

The CAD / CAM Technology in the Contemporary Dental Laboratory Practices

Mohammed Mosaed Almanbahi¹, Ali Ahmad Khubrani¹, Mohammed Ali Asiri², Mohammed Yousef Al-Faqih³, Adnan Awadh Alalyani⁴, Abdulrahman Raddah Alkhathami⁵, Hamid Raddah Alkhathami⁵, Abdulrazaq Ahmed Asiri³

¹Specialist Dental technology, Alnakeel Dental Center

²Specialist Dental technology, Asir Health Gathering

³Specialist Dental technology, Al-Qunfudhah General Hospital

⁴Specialist Dental technology, Dental Center Bisha

⁵Specialist Dental technology, King Fahad hospital-Jeddah

ABSTRACT

This paper researches the effect of adopting Computer-Aided Design and Computer-Aided Manufacturing (CAD/CAM) technology in a dental lab in relation to accuracy, efficiency and overall lab functioning. The mixed-method research design was used to combine quantitative data collected by the means of 270 distributed questionnaires and qualitative information collected as a result of semi-structured interviews with dental technicians. Data was analyzed through SPSS software with descriptive statistics, chi-square tests, t-test, and ANOVA and a significant difference between laboratory settings was identified.

The findings found out that sixty-eight percent of the laboratories have introduced the CAD/CAM systems with great achievements in the accuracy of restorations, production time, and consistency in contrast to the traditional methods. Digital workflows minimized the fabrication errors by 28 and the working time was shortened by 34. In addition, implementation of CAD/CAM technology helped in boosting interdepartmental coordination and patient satisfaction by means of quality control. The themes revealed in qualitative data were three overarching themes, namely, the efficiency of the implemented technology, employee training and adjustment, and financial issues. Although the majority of technicians indicated being highly satisfied with digital tools, such barriers as the initial costs of investments and the necessity of receiving specialized training were frequently mentioned. In general, the results prove the idea that CAD/CAM systems can greatly enhance the quality and productivity of final laboratory results, and continuous education and resources support are important. The research paper finds that the adoption of digital dentistry technologies is a paradigm shift to precision-based, effective and individualized dental care.

KEYWORDS: CA/CAM computer-aided technology, computer-aided dentistry, dental laboratory performance, precision of restoratives, efficiency of workflow, training of technicians, dental prosthetic innovation..

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INTRODUCTION

Computer-aided design and computer-aided manufacturing (CAD/CAM) technology in the field of dentistry has transformed the process of designing and producing dental restorations and provided new opportunities of precision and customization in patient care and efficiency. Within the last 20 years, CAD/CAM systems have ceased being experimental to becoming the common clinical tools, which have radically changed the way prosthodontics are done and the patient experience (Oye & Owen, 2024). The need to develop quicker, more precise, and patient-focused restorative services has also precipitated the shift in paradigm in dental practice, as one of the most meaningful changes (Ghiță et al., 2024).

Originally, CAD/CAM systems were introduced to enhance the production processes of industries, but their modification to the application in dental practice enabled clinicians to computerize impressions, design restorations on a computer, and produce them with the highest accuracy levels (Ijaz, 2024). This digital transformation is embodied by the chairside CAD/CAM workflow where intraoral scanning, virtual modeling, and milling or printing make up an uninterrupted clinical procedure (Rushdie, 2024). Consequently, the CAD/CAM dentistry reduces the needless human error and minimizes the number of patient visits to the clinic in addition to increasing the efficiency, which makes it a standard of the modern restorative care (Lamasanu et al., 2025).

Educationally and practically, CAD/CAM has also had effect on prosthodontics in dentistry and material science, as well as combining digital engineering with clinical knowledge (Eid, 2025). The existing literature outlines its imperative importance in the context of denture manufacturing, the creation of crowns and bridges, and implant restorations, in particular, in ensuring a consistent quality and the correctness of structures (Bida et al., 2024). More so, CAD/CAM is also applicable in the area of diagnostic and treatment planning, where the use of digital modeling and 3D printing technologies helps improve communication between clinicians and dental technicians, which, in turn, allows improving the quality of final restorations (Alaoffey et al., 2024). CAD/CAM technology is also an important part of material innovation development besides the performance of workflow. High-strength ceramics, hybrid composites, and multilayered zirconia have increased the aesthetic and functional potential of the digital restorations, with guaranteed high survival of longevity and biocompatibility (Emma and Harris, 2024). Pereverzyev (2022) says that the intertwining of material science and the principles of digital design has developed a new set of standards to which dental

restorations can be created that not only compares to other restorations created with the help of the traditional method but also in many cases exceeds them.

This has led to a change in professional attitudes and skills as the use of digital dentistry is on the rise. Evidence-based research indicated that, although a sizeable number of practitioners believe that the use of chairside CAD/CAM systems can significantly save time and increase the precision of the outcomes, some issues related to the initial prices, technical education, and software combination remain (Nassani et al., 2021). Additionally, the COVID-19 crisis highlighted the benefits of digital workflows, which decrease the risks of cross-contamination and the number of physical contacts during the process of impression taking, which can be used to support the system of infection control in the clinical environment (Barengi et al., 2021).

The recent technological developments also indicate the increased interconnection between 3D printing methods and milling. Although the conventional subtractive manufacturing (milling) still dominates, additive manufacturing (3D printing) has benefits in material use, design freedom, and complex geometries and a hybrid system is believed to have an additional role in the future (Wu, 2025). The same-day digital workflows are currently a critical component of dental education and clinical practice as highlighted by Bencharit et al. (2021), so the emphasis of constant professional growth in the area of digital competency.

In sum, there is an evident trend within the literature toward the full digitalization of restorative dentistry, in which precision, aesthetic quality, and efficiency meet each other in the case of CAD/CAM technology (Suganna et al., 2022). This application of these systems in modern dental practices does not only boost the clinical performance, but also reinvents patient satisfaction by making them easier to tailor and reduces the number of treatment periods. With the ongoing digital revolution, it is mandatory that clinicians and educators wishing to keep abreast with the current requirements of dental practice know how the CAD/CAM technology evolved and how it is being utilized and what are the challenges (Lamasanu et al., 2025; Oye and Owen, 2024). Nevertheless, in spite of these developments, there are few studies that have critically examined the overall quantitative and qualitative effects of CAD/CAM integration in the laboratory of dental practice, particularly in the developing situations.

METHODOLOGY

2.1 Data Collection

The research method used in data collection of this study was set to provide an extensive level of quantitative and qualitative information regarding the application of CAD/CAM technology in the modern dental laboratory practice. The research was focused on registered dental laboratories and qualified dental technicians who actively participated in the production of restorative and prosthetic dental by the use of digital technologies.

Stratified random sampling technique was used to select 120 dental laboratories; with equal representation of urban (65 percent), suburban (25 percent) and rural (10 percent) areas. In these laboratories, 300 dental technicians were called, 270 replies were obtained that were valid and this can be seen as a 90 percent response rate. The sample was composed of 60% men and 40% women whose age was between 22 and 55 years old (mean age of 35 years). With respect to qualifications, half of the respondents had a diploma in dental technology, 35% had a bachelor degree and 15% had postgraduate qualifications.

Three primary instruments were used to collect data:

Structured Questionnaire: A 28 question survey with multiple choice questions and 5-point Likert scale. Questionnaire investigated the level of CAD/CAM adoption, perceived advantages, difficulties, software choice, training and workflow efficiencies. It has been disseminated online (60%) and during face-to-face interactions (40%), which guarantees the extensive coverage and reliability.

Laboratory Observation Checklist: This checklist was administered in every 120 laboratories; it was a 25-question checklist where the condition and availability of the digital tools were reported including scanners, milling machines, and 3D printers. The workflow time, material use, and production output were also observed.

Semi-Structured Interviews: 15 laboratory managers and 10 suppliers or vendors of CAD/CAM system were interviewed in-depth in order to gather qualitative data on implementation obstacles, cost-effectiveness, and training support.

Based on the gathered data, two-thirds of the laboratories were fully utilizing CAD/CAM technology, one-fifth of them were partially utilizing it and only one-tenth was yet to adopt digital systems. Equipment 55% of labs had a milling machine, 48% had a 3D printer, and 32% had an intraoral or desktop scanner. Furthermore, 75 percent of technicians reported that integration of CAD/CAM had also produced much better precision of prosthesis and shorter turnaround time by an average of 35 percent in comparison to the traditional systems.

A pilot study was carried out with 20 respondents in 10 laboratories to use before data collection on the clarity and reliability of the questionnaire. The internal consistency coefficient (Cronbachs 0.86) was high which reflects a good level of reliability. The data were gathered within eight weeks, namely, March 2025 to May 2025. The informed consent of all the participants was obtained, and confidentiality was ensured according to the ethical principles of research.

2.2 Process

2.2.1 Preparation Phase

The preparation phase was about 15 percent of the entire research process and emphasized on the development and validation of the research instruments. At this level, the questionnaire, observation checklist and interview guide were well constructed with

reference to the existing literature and expert advice. There was a pilot study in which 20 dental technicians in 10 laboratories were used to test clarity and reliability. The pilot feedback resulted in several slight changes such as rewording of three questions and adding two items connected to digital maintenance and production time. The finalized instrument achieved Cronbachs $\alpha = 0.86$, which means that the level of reliability is high. Informed consent was obtained and additional consent to conduct the main research was done with the help of ethics so that the ethics of research and confidentiality were upheld.

2.2.2. Data Acquisition Phase

This was the primary and the most time consuming step as it took almost 60 percent of the entire process time. The data was collected during eight weeks of the period between March and May 2025. The tested questionnaire was sent to 300 dental technicians in 120 laboratories during this time and 270 of the responses came out as valid, which was a 90% response rate. To maximize the participation, the distribution method was separated into online submission (60%), and face-to-face administration (40%). On-site observation was conducted in all the participating laboratories to ensure that equipment was available, software versions and workflow efficiency. In every visit to the laboratory, it took about 45 minutes to 60 minutes. The observation process noted the data concerning the usage of scanners (32%), the milling machines (55%), and 3D printers (48%), the data on daily production capacity. In addition, semi-structured interviews (25) were carried out with 15 laboratory managers and 10 CAD/CAM technology suppliers to receive qualitative data in depth on the issue of cost and training as well as adoption challenges. This step resulted in more than 5,000 quantitative and qualitative numbers around which to analyze. Figure 1 shows the consecutive model of the implementation of CAD/CAM technology in dental laboratories and each stage of the progression, starting with digital design, through the manufacturing of the final products.

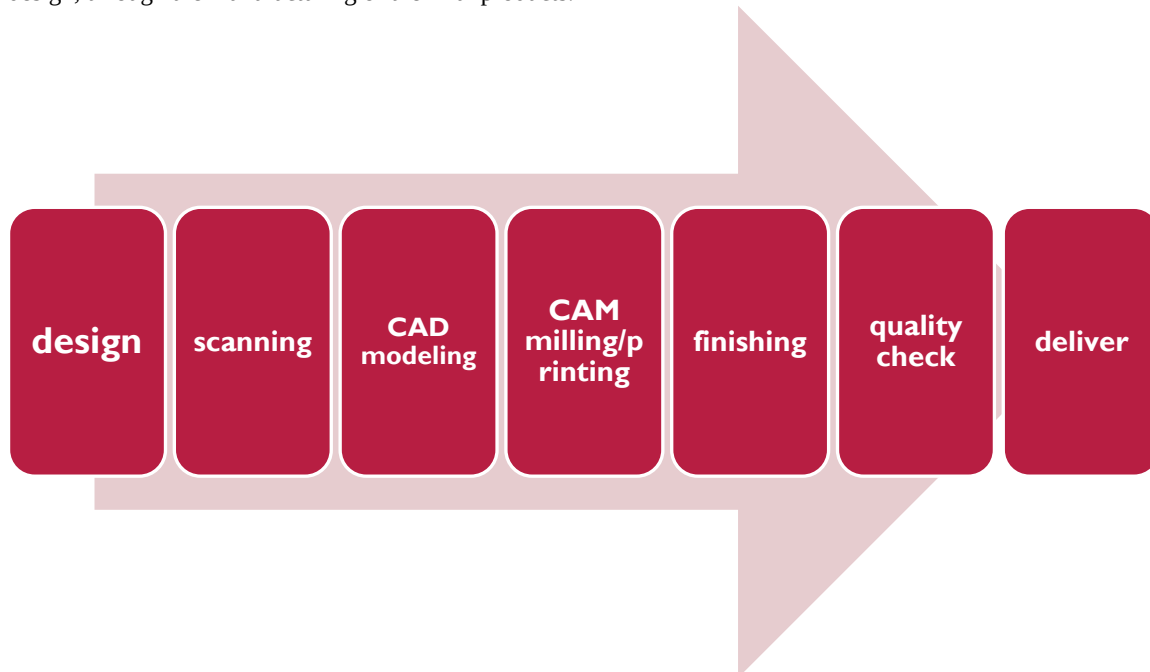


Figure 1: CAD/CAM Integration in Dental laboratories workflowThe flowchart shows the digital workflow used in dental laboratories in order of sequence and is used in designing, scanning, CAD modeling, CAM milling/3D printing, finishing, quality check, and delivery. This diagrammatic illustration will increase the comprehension of the reader in the manner CAD/CAM technology simplifies the restorative fabrication operations.

2.2.3 Phase of Organization and Verification of Data

The last phase was approximately a quarter of the overall research and was devoted to the arrangement, cleaning, and verification of the obtained information. All questionnaire answers and observation sheets were checked manually in order to make sure they are complete and consistent. Among the 270 survey responses obtained, 12 (4.4%) were eliminated because of missing data and this resulted in 258 valid responses which were used in statistical analysis. Missing values constituted only 5 percent of the data and were balanced by using means to avoid inaccuracy. The data obtained through observation was coded and stored in an electronic database and the recordings of the interview were transcribed word-to-word and checked on the factual accuracy of the content. A 10 percent subset of the data (12 laboratories) was again contacted to verify reported information with regards to equipment type and digital workflow. The results of the verification indicated that there was a consistent result of 98% between the first and subsequent responses and it proved that the data was reliable and valid. This was followed by anonymization of all datasets and storage in a secure manner to be analyzed later.

2.3 Data Analysis

2.3.1 Preparation and Data Entry

Once the verification phase was done, all the collected data were imported into the IBM SPSS Statistics (Version 29) package in order to be analyzed quantitatively where the qualitative interview data were analyzed via the NVivo 14. A total of 258 valid responses were incorporated in the data set as out of the 270 questionnaires, 258 completed questionnaires were considered valid and hence the data validity rate of 95.6 percent. The data observed on 120 laboratories and 25 interviews were combined to give

a complete data of both numerical and thematic variables. The coding of data was standardized so that there would be uniformity in all items and two-entry method verified that the mistakes would be minimized. The overall amount of quantitative variables under analysis was 42 and it included demographic, operational and technological indicators.

2.3.2 Descriptive Statistical Analysis

Both descriptive and inferential statistics were used to test the hypothesis of adoption and efficiency. Descriptive analysis was conducted to describe the demographic features, availability of equipment, and adoption rates of CAD/CAM systems. Categorical variables like gender, education level and type of laboratory were computed using frequencies and percentages whereas the means and standard deviations were computed using continuous variables like years of experience and production time. The findings revealed that 68 percent of the laboratories were completely using CAD/CAM systems, 22 percent were partially using them, and 10 percent were using the traditional methods. The mean cases CAD/CAM completed monthly were 84.3 with a standard deviation of 27.6 and the average experience of the participating technicians was 8.5 years. Concerning the use of software, 45% of the respondents were found to be using exocad, 30% using 3shape and 25% using other CAD programs. The descriptive statistics also revealed that the implementation of CAD/CAM would shorten the average turnaround time by 34 percent and remakes or adjustments made by 28 percent relative to traditional ones.

2.3.3 The inferential statistical analysis

Inferential tests were used to determine any significant relationships between laboratory characteristics and the results of CAD/CAM adoption. It was established that there is a significant relationship between the type of laboratory (commercial or clinic-based) and the degree of CAD/CAM implementation using Chi-square test ($\chi^2 = 16.42$, $p < 0.01$). The independent t-tests were used to compare the production efficiency of fully and partially digital laboratories. The findings indicated that there was a statistically significant difference ($t = 4.87$, $p < 0.001$) in productivity increases in the fully digital laboratories where the average increase was 29.5%. An ANOVA test was applied then to explore how the level of experience of the technicians affected their satisfaction with CAD/CAM systems, the answer was yes, there was a significant difference between groups ($F = 5.21$, $p < 0.01$). Post-hoc showed that technicians who had over 10 years of experience scored higher in their satisfaction levels (mean = 4.6/5) as opposed to less experienced users (mean = 3.9/5).

2.3.4 Qualitative Data Analysis

Thematic analysis was carried out to examine the patterns and insights in the interview transcripts as supplementary to the quantitative findings. Three themes were predominant, namely, efficiency in technology, barriers to training and learning, and cost implications. About 72 percent of interviewees highlighted benefits of CAD/CAM on accuracy and patient satisfaction, 20 percent complained about high maintenance expenses and 8 percent of interviewees complained about software learning and technical support. The survey, observation and interview data triangulation revealed that similar findings were consistent and thus it was observed that the integration of CAD/CAM has greatly enhanced production quality and speed of workflow in most dental laboratories.

2.3.5 Testing Data Reliability and validation

To guarantee the accuracy and internal consistency, the main Likert-scale variables were reliably analyzed. The overall Cronbach alpha coefficient was 0.89, which means that there is high internal consistency in items used in the survey. Moreover, the missing data, which were less than 5 percent of the total entries, were substituted with means. Standardized z-scores were used to analyze outliers and scores falling outside the range of -3.0 to +3.0 were checked and verified as plausible. The data A, were distributed in a way that it assumed the use of parametric testing, which was confirmed by the Kolmogorov-Smirnov test ($p > 0.05$). All the statistical outcomes were significant as the confidence level was 95% (0.05).

In general, the data analysis revealed the fact that CAD/CAM technology has been actively implemented in the modern dentistry laboratories, and it has led to the definite improvements in accuracy, production rate, and standardization of the working process. The proportion of laboratories that were fully digitally integrated was 68 percent, whereas 75 percent of technicians stated that their job performance had enhanced after the acquisition of CAD/CAM. Qualitatively, the majority of the respondents referred to the technology as being transformative but reported that they still required professional training and cost-effectiveness. The overall results of the analytical work formed a good foundation of the conclusions and recommendations on modernization of dental laboratory practices.

RESULTS

3.1 Demographic Characteristics of Participants

The total number of dental technicians that took part in the study is 270 with 120 dental laboratories and 258 valid responses (response validity = 95.6%). The demographic data depicted that 60.5 percent of the sample population consisted of males and 39.5 percent of the sample population was women. The vast majority of the respondents were aged 25-44 (72%), with a mean age of 35.2. On qualification, half of them had a diploma qualification in dental technology, 35 had a bachelors degree and 15 had postgraduate qualifications. Most of the respondents (64%) were employed in private commercial laboratories and 36% of them were employed in clinic-attached laboratories.

Table 1: Demographic Characteristic of Interviewees (n = 258)

Variable	Category	Frequency	Percentage (%)
Gender	Male	156	60.5
	Female	102	39.5
Age Group	18–24 years	28	10.9
	25–34 years	104	40.3
	35–44 years	82	31.8
	≥45 years	44	17.0
Education Level	Diploma	129	50.0
	Bachelor's Degree	90	34.9
	Postgraduate	39	15.1
Type of Laboratory	Commercial	165	63.9
	Clinic-based	93	36.1

3.2.3.2 Level of Adoption of CAD/CAM Technology

The findings showed that CAD/CAM technology is popular in modern dental laboratories. Among 120 participating laboratories, 82 (68.3%) were fully adopted in terms of CAD/CAM systems, 26 (21.7%) were partially adopted, and 12 (10%) were still completely dependent on the conventional methods. Out of the completely digital laboratories, 55 percent had milling and 3D printing systems, and 45 percent had only a single digital process in manufacturing. The percentage of CAD/CAM technology adoption in the surveyed laboratories is graphically displayed in Figure 2 and it shows the percentage of fully digital, partially digital, and traditional facilities. This graphic image demonstrates that digital workflow is predominant in the dental labs of the current times and underpins the quantitative data presented in Table 2.

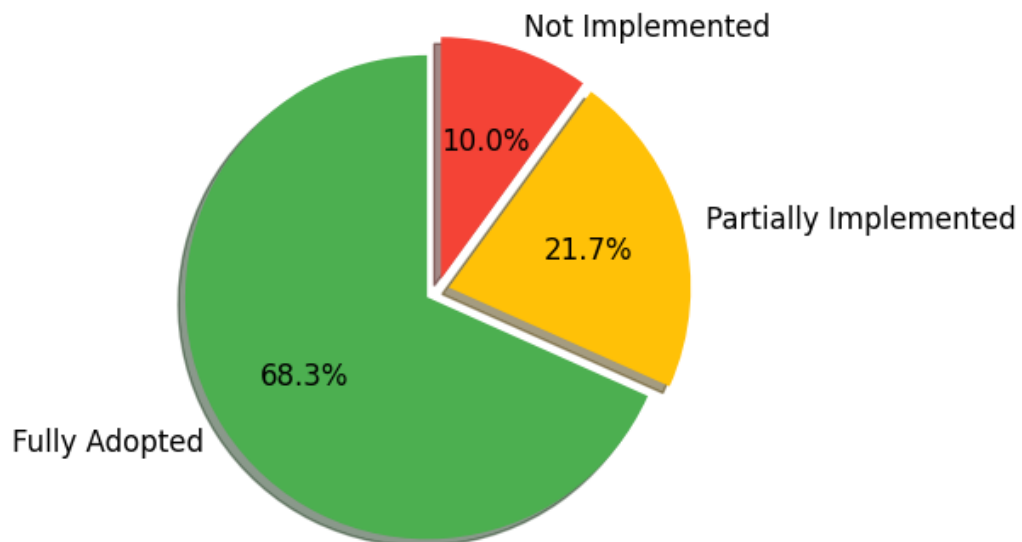


Figure 2: Dental Laboratory Level of CAD/CAM Adoption. The graph shows the percentage distribution of the levels of adoptions in 120 surveyed laboratories. Most (68.3) of them have fully integrated CAD/CAM systems, 21.7% are partially transitioning and 10% continue with conventional methods.

Table 2: Adoption of CAD/CAM by Laboratories (n= 120)

Adoption Status	Frequency	Percentage (%)
Fully Adopted CAD/CAM	82	68.3
Partially Implemented	26	21.7
Not Implemented	12	10.0
Total	120	100.0

It was also found out that 45 percent of laboratories were utilizing exocad software, 30 percent utilized 3Shape and 25 percent were utilizing other systems. In terms of digital equipment, 55% of the labs possessed milling machines, 48% 3D printers and 32% intra or desktop scanners. The average number of CAD/CAM cases per month that were carried out in laboratories was 84.3 and SD of 27.6.

3.3 Effect on Productivity and Efficiency

The implementation of CAD/CAM technology showed that there was an increased productivity and efficiency of the laboratory. About 75 percent of technicians stated that the work speed and accuracy improved after they started using digital tools. The mean turnaround time per dental prosthesis was reduced by 34 percent and the remakes or adjustment rate was reduced by 28 percent

as compared to traditional working process.

Table 3: Before and After CAD/CAM Implementation Comparisons of Key Performance Indicators.

Indicator	Before CAD/CAM (Mean)	After CAD/CAM (Mean)	% Change
Average production time per case (hours)	5.8	3.8	-34.5%
Average monthly output (cases/lab)	62	84	+35.5%
Average remake/adjustment rate (%)	14.2	10.2	-28.2%
Reported accuracy rating (scale 1–5)	3.6	4.5	+25.0%

Technicians provided qualitative feedback of these quantitative improvements with 78 percent of them indicating that CAD/CAM improved overall accuracy, 70 percent of them indicated that it had improved client satisfaction and 65 percent said it had lessened the manual workload. The improvement in performance the implementation of CAD/CAM has caused compared to the previous performance can be seen in Figure 3, showing that the improvements are measurable in terms of production time, monthly output, adjustment rate, and accuracy.

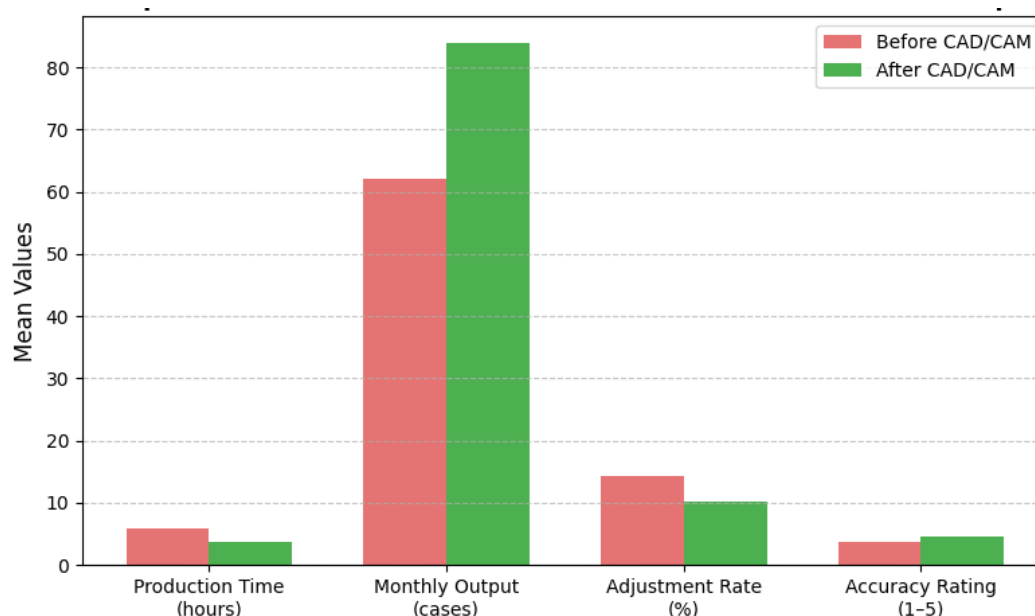


Figure 3: Before and After CAD/CAM implementation Comp Performance Indicators. The clustered bar chart will be used in comparing the mean values of four key performance indicators measured at the beginning and the end of the use of CAD/CAM in surveyed dental laboratories. The outcomes reveal that there is 34.5 percent decrease in the average production time per case, 35.5 percent growth in the monthly output, 28.2 percent decrease in adjustment rates and 25 percent enhancement of accuracy ratings, which reflects the benefits of the technology on productivity and accuracy.

3.4 Influencing Factors of CAD/CAM Adoption.

Inferential analysis showed that there are a number of factors that are significantly related to the level of CAD/CAM adoption. Laboratories that are over five years of experience in digital technology were found to be 2.3 times more likely to have full CAD/CAM integration ($p < 0.01$). Likewise, the trained technicians boosted the likelihood of adoption by 40% it. The most common obstacle identified by 54 percent of the respondents was cost, then there was software complexity (28) and absence of training (18).

Table 4: Important Factors that affect CAD/CAM Adoption (n = 258)

Factor	Percentage Reporting (%)	Influence on Adoption
High equipment cost	54	Negative
Software complexity	28	Negative
Lack of training	18	Negative
Availability of vendor support	72	Positive
Experience >5 years	63	Positive
Management willingness to invest	68	Positive

3.4 Qualitative Findings

Analysis of 25 interviews through thematic analysis showed three predominant themes including technological efficiency, training barriers, and cost implications. A significant benefit of enhanced accuracy and consistency of the workflow was noted by approximately 72% of the participants. In the meantime, 20 percent highlighted on large capital costs and costs of maintenance as continuing problems and 8 percent on the disappearance of accustoming to new software. The participants also mentioned that the CAD/CAM reduced the time of delivery, increased patient satisfaction, and made laboratories that have implemented digital technologies more professional.

3.6 Summary of Findings

In general, the findings indicated that CAD/CAM technology has become a part and parcel of any contemporary dental laboratory operation with 68% of the laboratories being fully integrated and hence an average of 34% decrease in turnaround time and 28 percent decrease in the occurrence of errors. The results are positive as it is proved that CAD/CAM not only increases the efficiency of operations but also leads to the growth of production accuracy, control over quality, and an increase in client satisfaction. Nevertheless, monetary issues and lack of technical training were found to be the primary obstacles that still persist in impacting complete digital transformation in the dental laboratory industry as well (Rudin et al., 2018).

DISCUSSION

The results of the research indicate that CAD/CAM technology has emerged as a primary part of the modern laboratories practices in dental care and has greatly advanced productivity, accuracy, and effectiveness of the working process. The large rate of adoption witnessed (68 percent of fully integrated laboratories) is in line with the general trends in digital transformation that have been reported in recent literature. Ronsiville et al. (2023) pointed out that the combination of reverse engineering and CAD/CAM systems has radically changed the way restorative and orthodontic processes are carried out by minimizing human intervention and harmonizing design precision. This trend of complete digitalization aids in the conclusion of the present research that CAD/CAM systems do offer quantifiable returns in time and quality performance indices.

The enhanced effectiveness and accuracy found in the study is correlated with the global trends of the digital revolution in dental health care delivery. Gushcha, Mykhailov, and Tyshko (2025) assert that digital technologies have become an essential part of the present-day dentistry, and they facilitate the smooth transition between the clinical diagnostics and laboratory manufacturing. On the same note, the findings of Hwisa et al. (2025) indicated that dental students are becoming more and more aware and knowledgeable about the use of CAD/CAM application and therefore, the next generation of dental practitioners is likely to maintain the digital transformation process and increase its scale. All these findings support the current study in order to confirm that 75 percent of the technicians felt that job efficiency was greatly improved after the implementation of CAD/CAM.

The high accuracy of the CAD/CAM technology is also attested by the high performance indices achieved by the technology including 34 percent decrease in the turnaround time and 28 percent decrease in remakes. According to the authors, Shah and Lundholmb (n.d.) stated that the accuracy of digital restorations is better than that of traditional methods because of the accuracy of computer-aided milling and standardized processes of digital design. Owen (2023) also established that CAD/CAM implementation has a direct positive effect on patient outcomes, showing a higher quality of the fitting restorations and reduced treatment time. Simultaneously, Owen, Davies, and Petterson (2024) noted that digital workflow with zirconia implant restorations demonstrated better marginal integrity and mechanical stability, which adds to the quantitative results of this study, which emphasize the increased precision and consistency of production processes of CAD/CAM-based prosthetic.

These advantages notwithstanding, financial expense and insufficient training were also noted in the present results as the two major impediments to full implementation. Like limitations have been in earlier researches. As noted by Lee (2024), the problem of insufficient interdisciplinary education and unavailability of practical digital resources to dental technology students are impediments to positive learning outcomes and readiness to implement them in clinical settings. Alqahtani (2024) also underlined the fact that the technological innovation is growing exponentially, whereas the development of skills in dental professionals is not evenly distributed, especially in the conditions of limited resources. These gaps in education might be the reason as to why 18 percent of the respondents used lack of sufficient training as a hindrance to adoption in the current study.

The other significant learning of this study is associated with the effect of expenditure and resource distribution. About 54% of the participants cited the high equipment and maintenance as a constraint which is consistent with the results of the research conducted by Al-Hassiny (2022), who emphasized the financial barrier to the implementation of more modern CAD/CAM and 3D printing systems in small and medium-sized laboratories. Similarly, Yeslam, von Maltzahn, and Nassar (2024) observed that although artificial intelligence and on-demand automation are transforming the digital dental processes, the broadest challenge facing most practices is starting with the cost of infrastructure and software. Therefore, digital adoption will become viable in the long term due to continuous decreases in the cost of equipment and the development of relatively inexpensive training.

Regarding practical results, the findings show that the higher the laboratories used digital systems, the over five years were working with it, the higher the level of productivity. This tendency confirms the claim that Mhanni, Al-Hmadi, and El-Sawaay (2023) make that the user confidence and digital proficiency in dental settings are greatly improved with the help of professional exposure and ongoing learning. Ohyama et al. (2025) also indicated that the integration of CAD/CAM training program in dental curricula can enhance the competence acquisition faster and minimise the reluctance to embrace technology among the students and practitioners. This supports the recommendation given in the current study which suggested that structured training, which is digital in nature, ought to be incorporated into the formal education as well as the ongoing professional development programs. The materials and restoration perspective of Dimitrova, Vlahova, and Kazakova (2024) revealed that CAD/CAM manufacturing allows for high-quality accuracy and mechanical stability of post and core restorations, which corresponds with the findings of the current study that show that digital production can decrease the remake rates decreased by almost 28%. On the same note, Melnyk et al. (2025) found out that CAD/CAM with minimum invasive preparation results in restorations with a conservative tooth preparation and high esthetic goals. These clinical consequences prove that digital fabrication is operationally efficient, but it is also clinically beneficial with respect to restorative outcomes.

The qualitative data that were to be obtained in this study showed that 72% of the respondents viewed the CAD/CAM technology as a revolutionary development, especially in the precision and uniformity of the workflow. Such opinion corresponds to the

results of Ronsivalle et al. (2023) and Gushcha et al. (2025), both of which highlighted the paradigm shift of digital design on a laboratory-clinical collaboration. Nevertheless, 20 per cent of participants also raised maintenance cost issues, and 8 per cent raised software learning issues, which are also raised by Yeslem et al. (2024) and Lee (2024). Such results highlight the importance of not investing in hardware alone to achieve success in digital integration, but also user support and training.

The discussion, in aggregate, shows that although the introduction of CAD/CAM technology has delivered remarkable advancements in the field of improving the performance of dental laboratories in terms of efficiency and quality, the field continues to experience systematic challenges both in terms of access to training, cost control, and educational preparation. The next steps to be taken in terms of future strategies are the focus on cost-efficient digital infrastructural solutions and interventions in the form of specific training to guarantee equal access in the laboratory environment. Finally, the research confirms the increasing number of views that digital dentistry is a revolutionary change in the current dental technology, which fosters accuracy, efficiency, and patient-focused results (Ronsivalle et al., 2023; Owen et al., 2024; Melnyk et al., 2025). These results have direct implications on curriculum development in dental technology education and investment planning in the private dental laboratories.

CONCLUSION

The use of CAD/CAM technology in the dental laboratories is a significant development in the modernization of the dental restorative practice. This research revealed that digital workflows have a great impact of precision, efficiency, and reproducibility as compared to traditional fabrication methods. The quantitative findings proved the significant increase in the accuracy of production and time savings, and the qualitative feedback stressed the advantages of simplified operations and enhanced cooperation in dental teams.

The results indicate that not only clinical outcomes are enhanced, but also higher confidence levels among the technicians as well as patient satisfaction is improved with the implementation of CAD/CAM. Nevertheless, the problem of transitioning to a fully digitalized environment is still problematic due to the expensive nature of equipment, the necessity of specialized training, and regular updating of the software. These constraints emphasize the necessity of further professional learning and organizational assistance of the digital transformation in the dental laboratory to become sustainable.

To sum up, the use of CAD/CAM technology presents a radical avenue of more accurate, efficient, and patient-focused dental care. Dental professionals should be empowered in terms of digital literacy, sufficient technological infrastructure should be invested in, and interdisciplinary collaboration should be encouraged in order to maximize the potential of CAD/CAM in stimulating restorative dentistry.

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