practices [16]. Interactive cranial implant planning approaches allow user engagement at each design step, enriching training and planning processes through hands-on experience [7].

Advanced imaging techniques, such as simultaneous acquisition of speech signals and MRI images, provide comprehensive analyses of anatomical changes, offering detailed insights crucial for surgical planning and training [8]. Detecting 3D landmarks from 2D projections and aligning surfaces using iterative closest point algorithms represent significant advancements in surgical planning, providing precise tools for educational and practical applications [14].

Advancements in telemedicine, virtual reality (VR), and augmented reality (AR) highlight these technologies' essential roles in transforming surgical planning and training within OMFS. By enhancing preoperative diagnosis, surgical procedures, and postoperative care, these innovations contribute to improved accuracy, operational efficiency, and educational outcomes, leading to better patient satisfaction and reduced healthcare costs. The integration of 3D imaging, VR environments, and AR applications not only facilitates precise surgical interventions but also enriches surgeons' training experiences, ensuring they are well-equipped to handle complex cranio-maxillofacial procedures [31, 21, 16, 6, 18]. Incorporating these developments into educational frameworks prepares practitioners to address surgical complexities, enhancing patient care and outcomes.

### 3.4 Integration of Robotics and Advanced Technologies

The integration of robotics and advanced technologies in modern surgical practices has significantly improved precision, efficiency, and outcomes in oral and maxillofacial surgery. Robotics combined with ultrasound technology enhances diagnostic and interventional procedures, facilitating improved targeting and treatment of anatomical structures while reducing human error [13]. This precision is especially beneficial in complex surgeries where minute deviations can significantly impact results.

Virtual and augmented reality (VR/AR) technologies have emerged as transformative tools in surgical planning and training. These technologies create immersive environments that allow surgeons to visualize and interact with three-dimensional anatomical models, enhancing their understanding and preparation for surgical procedures. The application of VR/AR in clinical settings and training highlights their potential to improve both educational outcomes and clinical practice by simulating real-world scenarios, enabling practitioners to refine their skills in a controlled, risk-free environment [16].

The integration of telemedicine and artificial intelligence into surgical practices signifies a transformative shift towards methodologies prioritizing precision, efficiency, and enhanced patient care. Telemedicine has improved access to postoperative care, leading to better clinical outcomes and increased patient satisfaction while reducing costs and wait times. Similarly, the application of large language models like ChatGPT in medical diagnostics streamlines communication and augments healthcare professionals' diagnostic capabilities, particularly in oral surgery. Together, these innovations reshape surgical methodologies, creating a more effective healthcare delivery system [18, 22]. By leveraging robotics, VR, and AR, surgeons achieve greater procedural accuracy, ultimately enhancing patient care and outcomes. As these technologies evolve, their integration into surgical practices promises to further enhance healthcare professionals' capabilities, driving innovations in patient treatment and surgical education.

## 4 Role of Telemedicine and Digital Health

### 4.1 Telemedicine and Remote Care

Telemedicine has revolutionized healthcare by enhancing remote patient care and consultations, notably in oral and maxillofacial surgery (OMS). It extends healthcare access to underserved populations, ensuring timely medical attention and adherence to safety protocols [17, 19]. By automating processes, telemedicine increases efficiency, with advanced registration techniques like cone-beam computed tomography (CBCT) and facial scans improving accuracy in remote care [4]. High-resolution imaging is crucial for preoperative planning, enabling precise models for effective remote consultations. Interactive reconstruction tools in cranial surgeries facilitate real-time remote consultations, enhancing patient care [7]. Video quality improvements through optimized technologies further augment telemedicine's capabilities [29]. Despite its benefits, telemedicine faces challenges such as regulatory barriers, reimbursement issues, and technological accessibility for lower socioeconomic groups [18]. Ensuring safety and efficacy in remote applications, particularly regarding standards for 3D printed medical devices, remains a concern [20]. Continuous innovation is essential to effectively meet modern healthcare demands, making telemedicine a critical component for enhancing service delivery and patient outcomes in OMS [24].

### 4.2 Remote Consultations and Monitoring

Remote consultations and monitoring have become integral to modern surgical care, leveraging telemedicine, augmented reality, and artificial intelligence to enhance patient management and surgical outcomes. These innovations streamline communication between healthcare providers and patients, improving postoperative care, clinical outcomes, patient satisfaction, and reducing costs for healthcare systems [20, 18, 21, 22]. Telemedicine seamlessly integrates remote consultations, particularly beneficial during preoperative and postoperative phases. High-resolution imaging technologies like CBCT enable the creation of detailed anatomical models that can be shared remotely, ensuring accurate assessments and effective surgical planning. In cranial surgeries, interactive tools for implant planning allow real-time patient engagement, improving outcomes and satisfaction [7]. Video technology advancements, such as the Optimised ProPainter method, enhance remote consultation quality, aiding surgical decision-making and patient monitoring [29]. Remote monitoring technologies are essential for postoperative care, enabling continuous observation and timely interventions. Automated systems integrating 3D imaging facilitate surgical site monitoring, providing critical data for postoperative care strategies [4]. The synergy between telemedicine and 3D printing allows for remote customization of medical devices, ensuring personalized patient care [20]. Challenges like data security, patient privacy, and technological accessibility persist, requiring collaboration among healthcare providers, technology developers, and policymakers to implement effective remote consultations and monitoring in surgical care [18]. By leveraging telemedicine's advantages, healthcare providers can enhance patient care and surgical outcomes, advancing surgical practices and patient satisfaction.

### 4.3 Digital Health Tools and Patient Outcomes

Digital health tools have transformed patient outcomes, particularly in orthognathic and oral maxillofacial surgery. Integrating advanced technologies such as artificial intelligence (AI) and three-dimensional (3D) modeling has significantly improved surgical precision and efficiency, enhancing patient care and satisfaction. AI aids in superimposing digital images for accurate treatment outcome assessments [1]. The application of 3D technology in surgical planning provides detailed anatomical insights, enhancing orthognathic surgery precision, with substantial documented benefits despite potential cost implications [6]. The POSG system exemplifies successful digital health tool integration, facilitating double-jaw surgeries without surgical splints and achieving excellent postoperative occlusion, thereby enhancing patient satisfaction and results. Digital health tools like EasySplint software streamline dental splint design, matching the precision of existing commercial solutions while significantly reducing design time, enhancing healthcare workflows and improving patient experience [30]. The positive impact of these tools on quality of life and facial aesthetics underscores the comprehensive benefits of digital health integration in surgical practices [3]. 3D printing technology plays a crucial role in advancing digital health tools, enabling the creation of patient-specific models and devices that enhance surgical outcomes and patient care. The ability to produce customized medical devices tailored to individual needs exemplifies 3D printing's potential to improve precision and personalization in medical treatments [20]. Collectively, these digital health tools contribute to a more efficient and effective healthcare delivery system, leading to improved patient outcomes and satisfaction. By continually integrating advanced technologies such as telemedicine, augmented reality, and artificial intelligence into surgical practices, healthcare providers can enhance patient care, optimize clinical outcomes, and personalize treatment plans. These innovations facilitate efficient postoperative monitoring and communication, reducing costs and wait times while ensuring patients receive tailored care addressing their specific needs and conditions [20, 18, 21, 22].

# 5 Nursing Informatics and Data Management

The integration of nursing informatics and data management is crucial for advancing patient care and operational efficiency in healthcare. As the sector adapts to challenges such as the COVID-19 pandemic, the importance of nursing informatics becomes increasingly apparent. This section examines how nursing informatics contributes to patient data management, emphasizing its role in data collection, analysis, and utilization to inform clinical practice and improve outcomes, thus highlighting its foundational role in healthcare delivery.

## 5.1 Role of Nursing Informatics in Patient Data Management

Nursing informatics plays a vital role in managing patient data, enhancing healthcare quality and safety through advanced information technologies. It supports data integration and analysis, essential for informed clinical decision-making and improved outcomes [24]. Established definitions and frameworks guide nursing informatics practice, ensuring alignment with best practices to enhance patient care [23].

The COVID-19 pandemic underscored the critical role of nursing informatics in managing patient data, necessitating adaptations in training and PPE access, impacting residency training, and highlighting the need for efficient data management systems in rapidly changing environments [27]. By categorizing research into training modifications and resident experiences, nursing informatics addressed the pandemic's challenges in oral and maxillofacial surgery (OMS) residency training.

Incorporating nursing informatics into healthcare systems enables effective management of large patient data volumes, facilitating timely access to critical information and supporting personalized, evidence-based care. This integration enhances operational efficiency through telemedicine and augmented reality technologies, improving patient safety and satisfaction by reducing wait times and streamlining communication between patients and providers. These advancements contribute to a more resilient healthcare system that adapts to evolving patient and professional needs [18, 21, 22].

## 5.2 Integration of Data Management Technologies in Surgical Care

Integrating data management technologies into surgical care enhances operational efficiency and patient outcomes by streamlining the collection, storage, and analysis of extensive patient data, crucial for informed decision-making and personalized treatment planning [24]. Advanced systems optimize workflows, reduce redundancy, and ensure essential information is readily available to surgical teams.

In oral and maxillofacial surgery, data management technologies optimize surgical planning and execution. Computer-aided design (CAD) and computer-assisted surgery (CAS) exemplify this integration, where detailed imaging and modeling data enhance surgical precision and outcomes [6]. These systems align preoperative and intraoperative data, facilitating precise interventions and minimizing errors [11].

Automated systems for data registration and analysis, such as those used in cone-beam computed tomography (CBCT) and face scan integration, illustrate efficiency gains achieved via data management technologies [14]. These systems streamline data alignment and interpretation, providing surgeons with real-time access to critical information that informs surgical decisions.

In postoperative care, advanced data management technologies, including telemedicine, enable continuous monitoring and analysis of patient data, facilitating timely medical interventions and improving patient satisfaction. This approach enhances care accessibility and leads to better recovery outcomes while reducing costs associated with traditional follow-up visits [21, 17, 23, 18, 22].

Leveraging these technologies allows healthcare providers to implement evidence-based practices that enhance patient safety and satisfaction, ultimately improving healthcare delivery and patient experiences.

The integration of data management technologies in surgical care represents a significant advancement in healthcare, offering innovative solutions that enhance efficiency and patient outcomes. By incorporating technologies such as telemedicine, augmented reality (AR), and 3D printing into surgical practices, healthcare providers can improve patient-centered care quality. These innovations increase access and efficiency, leading to better clinical outcomes, higher patient satisfaction, and reduced costs. Telemedicine facilitates postoperative care with decreased wait times and increased accessibility, while AR enhances surgical training and emergency diagnosis. The ongoing adoption of these technologies positions healthcare systems to meet the evolving demands of modern medical practice effectively [20, 18, 21].

### 5.3 Successful Implementations in Clinical Settings

Successful implementations of nursing informatics in clinical settings have significantly improved healthcare delivery and patient outcomes. By leveraging advanced information technologies, nursing informatics facilitates the integration and analysis of patient data, enabling informed decision-making and personalized care. A comparative analysis across countries reveals nuanced differences in the structure and understanding of nursing informatics, particularly in Australia, the USA, and Canada [23]. These variations underscore the importance of context-specific approaches to implementation, ensuring systems meet the unique needs of each healthcare environment.

In clinical settings, nursing informatics enhances operational efficiency and improves patient safety. The integration of electronic health records (EHRs) allows seamless data sharing among providers, minimizing redundancy and ensuring critical patient information is accessible. This advancement enhances healthcare delivery efficiency and supports better clinical outcomes and patient satisfaction, particularly in telemedicine and postoperative care contexts, where timely access to comprehensive data improves decision-making and resource utilization [23, 18, 17]. This integration facilitates coordinated care, ultimately leading to improved patient outcomes.

Decision support systems in nursing informatics have been crucial in guiding clinical decision-making by providing evidence-based recommendations that enhance treatment plan accuracy and effectiveness. Through advanced data analytics and predictive modeling, these systems improve risk identification and optimization of care pathways, leading to enhanced patient safety and satisfaction. They integrate with emerging technologies such as artificial intelligence and telemedicine, facilitating better communication between providers and patients, streamlining clinical procedures, and contributing to more efficient healthcare delivery. Consequently, they play a vital role in transforming patient care by ensuring timely interventions and personalized treatment plans [21, 17, 23, 18, 22].

The implementation of telehealth platforms, supported by advancements in nursing informatics, has successfully enhanced access to healthcare services, improved patient engagement, and achieved better clinical outcomes. Telemedicine has proven effective in postoperative care, resulting in increased patient satisfaction, reduced wait times, and cost savings for patients and healthcare systems. As digital technologies evolve, the integration of nursing informatics is crucial in optimizing telehealth solutions, contributing to a more efficient and patient-centered healthcare environment [23, 18]. These platforms facilitate remote monitoring and consultations, allowing timely medical attention without in-person visits, enhancing convenience for patients and alleviating the burden on healthcare facilities, particularly in rural and underserved areas.

The successful implementation of nursing informatics in clinical settings is vital for transforming healthcare delivery by integrating nursing practices with information and communication technologies (ICT), enhancing patient outcomes, and improving safety, efficiency, and accessibility of services. As digital technologies continue to evolve, the necessity for nurses to embrace these tools becomes increasingly vital, despite barriers such as limited computer literacy and insufficient educational support [23, 18]. Continued integration of these technologies into clinical practices ensures the delivery of high-quality, patient-centered care that meets the evolving demands of modern healthcare systems.

# 6 Challenges and Future Directions

The integration of telemedicine into surgical care presents both challenges and opportunities, necessitating a comprehensive understanding of these issues to optimize surgical outcomes. This section examines the multifaceted challenges associated with telemedicine implementation, focusing on critical issues that must be addressed for successful integration into surgical practices.

## 6.1 Challenges in Telemedicine Implementation

Telemedicine implementation in surgical care is hindered by several challenges, including the absence of standardized processes and regulatory frameworks, complicating the integration of telemedicine and technologies like 3D printing for medical devices [20, 18]. This lack of uniformity can result in inconsistent care quality and complicates the establishment of universal guidelines.

The COVID-19 pandemic has further highlighted telemedicine challenges, emphasizing the need for effective triage and resource management to prevent healthcare system overload. Complexities in resource allocation and patient prioritization arise due to potential staff shortages and PPE demands [10, 19]. Additionally, rapid adaptation to new infection control measures complicates consistent telemedicine implementation.

Technological challenges, such as integrating advanced technologies like 3D imaging and rapid prototyping (RP), require substantial investment and training, posing barriers for healthcare providers [6]. Variability in operator skill can impact diagnostic accuracy, especially in robotic-assisted procedures where precision is vital [13].

Security concerns regarding patient data further complicate telemedicine adoption, as ensuring confidentiality and integrity is critical amidst potential security breaches [18]. Disparities in technology access can limit telemedicine's reach, particularly for patients from lower socioeconomic backgrounds.

The complexity of diagnostic tools, such as AI-driven systems, presents additional challenges. Ensuring their accuracy and reliability requires oversight to mitigate biases and support clinical decision-making [22]. Small sample sizes in studies limit the generalizability of findings, emphasizing the need for further research and validation [3].

Addressing these challenges necessitates collaboration among healthcare providers, policymakers, and technology developers. Such partnerships are essential for enhancing access to surgical care, improving clinical outcomes, and increasing patient satisfaction while reducing wait times and costs. By overcoming adoption barriers and leveraging innovative technologies like augmented reality and artificial intelligence, stakeholders can optimize healthcare delivery and improve surgical outcomes [20, 21, 17, 18, 22].

## 6.2 Future Directions in Telemedicine and Digital Health

The future of telemedicine and digital health is set for transformation through innovative technologies and methodologies. Key advancements include optimizing Reverse Engineering (RE), Computer-Aided Design (CAD), and Rapid Prototyping (RP) technologies, particularly in exploring diverse materials for implants to enhance surgical outcomes [4]. Refining virtual planning techniques will be vital for applying these methods to complex surgical cases, broadening intervention scope and precision [5].

Developing more autonomous robotic systems and improved user interfaces for teleoperation in minimally invasive surgeries is promising, expected to enhance precision and ease of use across surgical contexts [13]. Additionally, refining Signed Distance Function (SDF) modeling processes and exploring additional features could improve tracking capabilities under diverse surgical conditions, enhancing technology robustness [12].

In augmented reality (AR), future research should validate AR systems and explore gamification's potential in surgical training, addressing gaps in non-technical skills development to maximize educational benefits [16]. Anticipated advancements in laser scanning for precise dentition data and improvements in edge smoothness will enhance surgical technology applications like EasySplint [30].

The COVID-19 pandemic has emphasized the necessity for robust telehealth services and outpatient care protocols. Future research should focus on developing these protocols and investigating the long-term impacts of the pandemic on surgical practices [10]. Expanding datasets to include a wider variety of patient profiles and speech tasks, alongside refining noise reduction techniques, will enhance telemedicine technologies' accuracy and applicability [8].

Developing regulatory standards and fostering collaborations among clinicians, engineers, and regulatory bodies are essential for supporting the safe implementation of new materials and technologies, particularly in 3D printing for healthcare [20]. Future research aims to establish a fully automatic non-rigid registration method to address significant geometric deformations, potentially utilizing machine learning [14]. Additionally, exploring larger cohorts and long-term psychological outcomes is crucial for validating and expanding existing findings, ensuring telemedicine and digital health initiatives effectively meet patient needs and enhance healthcare delivery [3].

### 6.3 Challenges in Implementing Nursing Informatics

Implementing nursing informatics in healthcare settings is fraught with challenges that impede effective integration and utilization. A primary obstacle is the existence of multiple definitions of nursing informatics, leading to confusion and inconsistency in its application across various healthcare environments [23]. This lack of a unified understanding complicates the development of standardized practices and guidelines, hindering seamless integration into nursing workflows.

Poor computer literacy among nurses is another significant challenge, limiting their ability to engage effectively with informatics systems. Many nurses lack the necessary skills and confidence to utilize advanced information technologies, resulting in underutilization of available tools and resources [23]. This deficiency affects healthcare delivery efficiency and impacts the quality of patient care as nurses struggle to access and interpret critical data.

Limited educational opportunities in informatics for nursing students exacerbate these challenges. The absence of comprehensive informatics training in nursing curricula means new graduates often enter the workforce without the requisite knowledge and skills to engage effectively with informatics systems [23]. This educational gap underscores the need for enhanced informatics education programs that equip nursing students with the competencies required to navigate and leverage informatics tools in clinical practice.

Addressing these challenges requires a concerted effort to develop clear and consistent definitions of nursing informatics, improve computer literacy among nurses, and expand educational opportunities in informatics for nursing students. By overcoming barriers to the effective use of digital technologies in nursing, healthcare organizations can significantly enhance the integration and functionality of nursing informatics. This enhancement is likely to lead to better patient outcomes, increased efficiency in healthcare delivery, and more effective resource utilization across various healthcare settings [23, 18, 21, 22].

### 6.4 Training and Educational Gaps in OMFS

Training and educational gaps in oral and maxillofacial surgery (OMFS) present substantial challenges that need addressing to ensure effective practice in this intricate surgical specialty. A critical issue is the lack of standardized training curricula aligned with global best practices, which is essential for consistency in training and adequately preparing practitioners for the diverse challenges encountered in OMFS [31]. Innovative training models that consider students' economic constraints are necessary to enhance the accessibility and sustainability of OMFS education.

Integrating advanced technologies, such as cone-beam computed tomography (CBCT), into OMFS training programs requires attention. While CBCT offers significant diagnostic advantages, its applications in under-researched areas remain limited, necessitating further exploration to enhance imaging techniques for soft tissue and develop advanced diagnostic software [26]. Expanding datasets for evaluation and enhancing software capabilities are crucial steps in addressing educational gaps in cranial implant planning [7].

The POSG system, which facilitates double-jaw surgeries without surgical splints, highlights a gap in training related to intraoperative plan modifications. Targeted educational initiatives are required to improve practitioners' understanding and execution of advanced surgical techniques. Additionally, limitations identified in studies with small sample sizes emphasize the need for further research to confirm findings and explore additional factors affecting surgical outcomes [2].

Future research should also focus on simplifying pain assessment tools and exploring emerging trends in pain management techniques, critical components of postoperative care in OMFS [32]. Furthermore, unanswered questions regarding the long-term psychological effects of orthognathic surgery necessitate tailored preoperative counseling and comprehensive postoperative support [33].

To address these educational gaps, it is imperative to develop comprehensive training programs that incorporate cost-effective solutions and leverage the latest technological advancements. By prioritizing enhancements in training and educational frameworks, the field of OMFS can ensure practitioners are well-equipped to deliver high-quality care and improve patient outcomes. Future research should also focus on developing a unified definition of nursing informatics, addressing educational gaps, and exploring emerging trends in digital health technologies [23].

## 7 Conclusion

The survey highlights the profound influence of technological advancements on orthognathic and oral maxillofacial surgery, emphasizing the role of cutting-edge imaging, modeling, and digital health technologies in refining surgical accuracy and enhancing patient outcomes. The implementation of sophisticated frameworks has notably improved the visualization and coherence of surgical imagery, while innovations in three-dimensional modeling of the mandible provide critical insights applicable to both clinical and forensic fields. Despite the high levels of patient satisfaction with surgical results, there remains a significant need for improved communication and educational strategies to better inform patients. As the discipline continues to advance, integrating digital health technologies and telemedicine will be pivotal in addressing existing challenges and expanding access to care. Embracing these technological innovations will enable healthcare providers to deliver superior, patient-focused care, meeting the evolving requirements of contemporary healthcare environments.

## References

[1] P Bouletreau, M Makaremi, B Ibrahim, A Louvrier, and N Sigaux. Artificial intelligence: applications in orthognathic surgery. *Journal of stomatology, oral and maxillofacial surgery*, 120(4):347–354, 2019.

[2] Junho Jung, Chi-Heun Lee, Jung-Woo Lee, and Byung-Joon Choi. Three dimensional evaluation of soft tissue after orthognathic surgery. *Head & face medicine*, 14:1–8, 2018.

[3] Hamideh Saghafi, Philip Benington, and Ashraf Ayoub. Impact of orthognathic surgery on quality of life: a comparison between orthodontics-first and surgery-first approaches. *British Journal of Oral and Maxillofacial Surgery*, 58(3):341–347, 2020.

[4] Nabeel I. Allawi. Application of reverse engineering and rapid prototyping for reconstruction of human mandible, 2021.

[5] Ali Alkhayer, József Piffkó, Carsten Lippold, and Emil Segatto. Accuracy of virtual planning in orthognathic surgery: a systematic review. *Head & face medicine*, 16:1–9, 2020.

[6] R-K Cao, L-S Li, and Y-J Cao. Application of three-dimensional technology in orthognathic surgery: a narrative review. *European Review for Medical & Pharmacological Sciences*, 26(21), 2022.

[7] Jan Egger, Markus Gall, Alois Tax, Muammer Ücal, Ulrike Zefferer, Xing Li, Gord von Campe, Ute Schäfer, Dieter Schmalstieg, and Xiaojun Chen. Interactive reconstructions of cranial 3d implants under mevislab as an alternative to commercial planning software, 2017.

[8] Daniel Aalto, Olli Aaltonen, Risto-Pekka Happonen, Päivi Jääsaari, Atle Kivelä, Juha Kuortti, Jean-Marc Luukinen, Jarmo Malinen, Tiina Murtola, Riitta Parkkola, Jani Saunavaara, Tero Soukka, and Martti Vainio. Measurement of acoustic and anatomic changes in oral and maxillofacial surgery patients, 2013.

[9] Young-Kyun Kim. Complications associated with orthognathic surgery. *Journal of the Korean Association of Oral and Maxillofacial Surgeons*, 43(1):3–15, 2017.

[10] Matthias Zimmermann and Emeka Nkenke. Approaches to the management of patients in oral and maxillofacial surgery during covid-19 pandemic. *Journal of Cranio-Maxillofacial Surgery*, 48(5):521–526, 2020.

[11] Minyoung Chung, Jingyu Lee, Wisoo Song, Youngchan Song, Il-Hyung Yang, Jeongjin Lee, and Yeong-Gil Shin. Automatic registration between cone-beam ct and scanned surface via deep-pose regression neural networks and clustered similarities, 2019.

[12] Wenwu Guo, Jinlin Wu, Zhen Chen, Qingxiang Zhao, Miao Xu, Zhen Lei, and Hongbin Liu. Surgtrack: Cad-free 3d tracking of real-world surgical instruments, 2024.

[13] Renáta Elek, Tamás D Nagy, Dénes A Nagy, Bence Takács, Péter Galambos, Imre Rudas, and Tamás Haidegger. Robotic platforms for ultrasound diagnostics and treatment. In *2017 IEEE international conference on systems, man, and cybernetics (SMC)*, pages 1752–1757. IEEE, 2017.

[14] Hyoung Suk Park, Chang Min Hyun, Sang-Hwy Lee, Jin Keun Seo, and Kiwan Jeon. Automatic 3d registration of dental cbct and face scan data using 2d projection images, 2023.

[15] Hyung Joon Seo and Youn-Kyung Choi. Current trends in orthognathic surgery. *Archives of Craniofacial Surgery*, 22(6):287, 2021.

[16] Ashraf Ayoub and Yeshwanth Pulijala. The application of virtual reality and augmented reality in oral & maxillofacial surgery. *BMC Oral Health*, 19:1–8, 2019.

[17] Chris Kimble. Business models for e-health: Evidence from ten case studies, 2015.

[18] Aaron M Williams, Umar F Bhatti, Hasan B Alam, and Vahagn C Nikolian. The role of telemedicine in postoperative care. *Mhealth*, 4:11, 2018.

[19] Radhika Chigurupati, Neeraj Panchal, Andrew M Henry, Hussam Batal, Amit Sethi, Richard D'innocenzo, Pushkar Mehra, Deepak G Krishnan, and Steven M Roser. Considerations for oral and maxillofacial surgeons in covid-19 era: can we sustain the solutions to keep our patients and healthcare personnel safe? *Journal of Oral and Maxillofacial Surgery*, 78(8):1241–1256, 2020.

[20] Piero Giacomelli and Asa Smedberg. The eve of 3d printing in telemedicine: State of the art and future challenges, 2014.

[21] Jinat Ara, Hanif Bhuiyan, Yeasin Arafat Bhuiyan, Salma Begum Bhyan, and Muhammad Ismail Bhuiyan. Ar-based modern healthcare: A review, 2021.

[22] Masoumeh Farhadi Nia, Mohsen Ahmadi, and Elyas Irankhah. Transforming dental diagnostics with artificial intelligence: Advanced integration of chatgpt and large language models for patient care, 2024.

[23] Nurses and midwives in the digit.

[24] Yohan Payan, Matthieu Chabanas, Xavier Pelorson, Coriandre Vilain, Patrick Levy, Vincent Luboz, and Pascal Perrier. Biomechanical models to simulate consequences of maxillofacial surgery, 2006.

[25] Cornelis Klop, Ruud Schreurs, Guido A De Jong, Edwin TM Klinkenberg, Valeria Vespasiano, Naomi L Rood, Valerie G Niehe, Vidija Soerdjbalie-Maikoe, Alexia Van Goethem, Bernadette S De Bakker, Thomas JJ Maal, Jitske W Nolte, and Alfred G Becking. An open-source, three-dimensional growth model of the mandible, 2023.

[26] Kaspar Höschel and Janos Juhasz. Cone-beam ct for dental radiography, 2018.

[27] Raphael E Huntley, David C Ludwig, and Jasjit K Dillon. Early effects of covid-19 on oral and maxillofacial surgery residency training—results from a national survey. *Journal of oral and maxillofacial surgery*, 78(8):1257–1267, 2020.

[28] Shruti Chhabra, Naveen Chhabra, Avneet Kaur, and Niti Gupta. Wound healing concepts in clinical practice of omfs. *Journal of maxillofacial and oral surgery*, 16:403–423, 2017.

[29] Pengze Li, Lihao Liu, Carola-Bibiane Schönlieb, and Angelica I Aviles-Rivero. Optimised propainter for video diminished reality inpainting, 2024.

[30] Xiaojun Chen, Xing Li, Lu Xu, Yi Sun, Constantinus Politis, and Jan Egger. Development of a computer-aided design software for dental splint in orthognathic surgery, 2017.

[31] Sanjeev Kumar. Training pathways in oral and maxillofacial surgery across the globe—a mini review. *Journal of maxillofacial and oral surgery*, 16:269–276, 2017.

[32] Nattapong Sirintawat, Kamonpun Sawang, Teeranut Chaiyasamut, and Natthamet Wongsirichat. Pain measurement in oral and maxillofacial surgery. *Journal of dental anesthesia and pain medicine*, 17(4):253–263, 2017.

[33] N Al-Hadi, S Chegini, ME Klontzas, J McKenny, and M Heliotis. Patient expectations and satisfaction following orthognathic surgery. *International journal of oral and maxillofacial surgery*, 48(2):211–216, 2019.

**Disclaimer:**

SurveyX is an AI-powered system designed to automate the generation of surveys. While it aims to produce high-quality, coherent, and comprehensive surveys with accurate citations, the final output is derived from the AI's synthesis of pre-processed materials, which may contain limitations or inaccuracies. As such, the generated content should not be used for academic publication or formal submissions and must be independently reviewed and verified. The developers of SurveyX do not assume responsibility for any errors or consequences arising from the use of the generated surveys.





AI-generated, for reference only.