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Perspective article

Current challenges of dental laboratory in Taiwan: The perspectives from a senior certified dental technician in a dental laboratory attached to a teaching hospital

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Dental care is conducted by a team (so-called dental team) composed of many professional members, including the dentists, dental technicians, medical radiation technologists, oral hygienists, dental assistants and even nurses engaged in dentistry.[1] Among them, dental technicians are mainly responsible for the fabrication of dental restorations to restore the patients' lost teeth and regain their normal oral functions. In 2009, Taiwan government legislated the Dental Technicians Act to clearly define the career and education strategies of dental technicians. Therefore, a qualified dental technician needs to fully understand the professional skills in the related fields such as oral anatomy, dental morphology, dental materials, fixed denture technology, and removable denture technology. However, dental restorations vary depending on the patients' oral condition, defect location, and personal expectations. For this reason, dental technicians need to prepare numerous instruments and equipment to handle the fabrication of complex and diverse dental restorations. In addition, the establishment of a dental laboratory requires sufficient space, appropriate ventilation equipment, and proper industrial waste disposal. These factors create significant challenges for the dental departments of hospitals and the dental clinics in establishing a dental laboratory.

Dental procedure is currently undergoing a digital transformation, promoting the dental care into the field of digital health care.[2] This is accompanied by advances in dental materials and equipment. For example, the traditional fabrication process of metal crowns requires impressions, casting models, wax engraving, investment casting, and polishing of the final restoration. The current digital process is oral scanning, digital design, processing machine milling, 3D printing, and polishing, making the dental care quality more accurate and faster.[3–5] In addition, the fully digital process without physical casts can still achieve good accuracy.[6] In addition, the simplification of the fabrication process means that the need for the type and quantity of dental equipment can be significantly reduced. This solves the problem that the dental departments of hospitals and the dental clinics cannot set up a dental laboratory due to space insufficiency. For this reason, after 2020, the number of cases of dental laboratories attached to the dental departments of hospitals or the dental clinics is increasing year by year. At this stage, dental technicians are no longer limited to an independent dental laboratory. Many hospitals and dental clinics have begun to provide dental technicians with different practice environments and ecologies. However, how these changes in the dental practice setting affect the clinical skills, education and training, and future development of dental technicians has not yet been discussed. Therefore, this study attempted to explore the career of dental technicians in Taiwan and the differences among the dental departments of hospitals, the dental clinics, and the independent dental laboratories through an interview with a senior and highly experienced certified dental technician (CDT) who was involved in a dental laboratory attached to a teaching hospital.

In this study, we used purposeful sampling to select a CDT who had extensive experience in the dental laboratory career to conduct an interview with him. Our questions for the CDT and his answers during the interview are shown in Table 1. The interview outline had 6 major items related to the dental laboratory career of a CDT in Taiwan, including (A) the working experience of this interviewed CDT, (B) the definition of the CDT and related laws and regulations in Taiwan, (C) the digital transformation and equipment of the dental laboratory in Taiwan, (D) the systems related to the CDT in Taiwan, (E) the characteristics of the CDT in Taiwan, and (F) the future development of the CDT in Taiwan.

The interviewed CDT started his dental laboratory career as a dental technician since 2013. So far, he has been engaged in this profession continuously for more than 11 years. Currently, he also taught courses in the professional field of dental technology in a dental technology school of a medical university. He considered that the field of dental technology includes medicine, anatomy, material science, color science, and art. Those who want to become the dental technicians in Taiwan need to receive formal school education and pass the national examination to obtain dental technician qualifications. In the dental practice, only dentists and dental technicians can make dental restorations. Therefore, in addition to dentists, dental technicians are an inseparable profession in the dental care in Taiwan, and almost all dental restorations are produced by the CDTs. The traditional fabrication of dental restorations is complex and requires a variety of equipment and materials. However, the space and environment of the dental departments of hospitals and the dental clinics are limited, and most of the dental laboratory work is concentrated in the dental laboratories. This led to the fact that in the past, the CDTs had only independent dental laboratories outside the dental departments of hospitals and the dental clinics as their professional workplace.

Excellent dental restorations must conform to each patient's oral structure, including the color, shape, fitness, and esthetics.[7] By communicating with the patients and recording their physiological information on chairside, the quality of dental restorations can be greatly improved. The CDTs of the independent dental laboratories cannot directly collect the patient information from the dental departments of hospitals or the dental clinics. It can only use cast models or digital photographs as a reference for the fabrication of dental restorations. Therefore, the dentists cannot discuss with the CDTs in a timely manner, while the CDTs cannot directly record the patients' information. This often causes errors or the need to modify the color of dental restorations after they have been installed intraorally.

Currently, the advances in dental digital equipment and materials have significantly reduced the fabrication process of dental restorations. The dental departments of hospitals or the dental clinics have begun to establish their own dental laboratories to improve the quality of dental care. This has changed the professional ecology of the CDTs in Taiwan. The CDTs can directly communicate with the patients and directly record the patients' oral condition in the dental departments of hospitals or the dental clinics, effectively improving the quality of dental restorations. In addition, the CDTs can immediately assist the dentists in modifying the restorations, also improving the efficiency of dentists in treating their patients (such as reducing the

Table 1 The questions for the senior certified dental technician (CDT) working in the dental laboratory attached to a teaching hospital and his answers during the interview in this study.

Item	The questions for the senior CDT and his answers
A	**The working experience of this interviewed CDT**
1	How many years have you worked in the dental technology? I worked as a CDT in the Chia-Gu Dental Laboratory from August 2013 to July 2019. In February 2020, I transitioned to the School of Dental Technology, College of Oral Medicine, Taipei Medical University, specializing in the dental technology. Additionally, I have served as a part-time CDT in the Division of Prosthodontics, Department of Dentistry, Taipei Municipal Wan-Fang Hospital since January 2023. Therefore, I have more than 11 years of experience in the dental technology.
2	Did you have any experience working in the dental clinics that have attached dental laboratories? Yes, I had more than six months of clinical experience in a dental clinic in Taichung before February 2020.
3	Did you have any other experience working in an attached dental laboratory? In January 2022, I collaborated with the Department of Dentistry, Wan-Fang Hospital to plan and establish a digital dental technology room. To date, this unit continued to have excellent dentists and dental technicians providing patients with the high-quality oral restorative care.
B	**The definition of the CDT and the related laws and regulations in Taiwan**
4	How can one obtain a dental technician qualification in Taiwan? The Dental Technicians Act was passed in 2009. In Taiwan, the citizens who pass the National Examination for Dental Technician (administered by the competent authority) and obtain the Dental Technician Certificates are eligible to receive the CDT qualifications.
5	What are the responsibilities of dental technicians? The CDT should perform dental technology services according to the written documents issued by the dentists. The work of a dental technician involves providing dental services that are performed outside the oral cavity, including the manufacturing, repair, or processing of major dental restorations such as the crowns, bridges, inlays, orthodontic devices, and removable dentures.
6	According to your perspectives, what are the different types of dental technician professions in Taiwan? Currently, the CDT occupations in Taiwan can be divided into (a) operating the independent dental laboratories, (b) being employed by the dental departments of hospitals, the dental clinics, or the independent dental laboratories, (c) working for the companies related to dental materials, and (d) being employed by research institutions to engage in scientific research and development.
7	How does the workplace affect the work content of the dental technicians? Currently, the CDTs' work areas are primarily in the dental departments of hospitals, the dental clinics, or the independent dental laboratories. In the dental departments of hospitals and the dental clinics, the CDTs can coordinate with the dentists' schedule. Most of them focus on performing the immediate dental restorations and the color matching or repair of restorations. In the independent dental laboratories, they are primarily responsible for producing a large amount of dental restorations. These restorations typically involve multiple teeth or technically challenging cases. Therefore, the work content of the CDTs varies depending on their workplace, and different service strategies are provided based on the clinical needs.
C	**The digital transformation and equipment of the dental laboratory in Taiwan**
8	What are the digital changes in dentistry in Taiwan? Currently, Taiwan's dental technology industry is transforming towards digitalization. The digital information of patients' oral structure is obtained mainly by using oral scanning technology. The related dental restorations are designed by using the digital software. Then, the final restorations are fabricated by using a milling machine or a 3D printer.
9	What different types of dental restorations can currently be designed by using the digital software? The dental restorations that can currently be designed through the digital software in Taiwan are: (a) Fixed dentures (such as the crowns, bridges, and dental implants); (b) Removable dentures (such as the complete and partial dentures); (c) Orthodontic devices (such as the bite plates, braces, and maintenance devices); and (d) Surgical guide.
D	**The systems related to the CDT in Taiwan**
10	What is the situation of the CDT educational system in Taiwan? Currently, schools with dental technology-related departments in Taiwan are divided into the universities (four-year programs) and the junior colleges (five-year programs). The schools have teachers specializing in the dental technology and are equipped with both the traditional manufacturing and the digital dental technology tools, including the intraoral scanners, desktop scanners, computer-aided design/computer-aided manufacturing (CAD/CAM) systems, and 3D printers. In addition, the clinical internship projects will be conducted during the study period in accordance with the requirements of the Dental Technicians Act. The details regarding the internship projects, hours, locations (conditions), and the requirements for the dentists and dental technicians who supervise the internships are as follows: (a) Internship projects and hours: The fixed prosthetic technology requires a total of 160 h, while the removable prosthetic technology and corrective prosthetic technology each requires a total of 80 h.

Table 1 (*continued*)

Item	The questions for the senior CDT and his answers
	(b) Conditions for internship sites: The internships must be conducted in the qualified medical institutions, the dental clinics, and the dental laboratories in the similar locations. (c) The internships should be conducted under the guidance of personnel who are licensed dentists or dental technicians and have more than 2 years of practical work experience.
11	What the CDT-related training courses are currently available in Taiwan? In Taiwan, the CDT is a profession that requires a national license. The practitioners must complete a certain number of continuing education hours (120 points) every six years to renew their practice licenses. Therefore, in addition to the educational curricula provided in the dental technology schools, many guilds, societies, and private educational institutions regularly offer dental technology-related training courses to facilitate the further education for the practitioners.
E	**The characteristics of the CDT in Taiwan**
12	According to your experience, what role does the CDTs play in the dental practice? In the dental care, the dentists are primarily responsible for the diagnosis and treatment within the oral cavity. When irreparable damage occurs, a CDT is needed to fabricate the necessary restorations. The final restoration is then placed in the patient's mouth by the dentist to restore the original oral function. Therefore, the CDTs play a crucial role in the clinical settings by recreating the patient's oral structures. This is especially true when the CDTs work in the dental departments of hospitals or the dental clinics, where they can directly observe the patient's oral condition, leading to more accurate and realistic restoration fabrication. Additionally, the CDTs in the clinical settings can quickly repair or adjust the dentures, reducing the time spent on the transportation and the number of patient visits compared to sending the restoration to the external dental laboratories for repair or adjustment.
13	What is the limitation of the CDTs in the dental practice? The Dental Technicians Act stipulates that the CDTs are prohibited from performing the tasks such as taking impressions, bite registrations, fittings, appliance placements, or other medical procedures inside the patient's oral cavity. Therefore, the limitation for the CDTs is that they cannot engage in any invasive treatment involving the patient's oral cavity.
F	**The future development of the CDT in Taiwan**
14	How has the digital transformation in the dental technology changed? In the past, the dental technology required numerous intricate steps for the fabrication of restorations. The introduction of digital equipment and systems has reduced the complexity of these processes. Additionally, the traditional dental technology required a wide variety of large equipment, which often had issues with ventilation and smoke extraction. The setup of a dental laboratory had to take into account factors like the space, cost, and ventilation, making it challenging to establish a dental technology practice. As a result, it was nearly impossible for the dental departments in hospitals and the dental clinics to meet the requirements for housing a dental laboratory. However, the shift toward digitization has significantly reduced the variety and size of equipment needed. More importantly, the digitization has decreased the emission of fumes and the production of medical waste. Consequently, the barriers to operate a dental laboratory have been greatly lowered. Many dental departments of hospitals and dental clinics can now establish in-house dental laboratories, providing the more comprehensive dental services.
15	What is the impact of the introduction of artificial intelligence on the CDTs? The human oral structure exhibits significant uniqueness, requiring custom-made dental restorations for each individual. The CDTs need to design the restorations tailored to the specific cases. Therefore, this highlights the necessity of precise design. The artificial intelligence, through training, can assist the CDTs in designing the basic structure of restorations, with the final adjustments and confirmations made by the CDTs. As a result, the integration of artificial intelligence could effectively enhance the efficiency of the CDTs in clinical restoration work and reduce the design time.
16	What are your views on the future development of the CDTs in Taiwan? The digitization of dentistry directly impacts the ecosystem of the CDTs. The advancements in equipment and materials, along with the integration of artificial intelligence, will significantly improve the working methods of the CDTs. In Taiwan, the CDTs can leverage these advanced technologies and equipment to enhance the efficiency, quality, and cost-effectiveness of restorations. The aging population suggests that the demand for dental restorations will gradually increase. However, the number of restorations each CDT can produce is limited by the time constraints. Therefore, in the future, the CDTs should consider how to apply digital technologies to overcome the time limitations and develop a stable digital manufacturing process. Ultimately, the CDTs in the dental departments of hospitals, the dental clinics, and the independent dental laboratories will be able to produce the dental restorations more quickly, accurately, and with higher quality, thereby providing the better services in the dental care.

number of appointments).[8] In Taiwan, the CDTs can have multiple career options, such as (1) operating a dental laboratory on their own, (2) being employed by a dental laboratory, and (3) being employed by a dental department of a hospital or a dental clinic. Therefore, the CDTs provide a variety of professional services within Taiwan's dental service system.

According to the Dental Technicians Act, the CDTs should produce dental restorations in accordance with the written documents issued by the dentists. They can only engage in the dental care extra-orally. The main limitation of a CDT is that he or she cannot perform dental procedures intra-orally, such as the oral scanning, dental implant fitting, and dental restoration try-in. Therefore, even a CDT employed in a dental department of a hospital or a dental clinic should be careful whether his or her performance falls outside the limitation of the Dental Technicians Act. In this regard, digital changes have a significant impact on the dental technology practice environment. The educational system for cultivating the CDTs should update in a timely manner to develop relevant courses in line with the current dental clinical situation.

On site of a hospital or a dental clinic, the CDTs are able to discuss directly with the patients to understand the patients' oral condition, tooth color, eating habits, oral cleaning habits, and personal demands. Combining this patients' information obtained directly on the front line may help the CDTs to work with the dentists to develop the appropriate dental restorations. In addition, when the patients have immediate problems such as restoration color modification, missing contact of the occlusal surface or the adjacent teeth, or correction of marginal shortage, the CDTs can handle these problems immediately. Therefore, the CDTs play an important role in the clinical dentistry.

This study attempted to explore the occupational profile of the CDTs in Taiwan and analyze the differences when the CDTs were associated with the dental departments of hospitals, the dental clinics, or the independent dental laboratories. The significance of this article is to outline the current challenges of dental laboratory work in Taiwan from the perspectives of a senior CDT, indicating the importance of the CDTs in the dental care, and showing the changes brought by the digital transformation of dentistry. In the future, we look forward to closer cooperation between the dentists and the dental technicians to discuss and formulate the fabrication of dental restorations to improve the quality of the dental care, demonstrating the cooperation in the practicing precision medicine and the whole-patient care.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

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