High speed handpiece- A Narrative Review.

S Lavanya[1], Ray Sarthak Arindam [1], V Vidyashree Nandini[2].

[1]Post graduate student, Department of Prosthodontics and Crown & Bridge, SRM Kattankulathur Dental college & Hospital, SRM Institute of Science and Technology, Chengalpattu district, Tamilnadu State, India.

[2]Professor and Head, Department of Prosthodontics and Crown & Bridge, SRM Kattankulathur Dental college & Hospital, SRM Institute of Science and Technology, Chengalpattu district, Tamilnadu State, India.

Abstract

Objective- To provide knowledge and to understand the evolution, contribution and application of airotor handpieces in Prosthodontics.

Background- In the early 1800s, mechanical hand drills were invented, but their performance was limited, only achieving a speed of 15 rotations per minute. Now, in the modern times we have handpieces which provide 2,00,000 rpm and due to this cutting tooth has become really easy and efficient. This review will incorporate the recent advances that have been done with handpieces like electric handpiece and even maintenance of handpieces will be covered in this review.

Methodology- Various published articles were collected and reviewed systematically to gain more insight about various applications of airotor handpiece in Prosthodontics. Search has been done electronically.

Results- Low-speed electric handpieces represent a substantial improvement over their air-driven counterparts and have largely replaced them. While high-speed electric handpieces also provide certain benefits compared to air-rotor handpieces, these benefits are not as pronounced.

Conclusion- Over the past century, no dental equipment has drawn more attention from patients and dentists than the dental handpiece. Dental drill phobia was widespread earlier and hence fear of the drill had to be gradually diminished. The most current innovation is speed-sensing intelligence which utilizes sensors to automatically control the speed.

Application- Airotors have a wide range of applications in prosthodontics. Some of them are tooth preparation for crowns, bridges, veneers and laminates, reduction of high points in prostheses, enameloplasty, implant abutment customization and many more.

Keywords- Airotor, Air turbine, Handpiece, Maintenance, Noise levels.

Address of correspondence: Dr. V Vidyashree Nandini, Professor & Head, Department of Prosthodontics and Crown & Bridge, SRM Kattankulathur Dental College and Hospital, SRM Institute of Science and Technology, Potheri, SRM Nagar, Kattankulathur – 603203 Tamil Nadu, India.

Email address: - vidyashv@srmist.edu.in **Phone no:** 9444901719. **DOI:** 10.5281/zenodo.13356703
Submitted: 29-May-2024 **Revised**: 10-Jun-2024 **Accepted:** 05-Jul-2024 **Published:** 16-Aug-2024
Bibliographic details: Journal of Orofacial Rehabilitation Vol. 4(2), Aug 2024, pp. 11-19.

Introduction

In any dentist's arsenal, the handpiece is a necessary component. It is a vital tool that can improve or hinder, depending on how well it functions and its maintenance. Making the proper handpiece choice is essential to ensuring the seamless operation of daily tasks. The two main kinds of handpieces—air-driven and electric—each have distinct qualities as well as advantages and disadvantages. Both can produce outstanding results, so it's critical to comprehend their unique benefits and distinctions.[1]

An innovative development that fundamentally altered how dentists prepare teeth for dental restorative materials was the invention of the air-driven handpiece about sixty years ago. The use of air-driven "high-speed" handpieces allowed practitioners to work more quickly while causing less harm to the patient's tooth and mouth. The high-speed handpiece is a precision tool that cuts teeth and removes tooth structure quickly, effortlessly and without the use of heat or vibration.[2] This innovation was one of the biggest strides ahead in the era of modern dentistry and offered a significant improvement over the "belt-driven" handpieces that they replaced. Many major developments have been done since 1957 with high speed handpieces, including changes that made the design more user friendly, the heads were made smaller for simpler patient access, the turbines quieter, and bur-changing more efficient.[1] The innovation of mechanical drills came into existence only in the early 1800s with their max speed reaching up to 15 rotations per minute only. Now, in these modern times we have handpieces which provide 2,00,000 rpm and due to this cutting tooth has become really easy and efficient.[3] Today, finishing and polishing techniques, prophylaxis, and laboratory uses are the only domains of low-speed handpieces. To provide dentists with instruments tailored to the specific speed requirements of different procedures, most dental delivery units are equipped with both high- and low-speed handpieces.[1]

History

According to the available data, dentistry was being practiced as early as 7000 BC. A tooth with a 9000-year-old dating exhibits evidence of a dental "drill" being used. Over the past 150 years, the development of dental handpieces has been documented. James B. Morrison created and patented a pedal-powered drill in 1871, completely altering the dental handpiece industry. In 1871, George F. Green from America was granted a patent for the first electric “dental engine” which had its own motor and handpiece. Early dental drills were large and operated at a sluggish 3000 rpm. The length of the procedures made them uncomfortable for the patient. Additionally, they were straight, making them difficult for the dentist to use. John Patrick Walsh of New Zealand created an air-driven handpiece in the 1940s that used air to rotate a cutting bur and included a contra-angle design to make it simpler to situate in the mouth. Dr. John Borden introduced air turbine handpieces in America by the 1950s, which were an improvement over Walsh's concept. The airotor, a high-speed contra-angle handpiece that was air-driven and had a maximum speed of 300,000 revolutions per minute, started a new era in high-speed dentistry. Despite their evolution, air-driven turbine handpieces are the most common ones to be used these days. These modern marvels can reach speeds that were unimaginable one hundred years ago. Today, a slow speed handpiece can normally run between 20,000 and 40,000 revolutions per minute (rpm), a high speed electric handpiece at 200,000 rpm, and an air turbine handpiece at over 400,000 rpm (6600 rpm/min).[4] The optimum range is typically between 180,000 and 330,000 rpm. The time it takes to complete a procedure is now shorter, the tooth is subjected to less stress and trauma, the patient is more comfortable, and the practitioner has superior ergonomics. (Figure. 1 and Figure. 2) [5]

Anatomy of handpiece

Body or shell

Brass is the common material used in manufacturing of handpiece. Despite being soft and prone to denting, this material is reasonably affordable and simple to machine. The cosmetic protective coating placed on brass may later tarnish or break off due to sterilization.

Another material that is frequently utilized to build handpiece bodies is stainless steel which is stronger and lighter than brass, however because of the greater manufacturing expenses associated with steel, prices are typically higher. Titanium weighs 40% less than stainless steel and is stronger and more corrosion-resistant than stainless steel during autoclaving, is currently the state-of-the-art material for handpiece manufacturing.

The head, which contains the turbine and an exterior sheath make up the majority of handpieces. Heat processing has occasionally caused the heads to separate from the outer shell, and several techniques have been used in the past to reunite these two components and also the head-body joint may become loose and the head may become damaged and interfere with the operation of the turbine.[6]

Handpieces are equipped with air or air-water coolant ports, designed to reduce pulp damage and enhance cutting and cooling efficiency by spraying water at the bur-tooth interface. The coolant deflects droplets from the air whirl created by the spinning bur, which results in more water being extracted from the tooth at high speeds.[7,8]

Air turbine

An air turbine handpiece is a high-speed rotating dental abrasive instrument powered by compressed air.[9] It is often known as turbines, have a lower head height, are lighter, and are simpler to operate, thereby resulting in better accessibility, decreased user fatigue, and in certain situations, a more comfortable user experience.[10]

A turbine rotates as air passes through the blades or vanes of the device. The turbine's head is housed within the handpiece. Compressed air is transferred from a high-pressure storage tank to atmospheric pressure, generating airflow. A turbine consists of two small bearings, impeller, two rings and chuck assembly.

The rotor speed of a turbine is between 380,000 and 450,000 revolutions per minute (rpm). Turbines speed can be divided into free and active rotations. Free rotations are the maximum rotational speeds with no load. Active speed refers to the actual speed at which the turbine is decelerated when the tooth structure is engaged by the cutting instrument. The typical active speed of high-speed handpieces is between 180,000 and 200,000 revolutions per minute. The spindle, which presses into the impeller creates a rotational motion and it rotates in the center of the system. Small wedge lock mechanisms that are built into the spindle are intended to firmly hold a dental bur in place. The hand piece head contains the entire turbine assembly.

As the air passes through the arm, it is pulled to rotate the bur. The air is sent back down the arm to the machine's exhaust pipe after passing over the turbine blades.[3]

Handpiece couplings

The 4-hole handpiece connector is the standard for both high-speed and low-speed handpieces. Additionally, there are five-hole and six-hole handpiece connections available. The four-hole connection is a variation of the traditional four-hole handpiece connector, featuring two large holes and two small holes.

The two large holes in the connector serve to supply and exhaust air for the drive component, which can be either a turbine or a micromotor. The smaller of these two large holes channels the drive air into the instrument, while the larger hole directs the exhaust air out of the instrument and back into the unit for expulsion.

The smaller two holes in the connector transport chip air and water flow into the instrument for cooling. In a 5-hole coupling, the fifth hole is used for light transmission. In a 6-hole coupling, the fifth and sixth holes carry the electric current to the lightbulb inside the handpiece, providing illumination. (Fig.3)[11]

Electric handpiece

When compared to an air-driven handpiece, an electric handpiece's constant speed and reduced noise are the most notable differences. However, an electrical handpiece's main drawbacks are the presence of numerous complex parts, such as gears and bearings. In contrast to an air-driven handpiece, which can lose torque as its turbine components wear out, an electric motor maintains enough strength to operate the attachment even in the event of internal part malfunction. The tissue gets burned due to the heat produced by friction.[12]

Parts Controlling Speed and Torque

Speed refers to both the number of rotations per minute (rpm) and the number of surface feet that a tool can cut per unit of time. Endodontic motors range in speed from 150 rpm to 40,000 rpm, from traditional to modern motors. The amount of force that causes an object to rotate is measured as torque. The term torque refers to the tendency of a force to cause an item to spin about its axis, fulcrum, or pivot.[13]

Gear system

Epicyclic ball race gear system

It is positioned in the hand piece’s shank. It has one outer ring and one inner ring. In between these two rings are ball cage and a ball bearings. If you hold the outside ring in place whilst turning the inside ring, you’ll notice that the cage that separates the balls, spins at a lower speed.

Epicyclic gear boxes with toothed gear

A static gear ring contains small gear wheels. Small gear wheels are the sun gear in the centre of the gear ring and planetary gear around it. Reduction hand pieces lower the drive speed while raising the torque. These hand pieces are used to turn large diameter instruments like bristle brushes or rubber cups in prophylaxis heads.[3]

Ball bearings

The ball bearings used in dental handpieces come in two varieties: metal ball bearings and steel ball bearings. Metal ball bearings were used in most dental handpieces to transmit the force of rotation to the bur. Ceramic-based ball has been proven to be up to 60% less weight than the steel-based ball commonly found in dental armamentarium. The lighter weight not only allows the dental handpiece to be held and moved more easily, but also generates much less centrifugal force at high speeds and reduces overall surface wear. Because the exterior ceramic ball bearing is tough, dirt or debris is much less likely to cause bearing failure. The other main benefits of using ceramic ball bearings in dental instruments are that they operate much cooler than steel ball bearings, which increases the bearing's service life. Additionally, the lubricant placed into ceramic ball bearings has a much longer lifespan. For example, if a lubricant is placed into steel ball bearings at temperatures used in dental hand instruments, ceramic ball bearings will last much longer than steel ball bearings.[3]

Mechanism

According to mechanism of working handpieces are divided into two types:

- Air driven
- Electric driven

The air driven mechanism works on two principles

1. Rotary vane principle
2. Swash plate principle

Rotary vane principle

The off-set with a cylinder that forms the center core is separated into chambers by vanes and seals between the core and the cylinder wall. The air in the high pressure chamber moves toward the low pressure chamber as air is pumped into it, where it is then released. Such motors are characterized by their smooth operation and high torque.[3]

Swash plate principle

The mechanism is initiated when a piston is lifted and pressed against a plate, resulting in the rotation of the disc. A succession of pistons achieves this by pressing against the disc. Once the current piston has completed its path, the next piston in the sequence assumes control and continues to revolve the disc. A rotational wave drives the disc's spin while also providing the air for the pistons.[3]

Maintenance

An essential component of any dental practice is high speed handpieces. To prolong their lifespan, use, care, and adequate maintenance are necessary.

Cleaning and lubrication

According to the Centers for Disease Control and Prevention (CDC) recommendations, water must be flushed through the handpiece in the operatory for 30 seconds after each use to remove any potential contaminants in the internal water line. Once inside the sterilization room, take off the bur and use a sponge and flowing water to clean the handpiece of any external debris.

Sterilization

Never sterilize a handpiece with a bur in the chuck. According to the sterilizer manufacturer's guidelines, a steam heat autoclave or chemical vapor sterilizer is to be used to a temperature of 135 degrees C or 275 degrees F and not more than that. A chemical sterilizer must be used with a thoroughly dry handpiece. A handpiece's chamber will oxidize from too much water, leading to corrosion. Make sure the paper is facing up if using a plastic or paper bag to guarantee complete sterilization. The sterilizing method that is most frequently advised is steam heat autoclaving.

Electric motors

Electric motors come in two varieties: brushless and those with carbon brushes. A brushed motor has carbon brushes, which can degrade over time and need to be replaced. The motor's lifespan may be shortened by a buildup of carbon dust caused by the brushes. When the oil from the attachment and the carbon particles combine, black grease is produced which is tough to clean. The motor should be cleaned every week, and the brushes should be changed every two years. The most recent electric motors available are brushless. It has a contactless magnet as its design which makes it need almost no maintenance.

Slow or low speed motor maintenance

Compared to high speed motors, slow speed motors need less lubrication and maintenance. The viscosity of the oil varies as well. Some slow speed motor models demand oil with a higher viscosity. All that is required are a few drops in the drive air line. Additionally, as a preventative step, oil the shift rings, sheath attachment points, and forward/reverse valves.

Handpiece repair- Fiber optic light

There is not much maintenance needed for the fiber optic light. The lens can be kept clean with a mild sponge scrub. Any member of the dental team can quickly replace the light. Replacement bulbs are frequently offered in pairs of two and some have to be taken out using a dental explorer. Some bulbs are in the tubing, while others are in the coupler itself.

Handpiece repair- Turbine

For repair of a turbine a new or after-market turbine can be bought and installed, returned to the manufacturer for replacement, or a reputable repair service can be used. It will maintain the same consistency as the original if you return it to the maker. Time will be saved by keeping it in-house but there is a chance of quality compromise.[5,14]

NOISE LEVELS- A drawback

The high-pitched noise that exacerbates a patient's stress and discomfort, as well as the unpleasant vibrations felt during tooth preparation, are one of the few drawbacks of the high-speed handpiece.[15] Early hand instruments had a higher noise level, said to be 80–94dB at 12– inches and 75–104dB 6 inches away, and a greater risk of damage (Stockwell (1971)). More recent models have a lower noise level, about the same or lower than what is prescribed in the OSH Act (1970), which is no more than 90dB for 8 hours of continuous exposure per day (9–10 inches). It is estimated that most turbine users use hand instruments at high speeds for about 15 minutes per day. A dentist who uses high-speed turbines for hours on end will fail with less than 8 hours allowed exposure.

The wear and tear of handpieces, combined with inadequate maintenance, can contribute to an increase in noise levels. It is well-known that the exhaust ends of dental handpieces produce a higher level of sound and can be a contributing factor to an increase in the noise level experienced by a dentist.

There are two main causes of handpiece noise. The first is aerodynamic and the second is structural. Aerodynamic causes are caused by turbulence in the path of the airflow. Structural causes are mainly caused by the Air Turbine Rotor Bearing.

The second cause of handpiece noise is the air flow pattern that develops around the rotors, spindles and shafts. Air intake occurs at the entrance of the handle. Air transfer and diffusion occur at the turbine rotor. Air return occurs at the return pipe. Finally, exhaust air occurs at the exhaust pipe. The outlet behind spindle can also increase the noise due to resonance

The reduction of noise from hand instruments is achieved through the installation of a turbine diffuser with a muffler which is mounted on or substituted for the exhaust pipe of the handpiece and the alteration of the handle material stainless steel lucite.

Conclusion

Over the past 100 years, various handpiece types have transformed dentistry. They are a crucial component of any dental office, and expanded function dental assistants and dentists rely on them every day to work at their best. Despite the fact that they are employed in every surgery, the dental team knows relatively little about them. Knowing how they operate can help extend their life and reduce repair expenses.[5] Over the past century, no dental equipment has drawn more attention from patients and dentists than the dental handpiece. Because dental drill phobia was so widespread, fear of the drill had to be gradually diminished. The most current innovation is speed-sensing intelligence which utilizes sensors to automatically control the speed.[1]

References

1. Lowe RA. The Dental Handpiece: Technology Continues to Impact Everyday Practice [Internet]. 2015. Available from: http://rgpdental.com

2. Bhandary N, Desai A, Shetty YB. Short Communication High speed handpieces. Bhandary N et al [Internet]. Journal of International Oral Health. 2014.

3. Shankar Narayan G, Sundaram Rajasekaran M. EVOLUTION AND MECHANISM OF DENTAL HANDPIECES [Internet]. 2018. Available from: http://www.journalcra.com

4. Mount GJ. Minimal intervention dentistry: Cavity classification and preparation. J Minim Interv Dent. 2009;2:150–63.

5. Hunter T. Dental Handpiece Maintenance and Repair. 2013.

6. Williams G. Anatomy of a handpiece: Understanding handpiece maintenance and repairs. 2021.

7. Chua H, Choi JJE, Ramani RS, Ganjigatti R, Waddell JN. The cooling efficiency of different dental high-speed handpiece coolant port designs. Heliyon. 2019;5.

8. Leung BT, Dyson JE, Darvell BW. Coolant effectiveness in dental cutting with air-turbine handpieces [Internet]. New ZealandDentai Journal. 2012. Available from: http://en.wikipedia.org/wiki/Thennal

9. Nishi Y, Fushimi H, Shimomura K, Hasegawa T. Performance and Internal Flow of a Dental Air Turbine Handpiece. International Journal of Rotating Machinery. 2018;2018.

10. Gulia SK, Kumar S, Kashyap R, Kour KP, Hameed A, Thakker R. Comparison between efficacy of turbine handpiece vs conventional motor handpiece in surgical removal of impacted third molar. Int J Health Sci (Qassim). 2022;770–7.

11. Pegg JE, Lothamer C, Rawlinson JE. The Air-Driven Dental Unit: Form and Function at a Mechanical Level. J Vet Dent. 2019;36:202–8.

12. Christensen GJ. Are electric handpieces an improvement? Journal of the American Dental Association. 2002;133:1433–4.

13. Mangat P, Ajaz Raina A, Vaidya S, Bhatacharya A, Dhingra A, Sharma V. Torque and Speed in Endodontics: A Review. International Journal of Oral Care and Research. 2018.

14. Hunter T. Dental handpieces: Maintenance, repair, and infection control, 3rd edition. 2021.

15. Chery jerry, Freitas V, Saman DM, Apeksha Gupta Cph. Comparison of Cavity Preparation Times Using Conventional High-Speed Handpiece Versus Er,Cr:YSGG Laser: A Pilot Study with Pediatric Dental Residents. 2022.

FIGURES

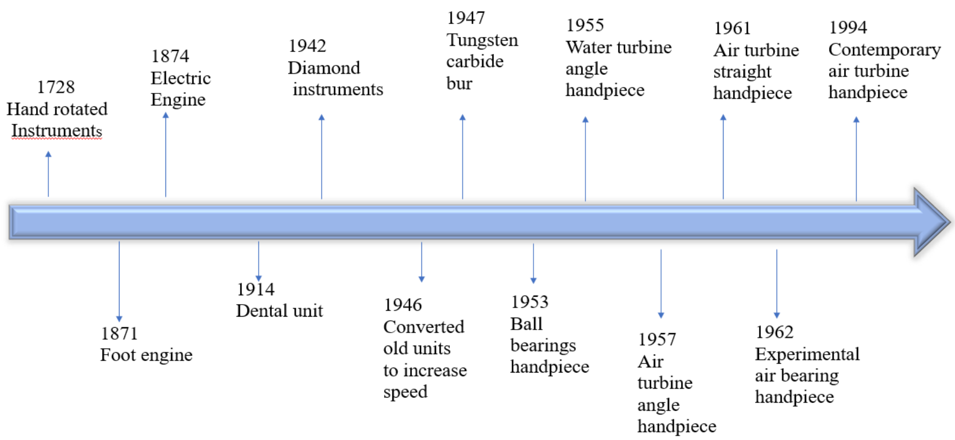

Figure 1.

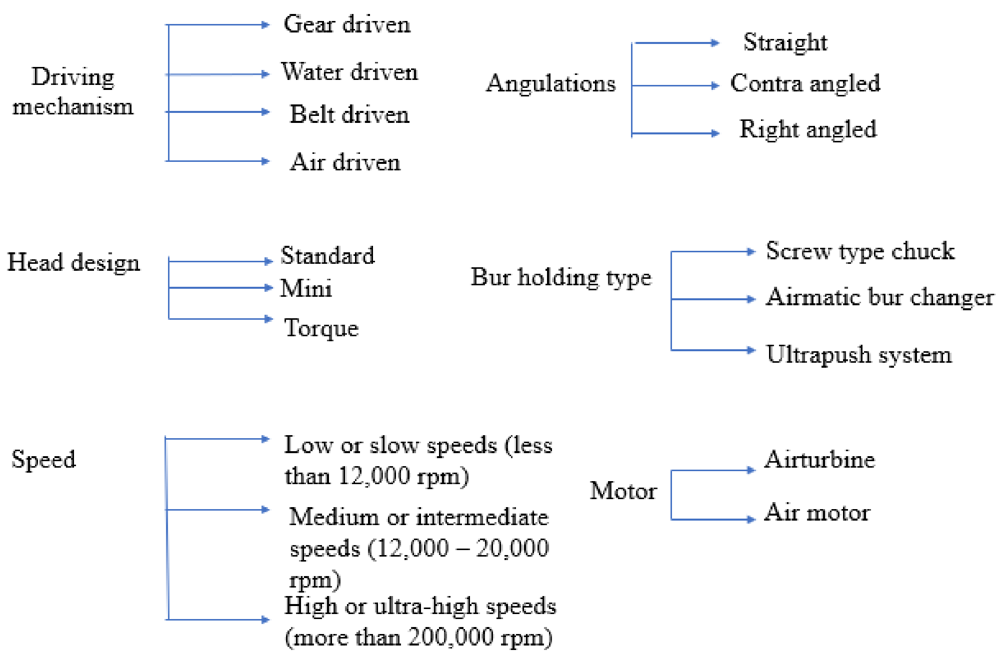

Figure 2.

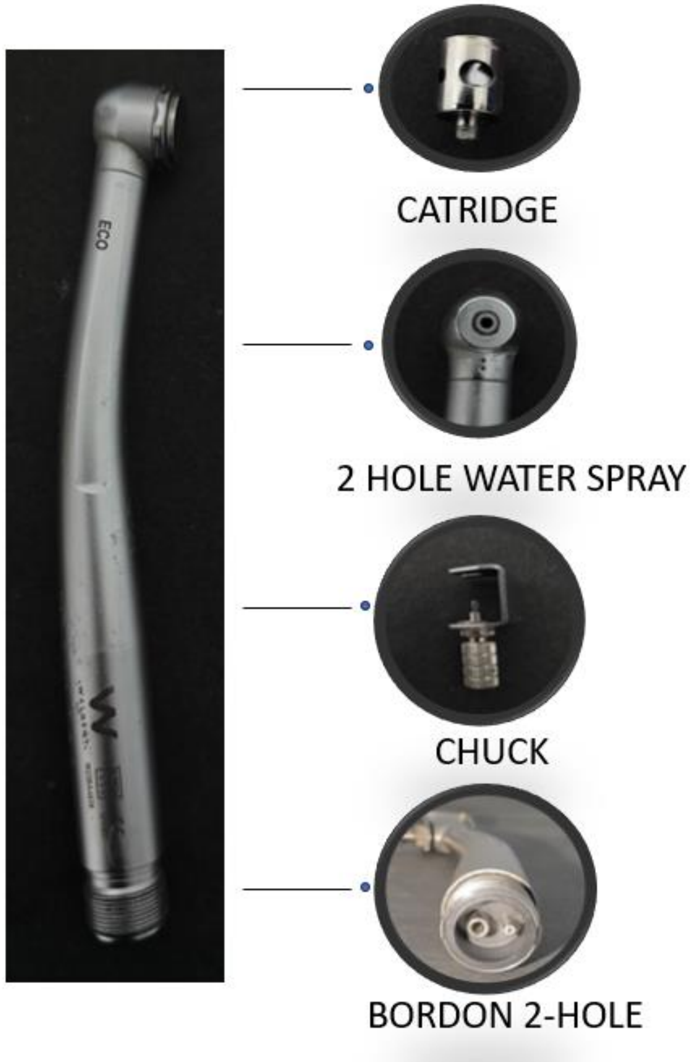

Figure 3.