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Original Article

Dental technology of Taiwan during the Japanese colonial period

Feng-Chou Cheng^{a,b,†}, Ling-Hsia Wang^{c,†}, Natsuyo Ozawa^d,
Chen-Ying Wang^{e,f}, Julia Yu-Fong Chang^{f,g,h,**},
Chun-Pin Chiang^{f,g,h,i,*}

^a School of Life Science, National Taiwan Normal University, Taipei, Taiwan^b Science Education Center, National Taiwan Normal University, Taipei, Taiwan^c Center for the Literature and Art, Hsin Sheng Junior College of Medical Care and Management, Taoyuan, Taiwan^d Department of Design, National Taiwan University of Science and Technology, Taipei, Taiwan^e School of Dentistry, National Taiwan University, Taipei, Taiwan^f Department of Dentistry, National Taiwan University Hospital, College of Medicine, National Taiwan University, Taipei, Taiwan^g Graduate Institute of Clinical Dentistry, School of Dentistry, National Taiwan University, Taipei, Taiwan^h Graduate Institute of Oral Biology, School of Dentistry, National Taiwan University, Taipei, Taiwanⁱ Department of Dentistry, Hualien Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, Hualien, Taiwan

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Abstract *Background/purpose:* During the Japanese colonial period, the Taipei Hospital had already provided complete dental services with a fixed price per treatment. This study tried to compare the differences in the prices of various dental treatments between the Japanese colonial period and today.

Materials and methods: This study used the "Dental Treatment Fees in the 27th Annual Report of Taipei Hospital (Taisho 12)" as the study materials to compare the differences in the prices of various dental treatments between the Japanese colonial period and today using the monthly salary of a novice elementary school teacher as an income benchmark.

Results: A hundred years ago, the Taipei Hospital had already provided the dental treatments such as scaling and endodontic, operative dentistry, prosthodontic, and orthodontic treatments. Of these treatment items, the prices for prosthodontic and orthodontic treatments

* Corresponding author. Department of Dentistry, Hualien Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, No. 707, Section 3, Chung-Yang Road, Hualien, 970, Taiwan.

** Corresponding author. Department of Dentistry, National Taiwan University Hospital, No. 1, Chang-Te Street, Taipei, 10048, Taiwan.
E-mail addresses: jyfchang@ntu.edu.tw (J.Y.-F Chang), cpchiang@ntu.edu.tw (C.-P. Chiang).

† These two authors contributed equally to this work.

were more expensive. After a century of development, the costs of scaling and operative dentistry treatments dropped, while the costs of endodontic, prosthodontic, and orthodontic treatments increased.

Conclusion: During the Japanese colonial period, Taiwan's dental treatment technology had already had the forms of modern dentistry with several dental specialties. At that time, the costs of dental treatments are quite expensive. Today's dental treatment items are more detailed and diverse. The health insurance system provides Taiwanese people with convenient and cheap general dental treatments such as scaling and treatments related to operative dentistry, endodontics, periodontics, and oral surgery. However, the costs of prosthodontic and orthodontic treatments increase and have to be paid by the patients themselves.

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Introduction

Taiwanese society entered modernization during the Japanese colonial period (1895–1945). The western medical system was first introduced to Taiwan during this period, and the license management system for dentists and physicians was also introduced into Taiwan. Therefore, medical personnel in the role of dentist began to appear in Taiwan. Those medical personnel engaged in dental services must obtain a license issued by the government after formal education and training before they can legally practice.^{1,2} In 1896 (Meiji 29), Dr. Sakai Chiyomatsu applied for permission of the government to open a dental clinic on the main street in Taipei City. He was the first officially licensed dental clinician in Taiwan on record.³ In 1906 (Meiji 39), Taiwan Government Taipei Hospital set up a dental treatment room in the Department of Surgery and appointed Dr. Fuze Zhengmei as the director. This was considered to be the beginning of Taiwanese hospital dentistry.⁴ According to statistics from Taiwan Government at that time, by 1909 (Meiji 42), there were only 4 dentists registered to practice in Taiwan. Of these 4 dentists, 3 worked in the dental clinics and the other one worked in the hospital. By 1942 (Showa 17), the number of dentists had increased to 567; of them, 546 served in the dental clinics, another 12 served in the hospitals, and the remaining 9 served in the public institutions. In addition, according to the information on the website of Taiwan Dental Association, in 1945 (Showa 20), the last year of Japanese colonial period, the number of dentists had increased to 738; of them, 493 were Taiwanese and the remaining 245 were Japanese.

During the Japanese colonial period, the colonial government did not implement a formal schooling of dental education in Taiwan. The increase in the number of dentists in Taiwan was mainly due to the fact that Japanese dentists came to Taiwan for practice, and Taiwanese returned to Taiwan for practice after graduation from the Japanese dental schools.² However, in the early period after the World War II, in 1946, Taiwan Provincial Health Bureau registered medical personnel and issued temporary certificates for dentists and physicians. Because of the evacuation of Japanese and the change of political atmosphere, the number of registered dentists at that time was only 98. However, after more than 70 years of development, by

2019, Taiwan has already had 8 dental schools. According to statistics of the Ministry of Health and Welfare, by 2020, there were 7098 dental institutions in Taiwan, including 6893 dental clinics. The number of dentists increased to 15,429; of them, 13,219 worked in the dental clinics, 2183 worked in the hospitals, and the remaining 27 worked in the western medicine clinics.⁵

Over the past 100 years, the field of dentistry in Taiwan has developed very well although it has experienced a difficult period after the World War II.² However, researches on Taiwan's medical history seldom pay attention to the issues of dentistry. Related studies were only the growth and distribution of the number of dentists. Few studies explored the forms and sub-specialties of Taiwan's modern dental technology during the Japanese colonial period. Based on the interpretation of historical materials, this study analyzed the content of dental services in Taiwan Government Taipei Hospital during the Taisho period, and explored the level of dental technology and the prices of dental services in Taiwan during the Japanese colonial period. The results of this study will be a very important reference for the future study on Taiwan's dental history.

Materials and methods

This study adopted the historical method, used the "Dental Treatment Fees in the 27th Annual Report of Taipei Hospital (Taisho 12)" as the study materials, and referred to Japanese dental textbooks during the Japanese colonial period to determine the contents of various dental treatments. Moreover, we selected corresponding items with the same or similar treatment contents from the 2021 National Health Insurance Fee Schedule and Reference List for Medical Services and the 2020 Taipei City Dental Fee Schedule for Medical Institutions.

In 1923, there were 19 items of dental treatments in Taipei Hospital: dental calculi scaling, rubber filling (gutta-percha or isonandra gutta filling), amalgam filling, cement filling, gold foil filling, porcelain crown, gold crown, platinum crown, gold clasp, porcelain inlay, gold inlay, orthodontics, dental bridge, rubber denture (A), rubber denture (B), gold base denture, cleft palate prosthesis (obturator), gold denture liner, and platinum denture liner (Table 1). Based on the monthly salary of a novice elementary school

Table 1 The cost of dental treatments in Taipei Hospital in 1923 and its proportion in the monthly salary (40 yuan)^a of a novice elementary school teacher.

Items	Treatment name	Treatment fee (yuan)	Proportion to a teacher's monthly salary (%)
1	Dental calculi scaling	1	2.5
2	Rubber filling or gutta-percha (isonandra gutta) filling	0.2–0.5	0.5–1.25
3	Amalgam filling	0.8–1.5	2–3.75
4	Cement filling	0.8–1.5	2–3.75
5	Gold foil filling	2–20	5–50
6	Porcelain crown	6–10	15–25
7	Gold crown	6–10	15–25
8	Platinum crown	18–30	45–75
9	Gold clasp	1–8	2.5–20
10	Porcelain inlay	3–10	7.5–25
11	Gold inlay	2–10	5–25
12	Orthodontics	5–20	12.5–50
13	Dental bridge	12–30 (6–15 for each additional tooth)	30–75
14	Rubber denture (A)	2–5 (1–3 for each additional tooth)	5–12.5
15	Rubber denture (B)	0.5–3 (0.5–2 for each additional tooth)	1.25–7.5
16	Gold base denture	15–20 (5–10 for each additional tooth)	37.5–50
17	Cleft palate prosthesis or obturator	3–10	7.5–25
18	Gold denture liner	2–5	5–12.5
19	Platinum denture liner	6–15	15–37.5

^a According to the 1920 regulations of Taiwan Government, the monthly salary of a novice elementary school teacher was 40 yuan.

teacher in Taiwan in the 1920s and the monthly salary of a today's elementary school teacher, this study further calculated the proportions of various dental treatment fees to the monthly salary of a novice elementary school teacher in order to compare the differences of the prices of various dental treatments between the Japanese colonial period and today.

The historical materials of this study included the Official Gazette of Taiwan Government, the annual report of Taipei Hospital, and Japanese dental textbooks during the Japanese colonial period, which could be searched online from the Taiwan Historica and the National Diet Library. We studied the contents and prices of dental treatment in Taipei Hospital during the Japanese colonial period, which could reconstruct the forms and sub-specialties of Taiwan's modern dental technology during the Japanese colonial period, and could further be used to compare the differences in the contents and prices of dental treatments between the Japanese colonial period and today's Taiwan (year 2021).

Results

The costs of different dental treatments in Taipei Hospital in 1923 and their proportions to the monthly salary of a novice elementary school teacher

In 1923, there were 19 items in the list of dental treatment fees in Taipei Hospital (Table 1). For the oral surgery, treatments such as tooth extraction and intraoral incision and drainage items belonged to surgical treatment items.

The names of surgical treatment items were not included in the annual report of Taipei Hospital. Thus, there was no way to know the charges of oral surgery treatment items. Of the 19 dental treatments, from a today's viewpoint, one belonged to general dentistry (item 1), one root canal treatment (item 2), five dental restorations (items 3, 4, 5, 10, and 11), four fixed dentures (items 6, 7, 8, and 13), seven removable dentures (items 9, 14, 15, 16, 17, 18, and 19), of which items 9, 18, and 19 were accessories for removable dentures (Table 1). In addition, there was one item belonging to orthodontics (item 12). The aforementioned dental treatment items indicate that the types of dental treatments at that time are close to those of today, and the prosthodontics has more treatment items than other dental sub-specialties (Table 1).

For the prices of dental treatments per unit, dental calculi scaling (item 1) was based on the whole mouth as a unit, root canal treatment, dental restorations, and fixed dentures (items 2–8, 10, 11, and 13) were based on a tooth as a unit. Furthermore, removable dentures and orthodontics (items 12, 14, 15, 16, and 17) were based on an arch as a unit. The accessories of removable dentures were based on a set as a unit. A removable denture per arch might have one or more gold clasps. In addition, a removable denture per arch only had one set of gold denture liner or platinum denture liner (Table 1).

According to the 1920 regulations of Taiwan Government, the monthly salary of a novice elementary school teacher was 40 yuan. This study used this as an income benchmark to calculate the proportions of various dental treatment fees to the monthly salary of a novice elementary school teacher at that time. Among them, the price of rubber filling was the lowest one (Table 1). It cost 0.2–0.5

Table 2 The cost of today's corresponding items of dental treatments in Taipei Hospital and its proportion to the monthly salary^a of a today's novice elementary school teacher.

Corresponding items	Treatment name	Treatment fee (NTD)	Proportion to a teacher's monthly salary (%)
1	Full mouth scaling	600	1.39
	Full mouth subgingival curettage (including root planing)	3200	7.42
2	Pulpotomy of a permanent tooth	600	1.39
	Endodontic treatment of a permanent tooth with single root canal	1210	2.81
	Endodontic treatment of a permanent tooth with two root canals	2410	5.59
	Endodontics treatment of a permanent tooth with three root canals	3610	8.37
	Pulpotomy of a primary tooth	800	1.85
	Endodontic treatment of a primary tooth	1010	2.34
	Endodontic treatment of a primary tooth with multiple canals	1690	3.92
3	Amalgam restoration with single surface	450	1.04
	Amalgam restoration with two surfaces	600	1.39
	Amalgam restoration with three surfaces	750	1.74
4	Glass ionomer cement restoration	400	0.93
	Composite resin restoration in anterior teeth with single surface	500	1.16
	Composite resin restoration in anterior teeth with two surfaces	650	1.51
	Composite resin restoration in anterior teeth with three surfaces	1050	2.43
	Composite resin restoration in posterior teeth with single surface	600	1.39
	Composite resin restoration in posterior teeth with two surfaces	800	1.85
	Composite resin restoration in posterior teeth with three surfaces	1000	2.32
5	No corresponding item for gold foil filling	—	—
6	Porcelain fused to metal (PFM) crown	12,000–28,000	27.82–64.91
7	Cast crown	9000–25,000	20.86–57.96
8	Same as corresponding item 7 for platinum crown	—	—
9	No corresponding item for gold clasp	—	—
10	Ceramic inlay	18,000–35,000	41.73–81.14
11	Cast alloy inlay (simple)	8000–18,000	18.55–41.73
	Cast alloy inlay (complex)	18,000–30,000	41.73–69.55
12	Single arch removable orthodontic appliance (general)	30,000	69.55
	Two-arch removable orthodontic appliance (difficult)	60,000	139.10
	Single arch fixed orthodontic appliance (general)	50,000	115.92
	Single arch fixed orthodontic appliance (difficult)	100,000	231.83
	Single arch fixed orthodontic appliance (highly difficult)	150,000	347.75
	Two-arch fixed orthodontic appliance (general)	100,000	231.83
	Two-arch fixed orthodontic appliance (difficult)	150,000	347.75
	Two-arch fixed orthodontic appliance (highly difficult)	200,000	463.66
13	Porcelain fused to metal (PFM) bridge and cast bridge	Calculated	—
	Same as corresponding items 6-8	based on the number of teeth	
14	Single arch unilateral alloy removable partial denture	20,000–28,000	46.37–64.91
	Single arch bilateral alloy removable partial denture	40,000–70,000	92.73–162.28
	Single arch complete denture	50,000–80,000	115.92–185.46
	Two-arch complete denture	100,000–160,000	231.83–370.93
15	Single arch unilateral temporary partial denture	6000–10,000	13.91–23.18
	Single arch bilateral temporary partial denture	10,000–18,000	23.18–41.73
	Single arch temporary complete denture	20,000–25,000	46.73–57.96
	Two-arch temporary complete denture	40,000–50,000	92.73–115.92
16	Same as corresponding item 14 for gold base denture	—	—
17	Temporary obturator (including speech aid)	25,000–40,000	57.96–92.73
	Permanent obturator (including speech aid)	60,000–120,000	139.10–278.20

(continued on next page)

Table 2 (continued)

Corresponding items	Treatment name	Treatment fee (NTD)	Proportion to a teacher's monthly salary (%)
18	Single arch denture relining (chair side processing)	7000~12,000	16.23–27.82
	Single arch denture relining (laboratory processing)	7500–10,000	17.39–23.18
19	Same as corresponding item 18 for platinum denture liner	—	—

^a According to the 2018 regulations of Ministry of Education, the monthly salary of a new full-time teacher in the public elementary or high school was 43135 NTD.

yuan for treatment of a tooth, which was only 0.5–1.25% of the monthly salary of a novice elementary school teacher at that time. The charges for amalgam filling and cement filling were relatively low, and they cost 0.8–1.5 yuan (2–3.75%) for filling a tooth. The full-mouth dental calculi scaling was 1 yuan (2.5%). In addition, gold foil filling for a tooth needed 2–20 yuan (5–50%), and the cost range was very large due to the various cavity sizes and the amount of gold foils used. Among the three types of crowns, porcelain crown and gold crown charged 6–10 yuan (15–25%) per tooth, while platinum crown was 18–30 yuan (45–75%) per tooth. The most basic dental bridge composed of 2 crowns needed 12–30 yuan (30–75%), and the dental bridge composed of 3 crowns required 18–45 yuan (45–112.5%). Among the two types of inlay, porcelain inlay cost 3–10 yuan (7.5–25%) per tooth, while gold inlay charged 2–10 yuan (5–25%) per tooth. An orthodontic device per arch (regardless of removable or fixed ones) required 5–20 yuan (12.5–50%). For the three types of denture, taking a complete denture with 14 teeth per arch as an example, a rubber denture (A) required 16–47 yuan (40–117.5%), a gold-liner denture cost 18–52 yuan (45–130%), and a platinum-liner denture needed 22–62 yuan (55–155%). Moreover, a rubber denture (B) required 7.5–31 yuan (18.75–77.5%) and a gold-base denture needed 85–160 yuan (212.5–400%) (Table 1). Furthermore, the above-mentioned two-arch complete dentures cost a double price.

In addition, taking a partial denture with 7 teeth per arch as an example, a rubber denture (A) required 9–26 yuan (22.5–65%) and a partial denture with two gold clasps cost 11–42 yuan (27.5–105%). A rubber denture (B) needed 4–17 yuan (10–42.5%) and a gold-base partial denture required 50–90 yuan (125–225%). Moreover, a cleft palate prosthesis (obturator) cost 3–10 yuan (7.5–25%) (Table 1).

The costs of corresponding items of dental treatments in today's Taiwan and their proportions to the monthly salary of a today's novice elementary school teacher

For 19 dental treatments in Taipei Hospital in 1923, this study searched for the costs of corresponding items with the same or similar treatment contents from the 2021 latest "National Health Insurance Fee Schedule and Reference List for Medical Services" and "Taipei City Dental Fee Schedule for Medical Institutions". Of the 19 corresponding items, 4 had the same or similar items in the current health

insurance dental treatment items (corresponding items 1–4), and 13 had the same or similar items in the current self-payment treatment items (corresponding items 6–8 and 10–19). Items 5 and 9 had no corresponding items (Table 2). Today, denture clasp was not an independent dental treatment, and almost no dentist used gold foils to fill a tooth cavity. In addition, the material for denture relining was mainly the acrylic resin. However, today's denture relining was one of the methods for denture repair. Therefore, almost no dentist made gold-liner denture and platinum-liner denture.

For the prices of various dental treatments per unit, full mouth scaling or full mouth subgingival curettage (corresponding item 1) was based on the whole mouth as a unit, pulpotomy or endodontic treatment, dental restorations, and fixed dentures (corresponding items 2, 3, 4, 6, 7, 8, 10, 11, and 13) were based on a tooth as a unit. Moreover, removable dentures and orthodontic treatments (corresponding items 12, 14, 15, 16, and 17) were based on an arch as a unit.

According to the 2018 regulations of Ministry of Education, the monthly salary for a new full-time teacher in the public elementary or high school was 43,135 NTD (22,435 for the monthly salary and 20,700 for the academic research). This study used this as an income benchmark to calculate the proportions of various dental treatment fees to the monthly salary of a today's elementary school teacher. Among them, the cost for a glass ionomer cement restoration was the lowest one, which was 400 NTD for a tooth and was equal to 0.93% of the monthly salary of a novice elementary school teacher (Table 2). The charges for amalgam and composite resin restorations were also relatively low, and they cost 450–750 NTD (1.04–1.74%) and 500–1050 NTD (1.16–2.43%) to fill a tooth, respectively. Moreover, full mouth ultrasonic scaling and subgingival curettage (including root planing) cost 600 NTD (1.39%) and 3200 NTD (7.42%), respectively (Table 2). In addition, pulpotomy or endodontic treatments of a permanent tooth cost 600–3610 NTD (1.39–8.37%), while the pulpotomy or endodontic treatments of a primary tooth cost 800–1690 NTD (1.85–3.92%). Of the two types of crown, porcelain fused to metal (PFM) crown was 12,000–28,000 NTD (27.82–64.91%) per tooth, and cast crown was 9000–25,000 NTD (20.86–57.96%) per tooth (Table 2). The price difference was mainly related to the type and amount of metal used, while the price of PFM bridge and cast bridge were calculated based on the number of crowns. For the two types of inlay, ceramic inlay was 18,000–35,000 NTD (41.73–81.14%) per tooth, and cast

alloy inlay was 8000–30,000 NTD (18.55–69.55%) per tooth. The price difference is mainly related to the type and amount of metal used as well as their technical difficulties (Table 2). A removable orthodontic appliance per arch cost 30,000–60,000 NTD (69.55–139.10%), while a full mouth two-arch fixed orthodontic appliance cost 100,000–200,000 NTD (231.83–463.66%). The price difference was mainly related to the technical difficulties (Table 2). In addition, one arch fixed orthodontic appliance was rarely used in today's dental practice.

Today's dentures were divided into two categories: permanent and temporary dentures. A one-arch permanent complete denture cost 50,000–80,000 NTD (115.92–185.46%), and a one-arch temporary complete denture cost 20,000–25,000 NTD (46.73–57.96%) (Table 2). If the above-mentioned dentures were two-arch complete dentures, their prices were double. In addition, a single arch unilateral alloy removable partial denture required 20,000–28,000 NTD (46.37–64.91%), and a bilateral one required 40,000–70,000 NTD (92.73–162.28%). However, a single arch unilateral temporary partial denture needed 6000–10,000 NTD (13.91–23.18%), and a bilateral one needed 10,000–18,000 NTD (23.18–41.73%) (Table 2). Today's obturators were divided into temporary and permanent ones. A temporary obturator (including speech aid) required 25,000–40,000 NTD (57.96–92.73%), and a permanent obturator (including speech aid) cost 60,000–120,000 NTD (139.10–278.20%). Furthermore, the denture relining was a kind of denture repair method which required 7000–12,000 NTD (16.23–27.82%) for chair side processing and 7500–10,000 NTD (17.39–23.18%) for laboratory processing (Table 2).

The differences in the prices of various dental treatments between the Japanese colonial period and today

From the Japanese colonial period to today, Taiwan's dental technology has been developed for more than a hundred years. Although there might be great differences between the two different periods, this study attempted to find today's dental treatments that were the same as or similar to the dental treatments in Taipei Hospital during the Japanese colonial period. We used the proportions of their prices to a novice elementary school teacher's monthly salary of the same period as a way to compare the differences in dental treatment fees between the two different periods (Tables 1 and 2). Among 19 dental treatment items in Taipei Hospital, denture clasp was not an independent treatment item in today's dental treatment classification, and gold foil filling was hardly performed by dentists today. There were 4 items that had the same or similar corresponding items in the current health insurance dental treatment items. Comparing the costs for dental calculi scaling, amalgam filling, and cement filling in the Japanese colonial period to those for the modern counterparts (full mouth ultrasonic scaling, amalgam restoration, and glass ionomer cement and composite resin restorations), their prices decreased (Tables 1 and 2). In particular, the price difference between cement filling and

glass ionomer cement restoration was the largest. In addition, comparing the cost for the rubber filling to those of modern counterparts (pulpotomy or endodontic treatment), their prices increased (Tables 1 and 2). However, the items of today's endodontic treatment were more detailed.

The other 13 items had the same or similar corresponding items in the current self-payment dental treatment items. However, gold denture liner and platinum denture liner were the accessory parts of removable dentures, which were different in meaning from today's denture relining (a kind of denture repair method). In terms of crown, comparing the costs of porcelain crown and gold crown in the Japanese colonial period to those of modern counterparts (PFM crown and cast crown), their prices increased (Tables 1 and 2). However, the price of platinum crown was not lower than that of today's cast crown. In terms of inlay, comparing the costs of porcelain inlay and gold inlay to those of the modern counterparts (ceramic inlay and cast alloy inlay), their prices also increased (Tables 1 and 2). During the Japanese colonial period, the orthodontic device per arch (regardless of removable or fixed ones) required up to 50% of a novice elementary school teacher's monthly salary. However, in today's Taiwan, the simplest single-arch removable orthodontic appliance required 70% of a novice elementary school teacher's monthly salary, and the most difficult two-arch fixed orthodontic appliance cost more than 4-fold a novice elementary school teacher's monthly salary, indicating that the price has increased a lot (Tables 1 and 2). In terms of complete denture, the price of rubber denture (A) without gold or platinum denture base was relatively lower than that of today's permanent denture. However, the price of rubber denture (A) with gold or platinum base was close to that of today's permanent denture. The price of rubber denture (B) was not much different from that of today's temporary denture. Finally, in terms of obturator, comparing the cost of cleft palate prosthesis to that of today's obturator, the price increased a lot (Tables 1 and 2).

Discussion

In the past, researches on Taiwan's medical history rarely involved the issues of dentistry, and there was no study related to what extent of the level of dental technology in Taiwan during the Japanese colonial period or what dental treatment items that the dentists could provide to the patients at that time. In fact, historical materials that systematically present Taiwan's dental and medical technologies during the Japanese colonial period may not exist,⁶ because the dentists in Taiwan during the Japanese colonial period were mainly Japanese dentists who came to Taiwan for practice and Taiwanese dentists who graduated from Japanese dental schools and then came back to Taiwan for practice.² Perhaps we could also use the Japanese dental textbooks (published around 1890–1920) during the Japanese colonial period and discovered the learning content of dental students at that time to infer what dental technology was available in Taiwan at that time. Even so, it was still not clear what dental treatment items the dentists in Taiwan could provide to the patients at that time. Fortunately, the annual report of Taipei

Hospital recorded dental treatment fees, which gave us the opportunity to determine what dental treatment items were available in Taiwan during the Japanese colonial period.⁴ Therefore, we could explore the content and prices of dental treatments at that time, and further compared the difference from today's corresponding items. In addition, Taipei Hospital was the most advanced modern hospital in East Asia at that time, so it could be inferred that its dental treatments should be the most complete in Taiwan at that time. Taipei Hospital published an annual report every year. There was a total of 40 annual reports, which recorded hospital deeds from 1897 to 1936. In fact, each annual report contained detailed statistics on related deeds. It was a precious historical material for studying the development of National Taiwan University Hospital and Taiwan's medical history.¹ It was also very important for studying the Taiwan's dental history.

According to Taiwan's dentist-related laws and regulations, as early as 1918 (Taisho 7), Taiwan Dentist Order stipulated the names of the dental specialties. At that time, there were 11 dental specialties: Operative Dentistry, Alveolar Dentistry, Oral Surgery, Dental Extraction, Prosthodontics, Fixed Prosthodontics, Jaw Prosthodontics, Oral Palate Prosthodontics, Orthodontics, X-ray, and Pediatric Dentistry.⁶ In fact, according to the content of dental treatments in Taipei Hospital, its dental specialties were comparable to the above-mentioned dental specialties, and these specialties were also close to today's dental specialties. Among them, the dental treatment items objectively belonged to the treatment items of today's general dentistry, operative dentistry, endodontics, prosthodontics, and orthodontics. In addition, in the relevant statistics of Taipei Hospital in 1923 (Taisho 12), the list of disease names of dental patients included 53 oral and dental diseases.⁴ It could be inferred that the dentists of Taipei Hospital had the professional ability for oral pathology and diagnosis. Among their diagnoses for dental outpatients, there were dental trauma, impaction, cleft lip and cleft palate, acute periodontitis, chronic periodontitis, suppurative periodontitis, prolonged retention of deciduous tooth, amelogenesis imperfecta, malalignment, and supernumerary tooth.⁴ In addition, they also had a record for treating 3 inpatients, indicating that the dentists of Taipei Hospital also have the professional ability to operate oral surgery, periodontics, and pediatric dentistry.

Furthermore, at the end of 1895, Wilhelm Conrad Röntgen discovered X-ray. Moreover, two weeks after the publication of Röntgen's discovery, the German dentist Otto Walkhoff acquired a radiograph of his own teeth with the help of Fritz Giesel in 1896. The use of X-ray for medical photographs spread worldwide from 1896. Then, the first dental X-ray machines were manufactured in Germany by the company now known as Siemens in 1905.⁷⁻⁹ However, from 1906 when Taipei Hospital set up a dental treatment room in the Department of Surgery to 1923, Taipei Hospital had 18-year experience in performing dental treatments. In addition, Taiwan's dentist-related laws and regulations at that time also listed the dental radiography as one of the dental specialties. Therefore, we believe that the Department of Dentistry of Taipei Hospital at that time probably already had dental X-ray machines, as well as the dentists of Taipei Hospital

also had the professional ability to operate dental X-ray machines and to use the dental radiography for diagnosis of the jawbone diseases.

In 1923, there were 3 dentists in the Department of Dentistry of Taipei Hospital, and there were 4511 dental outpatient visits in the same year.⁴ Therefore, in 1923, the average annual outpatient visits per dentist in Taipei Hospital were 1504 (4511/3). However, in 2019, there were 140 dentists in the Department of Dentistry of National Taiwan University Hospital, and there were 144,730 dental outpatient visits in the same year.¹⁰ Therefore, in 2019, the average annual outpatient visits per dentist in National Taiwan University Hospital were 1034 (144,730/140). In addition, there were 15,127 dentists in Taiwan in 2019, and there were 35.13 million health insurance dental outpatient visits in the same year.¹¹ Therefore, the average annual health insurance outpatient visits per dentist in Taiwan were 2322 (35.13 million/15,127) in 2019. It could be seen that the outpatient workload of dentists in Taipei Hospital during the Japanese colonial period was not less than that of dentists in today's National Taiwan University Hospital. In fact, the treatments required for all types of oral and dental diseases that appeared in Taipei Hospital in 1923 also covered all dental treatment items of Taipei Hospital at that time. With only 3 dentists having to complete all dental outpatient visits, we believe that the dentists of Taipei Hospital at that time were general practitioners with all professional capabilities of dental specialties. In addition, they sorted out 53 dental diseases from 4511 dental outpatient visits, which could also confirm that they also had the professional ability for oral pathology and differential diagnosis.

Based on the dental treatments of Taipei Hospital, we could find the development of dental technology in Taiwan during the Japanese colonial period. According to Japanese dental textbooks before the 1920s, there were hand instruments for dental calculi scaling. However, there were also different kinds of hand instruments for removal of supragingival and subgingival calculi. In fact, ultrasonic instruments (or machines) only began in the 1950s,¹² so it could be determined that dental calculi scaling was only performed by hand instruments at that time. However, the subgingival calculi also had another name, so-called the blood stone. Therefore, we speculated that the dental calculi scaling at that time might mainly achieve to remove the supragingival calculi. In addition, the earlier surgical textbooks also had the record of using hand instruments for dental calculi scaling, suggesting that earlier surgery also deals with dental problems.

According to Japanese dental textbooks before the 1920s, there was gutta percha as the intracanal filling material for endodontic treatment. Therefore, the rubber filling in the dental treatment items of Taipei Hospital should be the current endodontic treatment. In fact, the gutta percha was introduced in 1842 to the profession, by Dr. William Montgomerie, a surgeon in the British army in the Indies. In 1867, Bowman used gutta percha for the first time to obturate tooth root canals. Then, commercial manufacture of gutta percha points in dentistry was done by SS White in 1887.¹³⁻¹⁶ At that time, the Department of Dentistry of Taipei Hospital probably used gutta percha points for endodontic treatment.

In 1826, the first amalgam restoration was performed by August Taveau, of Paris, who mixed shavings from French five-franc pieces with mercury. In 1855, cohesive gold foil was discovered by Robert Arthur. This was a major advancement in dentistry.¹⁷ Doubtlessly, in the 1920s, Taiwan also had the dental techniques for amalgam and gold foil restorations. The operation technique of amalgam restoration is simple, and this material is also inexpensive. Thus, amalgam is still used in today's Taiwan, and is also one of the dental treatment items of Taiwan Health Insurance. However, the operation technique of gold foil restoration is relatively complicated, and gold material is very expensive. With the advancement of filling materials, gold foil has been almost completely replaced by other filling materials. Currently, there is no such item in the dental treatment projects officially announced in Taiwan.

In addition, there are some significant events in the history of operative dentistry. Zinc oxychloride cement was introduced as a filling material and a cement in 1860. In 1897, zinc phosphate cement was introduced by Otto Hoffman in dentistry. Zinc phosphate represented an improvement over zinc oxychloride and was used as a filling material and a cement. In 1908, silicate cement was introduced in the United States, although earlier, cruder forms were used in Europe in the late 1800s. It was the first direct semi-esthetic filling material, and remained in widespread use in the 1960s and early 1970s. Then, in 1960, composite resin was introduced to dentistry, and replaced silicate cement as the primary direct esthetic filling material. In 1972, glass ionomer cement was first described by Wilson and Kent in dentistry.¹⁷ Therefore, in the 1920s, the material used for cement filling in the Department of Dentistry of Taipei Hospital was probably zinc phosphate cement or silicate cement, which was considered to be a relatively new dental technique at the time. Now these two materials are no longer used as formal filling materials. However, the cement filling in the Japanese colonial period was similar to the current glass ionomer cement and composite resin restorations.

Furthermore, in 1839, Charles Goodyear discovered a method of producing a mixture of sulfur with caoutchouc (natural rubber or india rubber) to form a material with greater flexibility. A harder rubber or known as vulcanized rubber was invented by Charles' brother, Nelson Goodyear in 1851. It was further developed and introduced as a denture base material in 1855. However, the acrylic resin was first introduced in mid 1940s, commonly used as a denture base material for removable prostheses fabrication due to its favorable working characteristic, excellent aesthetics, adequate physical and mechanical properties, and inexpensive cost. Then, it replaced vulcanized rubber as the denture base material.¹⁸ Therefore, in the 1920s, the material used for making the partial denture or complete denture (so-called rubber denture) in Taipei Hospital was india rubber. At that time, in order to avoid the irritation of rubber and improve the ease of cleaning for denture tissue side, there were techniques to add gold denture liner or platinum denture liner to repair the dentures, but these techniques and practices have been eliminated as time goes on.

From the Japanese colonial period to today, Taiwan's dental technology has been developed for more than a

hundred years. Compared with the dental treatments in Taipei Hospital during the Japanese colonial period, today's dental treatments are divided into more detailed items, indicating that Taiwan's dental technology has a great progress. Among the comparable dental treatment items between the Japanese colonial period and today, the prices of general treatments such as scaling and operative dentistry (amalgam restoration, glass ionomer cement and composite resin restorations) have shown a decline. Although the price of endodontic treatment has increased slightly due to technical difficulties, the above items are currently covered by health insurance in Taiwan. It is convenient and unburdened for current Taiwanese people to receive general dental treatments such as those in general dentistry, operative dentistry, endodontics, periodontics, and oral surgery (including outpatient surgery and surgical room surgery). On the other hand, the prices of treatments related to prosthodontics and orthodontics that are not covered by health insurance have shown an increase. In particular, the price of treatments in orthodontics has increased the most. The price of difficult orthodontic devices exceeds the monthly salary of a novice elementary school teacher by 4 times or more. Nowadays, Taiwanese people have a lot more burdens in receiving self-payment dental treatments such as those in prosthodontics, orthodontics, and non-health insurance items in operative dentistry, endodontics, and periodontics. In addition, the cleft palate is now mostly treated by surgery and the effect and prognosis are also good. Therefore, few dentists in Taiwan now construct obturators for the patients with cleft palate.

Taking the living expenses of a Japanese civil servant family (4 people with husband, wife, and 2 children) with a monthly income of 80 yuan in 1916 as an example, of the monthly expenditure, 3.6 yuan was used for housing, 1 yuan for entertainment, and 1 yuan for medical expense and reserve.¹⁹ This comparison indicates that it is very expensive to receive dental treatments in Taipei Hospital at that time, especially for prosthetic and orthodontic treatments. For example, a set of 3 teeth bridge cost 18–45 yuan. At that time, it was equivalent to 22.5–56.25% of the official family monthly income, which was not affordable by the ordinary people.

This study explored the dental treatment items and the cost for each item in Taipei Hospital during the Japanese colonial period, and compared them with today's corresponding dental treatments and costs. We conclude that the technology of dental treatments in Taiwan during the Japanese colonial period already have had the forms of the modern dentistry with several dental specialties. Moreover, the costs of dental treatments at that time are quite expensive. After a century of development, dental treatment items are more detailed and diverse. The health insurance system provides current Taiwanese people with convenient and cheap general dental treatments such as scaling and treatments related to operative dentistry, endodontics, periodontics, and oral surgery. However, the prosthodontic and orthodontic treatments have to be paid by the patients themselves and are more expensive than similar dental treatments in Taipei Hospital during the Japanese colonial period.

Declaration of competing interest

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

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