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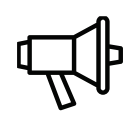


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**ISSUE 1**



Acceptance of papers **January, 2026**



**Acceptance of papers**  
Published monthly



**Topics**  
economics, technology, social sciences



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JOURNAL **"INNOVATION SCIENCE AND  
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UNDER THE NUMBER **C-5669633** BY THE  
AGENCY FOR INFORMATION AND MASS  
COMMUNICATIONS (AOKA) OF THE  
REPUBLIC OF UZBEKISTAN, EFFECTIVE  
FROM OCTOBER 9, 2024.

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The scientific electronic journal "Innovation Science and Technology" has been included in the list of scientific publications recommended for the publication of main scientific results of dissertations for the award of PhD and DSc degrees in economics and technical sciences, in accordance with the Resolution No. 370 of the Presidium of the Higher Attestation Commission of the Republic of Uzbekistan, dated May 8, 2025.

Electronic publication, Issue 1. 57 pages.  
Approved for publication on January, 2026.

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# DIGITAL DENTISTRY: LITERATURE REVIEW

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**Abstract:** Due to tooth loss, a large number of patients require dental reconstruction. Prior to any surgical procedures or prosthetic treatment, patients seek to visualize the aesthetic outcome of their future smile as early as possible. In clinical practice, many dentists rely on verbal explanations of the anticipated post-treatment appearance of the teeth, leaving the final image to the patient's imagination. However, Digital Smile Design (DSD) technology enables a clear and accurate visual representation of the expected final result. The key advantages of this technology include rapid prototype generation, high manufacturing accuracy, and improved communication between the clinician and the patient. The implementation of DSD simplifies clinical workflows, reduces data-processing time, and facilitates the achievement of predictable and aesthetically pleasing restorative outcomes.

**Key words:** digital dentistry, digital smile design, CAD/CAM, aesthetic dentistry, digital technologies.

**Annotatsiya:** Tishlarning yo'qotilishi natijasida ko'plab bemorlar tish qatorini rekonstruksiya qilishga muhtoj bo'lmoqda. Har qanday jarrohlik aralashuvi yoki protezlashdan oldin bemorlar bo'lajak tabassumining estetik natijasini imkon qadar erta ko'rishni xohlashadi. Amaliyotda ko'plab stomatologlar davolashdan keyingi tishlarning ko'rinishini og'zaki tushuntirish bilan cheklanib, bemorning tasavvuriga tayanadilar. Biroq, Tabassumning raqamli dizayni (Digital Smile Design — DSD) texnologiyasi yakuniy natijani vizual tarzda aniq namoyish etish imkonini beradi. Ushbu texnologiyaning asosiy afzalliklari tezkor prototip yaratish, yuqori ishlab chiqarish aniqligi va shifokor hamda bemor o'rtasidagi muloqotni sezilarli darajada yaxshilashdan iborat. DSD klinik ish jarayonini soddalashtiradi, bemor ma'lumotlarini qayta ishlash vaqtini qisqartiradi va estetik jihatdan prognoz qilinadigan natijalarga erishishni ta'minlaydi.

**Kalit so'zlar:** raqamli stomatologiya, tabassumning raqamli dizayni, CAD/CAM, estetik stomatologiya, raqamli texnologiyalar.

**Аннотация:** Вследствие утраты зубов значительное число пациентов нуждается в реконструкции зубного ряда. До начала хирургических вмешательств или протезирования пациенты стремятся как можно раньше увидеть эстетический результат будущей улыбки. В клинической практике многие стоматологи ограничиваются устным описанием предполагаемого внешнего вида зубов после лечения, полагаясь на воображение пациента. Однако технология Digital Smile Design (DSD) позволяет наглядно визуализировать прогнозируемый конечный результат. К основным преимуществам данной технологии относятся быстрое создание прототипов, высокая точность изготовления и значительное улучшение коммуникации между врачом и пациентом. Применение DSD упрощает клинический рабочий процесс, сокращает время обработки данных и обеспечивает достижение предсказуемых эстетических результатов при восстановлении зубов.

**Ключевые слова:** цифровая стоматология, цифровой дизайн улыбки, CAD/CAM, эстетическая стоматология, цифровые технологии.

## INTRODUCTION

A person's appearance and facial characteristics create the initial impression. A person's well-being and quality of life are significantly enhanced by an attractive smile and harmonious facial aesthetics [1–3]. The lower part of the face is dominated by the oral region, which immediately attracts the attention of others [4–6]. As Martin Charnin aptly stated, "You're never fully dressed without a smile." Therefore, understanding how a patient's smile will appear after treatment is essential for individuals with oral abnormalities [2]. Digital dentistry can effectively contribute to addressing this need [2, 4, 7].

## LITERATURE REVIEW

Digital dentistry has emerged as a transformative direction in modern dental practice, integrating computer-based technologies into diagnosis, treatment planning, and prosthetic rehabilitation. Beuer, Schweiger, and Edelhoff in 2008 provided one of the earliest comprehensive overviews of digital dentistry, highlighting how CAD/CAM systems significantly improved precision, efficiency, and standardization across major clinical indications. Their work emphasized the gradual shift from manual techniques toward digitally driven workflows in restorative and prosthetic dentistry.

The evolution of CAD/CAM dentistry was further detailed by Mormann in 2006, who analyzed the development of the CEREC system over two decades. His research demonstrated that chairside CAD/CAM technologies enabled same-day restorations with high accuracy, reducing treatment time while maintaining functional and aesthetic quality. Miyazaki and colleagues in 2009 complemented this perspective by examining the restorative materials compatible with CAD/CAM systems, concluding that material advancements played a crucial role in the clinical success of digital restorations.

A major advancement within digital dentistry is the introduction of Digital Smile Design (DSD), which focuses on esthetic planning and patient communication. Coachman and Calamita in 2012 described DSD as a digital communication tool that allows clinicians, technicians, and patients to share a common visual language. Their study showed that DSD enhanced predictability in esthetic outcomes and strengthened interdisciplinary collaboration during treatment planning.

The clinical relevance of DSD was further supported by Jafri and Ahmad with co-authors in 2020, who identified Digital Smile Design as an innovative instrument in esthetic dentistry. They emphasized that DSD improves patient involvement by enabling visualization of expected outcomes prior to treatment. Similarly, Bini in 2017 explored specialized software strategies for virtual esthetic planning, demonstrating how digital tools allow clinicians to harmonize facial, dental, and gingival parameters in a structured and reproducible manner.

From a diagnostic and accuracy standpoint, Cattell and co-authors in 2019 conducted a systematic review assessing the precision of CAD/CAM-generated restorations. Their findings confirmed that digitally fabricated restorations often surpass conventional methods in marginal fit and internal accuracy. Zimmermann and Mehl in 2015 also reviewed virtual smile design systems, concluding that such systems are particularly valuable for consultation and esthetic case planning, especially when patient comprehension of complex dental outcomes is limited.

In the regional and applied clinical context, studies by Arikhova, Borisov, and Sevbitov in 2020 analyzed the principles of digital smile design and its growing relevance in clinical practice. More recent research by Qobilovna and Nodirovich in 2023, as well as Anvarovich and Qobilovna in 2023, demonstrated the effectiveness of modern orthopedic and periodontal approaches that complement digital workflows. These studies collectively confirm that digital dentistry, supported by CAD/CAM and DSD technologies, represents a scientifically grounded and clinically effective paradigm for contemporary restorative and esthetic dentistry.

## RESEARCH METHODOLOGY

The research methodology of this study is based on a structured literature review approach. Scientific data were collected from peer-reviewed international journals and indexed academic databases focusing on digital dentistry, CAD/CAM systems, and Digital Smile Design technologies. The selected sources were analyzed using comparative and thematic analysis methods to identify key trends, technological advantages, and clinical outcomes reported in previous studies.

## ANALYSIS AND RESULTS

Digital dentistry is a contemporary field of dentistry that aims to reduce manual labor while enabling highly precise patient care [8]. CAD/CAM (Computer-Aided Design/Computer-Aided Manufacturing) technologies make it possible to automatically design and fabricate crowns, prostheses, and implants using Digital Smile Design (DSD) technology [7, 9–10].

By applying reference lines to patients' digital photographs, Digital Smile Design evaluates the aesthetic relationships among the gingiva, teeth, face, and smile [2, 4]. The use of digital dentistry allows for the integration of clinical treatment planning with patients' aesthetic expectations [11]. This approach optimizes the fabrication and application of tooth-colored restorative materials, thereby reducing the need for metals, glass-ceramics, and other traditional materials. Nevertheless, research has demonstrated that combining conventional and digital techniques, such as DSD, yields superior outcomes; in particular, it minimizes the need for intraoral adjustments and helps prevent unnecessary tooth wear [2].

Orthopedists can assess tooth positioning in three dimensions using diagnostic wax-up models. Compared with the use of DSD alone, this method represents a more effective diagnostic tool for comprehensive dental rehabilitation. Digital techniques such as DSD are particularly valuable during consultations, as patients often find it difficult to comprehend outcomes envisioned by orthopedists based on years of professional experience [12]. These digital programs allow smile designs to be visualized in both two-dimensional (2D) and three-dimensional (3D) formats [13]. Moreover, they enable the superimposition of completed virtual models onto a patient's photograph, providing a realistic preview of the expected results [12–14].

The following software programs may be used to create virtual smile designs:

- Photoshop CS6 (Adobe Systems Inc., USA);
- Keynote (Apple Inc., USA);
- Aesthetic Digital Smile Design (ADSD) by Dr. Valerio Bini;
- 3D Creator (Sony Corporation, Japan);
- SDP (Smile Designer Pro) (Tasty Tech Ltd., Canada);
- Cerec SW 4.2 (Sirona Dental Systems Inc., USA);
- Planmeca Romexis Smile Design (PRSD) (Planmeca, Finland);
- Coachman's DSD App (DSD App LLC, USA) [15, 16].

Although the first two programs were not originally designed specifically for DSD, clinicians have successfully adapted them for use as Digital Smile Design tools. In contrast, SDP and ADSD are promoted as specialized software solutions for digital smile design [15]. The advancement of computer-based tools for dental design and restoration has had a substantial impact on aesthetic dentistry, simplifying both laboratory and clinical procedures [17].

A closer examination of CAD/CAM equipment and DSD applications reveals that these systems typically consist of a computer, a milling unit, and an intraoral scanner [18–21]. When using a CAD/CAM system, the dentist initially prepares the teeth using a dental handpiece, for example, for prosthetic restoration. Subsequently, an intraoral camera is employed to obtain a virtual impression [22]. Compared with conventional impression-taking techniques, which often induce gag reflexes and discomfort, this step offers significant advantages in terms of patient comfort [23–24].

Further procedures are performed digitally without the patient's presence, using DSD and CAD/CAM software. Based on data obtained from the intraoral scanner, the dentist creates a three-dimensional model of the future prosthesis and positions it on the patient's digital image. Typically, this process takes approximately two hours. Once both the patient and the dentist are satisfied with the design, the 3D model is saved and transferred to the milling machine [18]. After fabrication, the prosthesis is delivered to the dental office and fitted to the patient [25].

One of the primary advantages of these technologies is their superior manufacturing accuracy compared with manual techniques. Studies comparing original wax-ups with milled and conventionally fabricated mock-ups have demonstrated higher precision with digital technologies [26–28]. Another notable benefit of CAD/CAM systems is their minimally invasive and painless nature, which enhances patient comfort [29]. In addition, DSD accelerates the development of restoration prototypes and the processing of patient data [30]. Importantly, DSD allows patients to participate actively by suggesting modifications and previewing treatment outcomes in advance [8]. This facilitates aesthetic rehabilitation planning and improves communication between patients and clinicians [2, 13, 31–32]. Furthermore, CAD/CAM technology supports the use of a wide range of materials, including crowns, bridges, and veneers [25–26], and enables model fabrication even in complex clinical situations [7].

Despite these advantages, certain limitations exist. Crowns, veneers, and prostheses produced using DSD and CAD/CAM technologies may be up to three times more expensive than those fabricated by dental technicians using conventional methods [33–35]. Another significant drawback involves the technical complexity of the equipment and the time required to train personnel to operate high-precision CAD/CAM systems in combination with DSD software [27].

## CONCLUSION AND RECOMMENDATIONS

Digital technologies have considerably simplified dentists' professional activities. They enable clinicians to visually demonstrate planned modifications and provide a comprehensive explanation of the proposed treatment strategy. Notably, patients can offer feedback and suggestions from the initial stages of treatment planning. Procedures that previously required several days can now be completed with greater speed and precision through the use of CAD/CAM technology. When combined with Digital Smile Design (DSD), these technologies ensure accurate and predictable restorative outcomes using materials with superior physical and aesthetic properties.

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**Proofreader:** Zokir ALIBEKOV

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## 2026. № 1

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