

Retrospective Analysis of Common Failures and Maintenance Strategies of Dental Units

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Abstract: The dental unit integrates multiple parts, including waterway, positive pressure airway, negative pressure airway, waste water discharge pipeline, and control circuit, and some optional functions are assembled by third-party accessories, resulting in a higher failure rate. The purpose of this article is to conduct a retrospective analysis of common faults of dental units, explore potential problems behind the dental units, and propose maintenance strategies for the stability and reliability of dental units, in order to reduce the failure rate and occurrence of human-induced faults. The results indicate that through retrospective analysis of common faults of dental units and targeted inspection and maintenance strategies, equipment failure rate has been effectively reduced, ensuring the safety and efficiency of oral medical work. These measures can also provide useful experience and reference for peers.

1. Introduction

With the popularization of people's awareness of oral health and the increasingly prominent global oral health issues, the demand for oral medical services is constantly increasing. More and more patients need to seek treatment and care from dentists, which also puts higher demands on doctors and diagnostic equipment [1-3]. However, the structure of the device is complex, including multiple components such as water, gas, and electrical circuits. Some optional components are assembled, and the number of hospital configurations is large. With the increase of service life, high failure rate has become an unavoidable problem. Once a malfunction occurs, it will directly affect clinical diagnosis and treatment work, and even cause safety accidents [4-5]. Through a retrospective analysis of the common causes of malfunctions in dental units, this article proposes targeted inspection and maintenance strategies, effectively reducing equipment failure rates, ensuring clinical safety diagnosis and treatment to provide reference for further improving medical quality.

2. Basic structure of dental unit

The overall structure includes a treatment bed, treatment table, assistant position instrument bracket, dental lamp, control pedal, and independent water supply system [4]. A treatment bed is a reclining chair that can freely adjust its orientation, providing a comfortable treatment environment for patients; The treatment table provides a table top and instrument bracket that can be placed during treatment. The instrument bracket includes high-speed handpieces receiver, low-speed handpieces receiver, three-purpose spray gun receiver, and optional dental cleaning receiver to meet

different treatment needs. The assistant position instrument bracket includes a salivation device, an air-water syringe nozzle, and an optional UV curing lamp; The salivation device provides negative pressure function, divided into strong suction and weak suction, which can suck blood, saliva, and water sprayed by treatment equipment in the dental cavity during the surgical process. The controllable foot pedal can control the operation of the handpieces and the switch of the cooling water. A dental lamp is a necessary lighting device for observing dental conditions, while an independent water supply system can provide cooling water for the use of air-water syringe and dental equipment. The mutual cooperation of the above parts constitutes a complete dental unit and provides solid support for patients' oral treatment.

3. Fault analysis

The hospital has 26 dental comprehensive treatment units with the model A-dec 200, which have been in use for about 5-10 years and have encountered many problems. Maintenance data from the repair system was downloaded and collected for a total of 12 months from September 1, 2021 to August 30, 2022, as shown in Table 1. A total of 362 repairs were reported, including 174 urgent repairs, with an urgent rate of 57%. The expedited repair rate is high, mainly focusing on issues such as dental cavity lamps, suction of salivation devices, leakage of high-speed and low-speed handpieces, leakage of spray guns, and inability to lift the treatment bed.

Table 1: Failure statistical table of dental unit

Serial number	fault type	Number of repairs reported	Repair rate (%)
1	The dental lamp does not light up	65	18
2	Heavy shadow of dental lamp	7	1.9
3	Dental lamp sliding	5	1.4
4	Treatment bed lifting	22	6.1
5	Operating table tilted	8	2.2
6	Sliding operation table	12	3.3
7	Low speed handpieces has a slow speed	16	4.4
8	Low speed handpieces do not rotate	21	5.8
9	Fast machine grinding cannot move	27	7.5
10	handpieces not coming out of water	20	5.5
11	Water leakage at the hand interface	32	8.8
12	Cracked handpieces skin tube	12	3.3
13	The spray rod of the air-water syringe can fly	19	5.2
14	Triple gun rebound	19	5.2
15	Sucking saliva without suction	51	14.1
16	Aspiration tube fissure	9	2.5
17	Weak or no vibration of the dental cleaning machine	5	1.4
18	The dental cleaner does not come out of water	3	0.8
19	Button malfunction	5	1.4
20	Loose headrest	4	1.1

3.1 Failure of the dental cavity lamp to light up

(1) To check if the pressure of the barometer is greater than 4.0Kpa. If the total intake pressure is lower than this value due to the use of multiple dental units, or if the water bottle is not tightened, resulting in air leakage, the total intake pressure is too low, causing the pneumatic switch to be unable to conduct and the power module to be powered off.

(2) To check if the light bulb is damaged or if the pins on the lamp base are carbonized, resulting in poor contact;

(3) To check whether the voltage of the light control panel on the ground box is normal, whether the plug wires are in good contact, and whether the circuit breaker of the power module control light panel is tripped. Due to the high power of the lamp, it is easy to carbonize at the wiring point. It is recommended to replace the base plate, plug socket, and cable if it was obviously carbonized;

(4) To check if the air compressor filter and pressure reducing valve are leaking. As the noise during the operation of the air compressor can mask the sound of leakage, it is necessary to wait until the dental unit in the clinic is stopped before checking.

The phenomenon of light failure often occurs in the early stage, mainly due to unstable air supply. When the pressure is below 4.0Kpa, the pneumatic switch cannot be connected, and the power module cannot connect to 220V mains power; To consider increasing the number of air compressors, improving the stability of gas supply, and replacing pneumatic electric switches with lower pressure values to ensure that the dental treatment device can still operate normally under low pressure conditions.

3.2 Abnormal suction of salivation device

(1) If the salivation devices of multiple dental units fail, it is highly likely that the negative pressure machine in the machine room has malfunctioned. It is necessary to check whether the negative pressure machine has tripped and whether the control motherboard fuse has blown.

(2) If the strong suction saliva suction is normal but the weak suction saliva suction device suction cannot be normal, it is possible that the internal pipeline of the weak suction saliva is blocked. To check the screen of the solid collector and clean it, then start the strong suction saliva device to activate the operation of the negative pressure machine and use a toothpick to poke the outlet of the small suction piece a few times, and the blockage in the pipeline would be discharged by the negative pressure.

Before leaving work every day, use a saliva drainage device to suck disinfectant and rinse the pipeline, as well as remove debris such as broken teeth or cotton from the solid collector, to prevent blood clotting or foreign objects inside the pipeline from causing blockage.

3.3 Treatment bed cannot be raised or lowered or the back cannot be adjusted

(1) Trigger limit switch: In order to protect the safety of patients and their medical staff, the dental unit is equipped with limit switches, which are located below the dental chair, below the spittoon, and on the back of the treatment table. The problem usually occurs under the dental chair and under the spittoon, and special attention should be paid to investigation. For example, the limit switch under the dental chair mainly displays when it drives the roller to rotate when the dental chair rises, and when it rises to a certain extent, it will trigger the switch to close, causing it to be unable to rise. When the switch shifts, it may cause it to be unable to rise.

(2) Battery valve failure: There are four battery valves under the hydraulic system that control the downward and upward movement of the dental chair, as well as the upward and downward movement of the back. There are also cases where the valve cannot be lifted or lowered due to touching the battery valve. At this time, check if the resistance value of the wiring is around 1.2K Ω . If the resistance value is abnormally high, it can be judged as damaged.

3.4 Slow handpieces speed

- (1) The driving gas of the handpieces is not adjusted to the appropriate pressure;
- (2) If it is an independent water supply system, check if the threads of the water bottle are twisted, causing air leakage from the edge of its threaded port and causing insufficient air pressure.

3.5 Water and air leaks from the syringe

(1) Normally, the water and gas supply button is frequently pressed, and the internal rebound relies on the spring. Prolonged use can cause the spring to lose its rebound performance, leading to water and air leakage. It is necessary to clean the internal stains and replace the spring.

(2) The frequent insertion and removal of the nozzle causes damage to the internal O-ring, resulting in water and air leakage.

Maintenance strategy: Regularly check for water leaks and replace the diaphragm and spring.

4. Maintenance strategy

It could be found that in addition to the above issues, there are also many potential problems. Medical staff have strong adaptability and only report for repairs when they are completely unusable. For instruments in a "sub healthy" state, some medical staff choose to adapt, while others, who lack experience, fail to detect the problem. Due to the fact that many functions of the dental unit are assembled through the use of additional third-party accessories, even experienced medical staff do not know how to use many detailed functions, such as the cooling water, cooling air, dental cleaning water hidden under the treatment table, and the power adjustment of low-speed handpieces. Therefore, medical engineering personnel with professional knowledge are needed to delve into the clinical front-line beyond maintenance, identify and solve these problems for clinical departments, and ensure that the dental unit is always in optimal working condition. The maintenance strategy of the dental unit mainly includes three parts: appearance maintenance, functional testing, and air source maintenance.

4.1 Appearance maintenance

- (1) Check if the cooling water and cooling cyclone buttons are missing;
- (2) Check if the head rest of the treatment table is loose;
- (3) Check if the instrument tray is twisted;
- (4) Check if the fast and low speed handpieces receiver skin is broken;
- (5) Check for aging or loss of dental handpieces connector film;
- (6) Check if the instrument bracket is uneven.

Due to the unreasonable design of the instrument itself or the confusion of the functions of third-party components assembled under the table, such as dental cleaning water, dental cleaning power, and low-speed handpieces power adjustment knob. Therefore, the addition will be attached next to the knob, identifying the corresponding functions, and providing training for medical staff.

4.2 Functional testing

4.2.1 Handpieces power test

Dental handpieces are divided into dental high-speed handpieces and dental low-speed handpieces. Their working principle is to use compressed air as the power to drive the wind wheel to rotate at high speed, thereby driving the dental needle to complete tasks such as drilling and grinding the tooth body ^[7]. The speed of high-speed handpieces is generally above 300000

revolutions per minute, while the speed of low-speed handpieces is generally between 22000 and 25000 revolutions per minute [8]. Insert the air pressure measuring device between the handpieces hose and the high-speed or low-speed handpieces, step on the control pedal, test the output driving air pressure value, and adjust the driving pressure of the handpieces to the pressure value shown in Table 2 through the compressed air adjustment screw below the instrument panel, so that the handpieces speed meets the expected requirements. The test diagram is shown in Figure 1.

Table 2: The rotational speed and corresponding pressure values of handpieces

Handpieces type	Speed range/RPM	Pressure value/M Pa
High speed handpieces	300000 - 500000	0.26-0.29
Low speed handpieces	18000-25000	0.20-0.25



Figure 1: Pressure testing of hand pieces

4.2.2 Simulated treatment position dental handpieces leakage test

When the handpieces and the receiver are not bent, there may not be water leakage. However, due to the bending of the handpieces when the doctor is treating patients, the angle joint is prone to stress and water leakage. Therefore, it is necessary to simulate the low hand position of the patient and conduct a water leakage test on the handpieces, as shown in Figure 2.

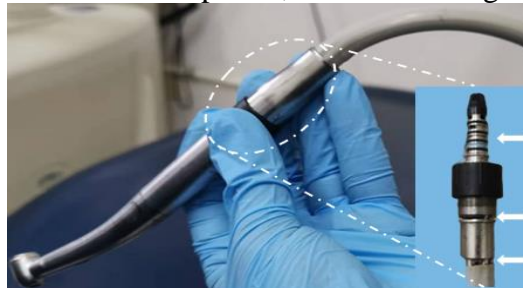


Figure 2: Leakage test and leakage point at low handpieces position

4.2.3 Handpieces cooling water and gas testing

The cooling water and cooling air knob was adjusted to test whether they are normal, and adjust them to the optimal working state to ensure that the water vapor emitted by the handpieces is uniform.

4.2.4 Functional testing of air-water syringe cleaning machines

- ① The button rebounds well, water and air should be clearly distinguished, and water should not be mixed with the air jet. When both buttons are pressed at the same time, the sprayed water vapor is a mist;
- ② The test of the power and water regulation function of the dental cleaning machine.

4.2.5 Dental Lamp Test

① Light test: The weak range is 8000lx~15000lx, and the strong range is greater than or equal to 15000lx. If it does not meet the standard, the halogen light bulb needs to be replaced [6];

② Focal length test: Set the focal length to about 60cm from the head position, which can provide doctors with a clear therapeutic field of view. If the focal length is set too far, the light range will be large and scattered, which will produce shadows and need to be adjusted;

③ Lamp stability test: To move the lamp position without significant deviation, if it does not meet the standard, adjust the corresponding damping screw.

In summary, the overall maintenance report of the dental treatment table is listed as shown in Figure 3.

Maintenance report form for dental units

1. Equipment Basic Information						
Department used				Room number		
Equipment Bar Code				Model Specification		
Department date				/		
2. Appearance Inspection						
Inspection and maintenance content				Inspection and maintenance results (1)Qualified (2)Restoration (3) To be repaired		
Appearance and Accessories	Is the treatment table holster broken					
	Is the instrument tray crooked					
	Does the instrument tray slide					
	Is the cooling water, cooling gas knob missing					
3. Function Check						
Fast Machine	Cell phone serial number	Appearance		Functional Testing		
		Missing diaphragm	Pipeline skin broken	Cooling water, cooling gas regulation	Simulation test location (water leakage)	Pressure level (0.22-0.3 Mpa)
	Phone1					
	Phone2					
	Phone3					
Slow Machine	Appearance		Functional Testing			
	Missing diaphragm	Pipeline skin broken	Cooling water, cooling gas regulation	Power regulation	Simulation test location (water leakage)	Pressure level (0.2-0.3 Mpa)
Triple use guns	Does the nozzle come loose			Is the key normal		
Tooth cleaning machine	Water regulation			Power Regulation		
	Focal length test					
Oral Light	Focal length		Stability		Light test	
Instruments Status	1. Normal 2. Part of it is problematic, and can be used 3. Fault, further repair required					
Remarks						
Maintenance staff				Date of inspection		
Section sign-off				Completion Date		

Figure 3: Maintenance report form for dental units

4.3 Air source maintenance

The air compressor and negative pressure machine are the most basic conditions for ensuring the

normal operation of the dental unit. The internal of the dental unit is controlled by a pneumatic switch to start the treatment table. Once the pressure decreases or causes the equipment to automatically shut down, if it is not maintained for a long time, it may cause the entire dental department to stop. In retrospect, there were many cases in the early stage where the dental cavity lights did not light up, mostly due to the air source. The main reason was that the air compressor was not properly maintained in a timely manner. Therefore, timely maintenance of the air source can be carried out according to Table 3.

Table 3: Inspection items for air compressors and vacuum pumps in the equipment room

project	cycle	Inspection items
machine room	everyday	Operating temperature and humidity 1-25 °C
Air compressor	everyday	① Check the output pressure of the air compressor, 6.5-7.5 BAR
		② Check for air leakage in the air compressor
		③ Discharge internal water
Negative compressor	weekly	Check operation and clean the filter

Checking the operating temperature and humidity of the computer room to ensure that the temperature and humidity in the room are consistent with those in the treatment room, which can reduce condensation water in the pipeline and ensure the smooth operation of the air compressor and negative pressure machine. Due to the fact that the air source is built together by multiple air compressors, the continuous operation of the air compressor may be caused by the leakage of the filter screen or pressure regulating valve of a certain air compressor, which affects the machine's lifespan.

5. Conclusion

Since the implementation of the above maintenance strategy in September 2022, it has been found that the total number of repairs has significantly decreased, as shown in Figure 4. Especially after inspecting and replacing the dental handpieces connector diaphragm and simulating the low hand handpieces water outlet test, the number of repairs related to dental handpieces water leakage has plummeted and stabilized in the following months.

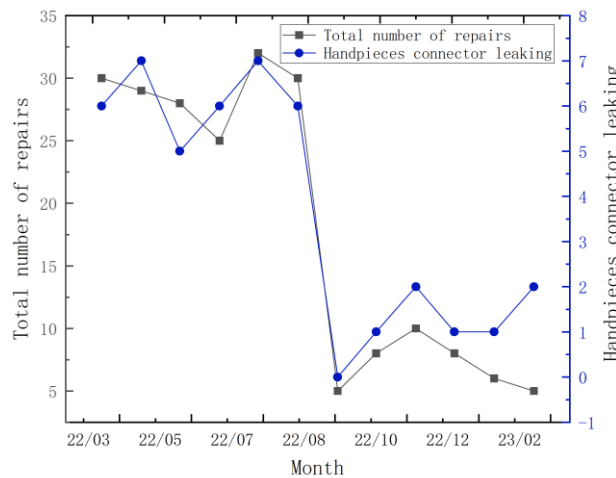


Figure 4: Monthly trend chart for maintenance quantity of dental unit

The dental unit integrates water, electricity, and gas, and due to frequent use, problems increase with age. The main reason for the high failure rate of dental units is lack of maintenance for a long term^[9]. Medical engineering personnel should not only do a good job in daily maintenance tasks, but also use the repair management system to retrospectively analyze repair failures, and find potential problems in the clinical front line to propose preventive maintenance strategies. This not only effectively reduces the failure rate, but also solves problems beyond repair reporting, such as ensuring that the equipment is always in normal condition, and improving the quality of clinical medical treatment.

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