

# High-speed Dental Tools in Dentistry - A Review

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## ABSTRACT

A clinical expertise behind the use of sharp hand and rotary instruments requires ability and coordination gained only through extensive training. For the performance of detailed dental procedures, the clinician must possess adequate knowledge behind the application of dental instruments. During clinical practice, the dentist operates on oral tissues within the oral cavity where even 1 mm discrepancy is crucial behind success and failure. The present article reviews the role of high-speed instruments used in division of fixed prosthodontics and their regulatory mechanisms.

**Key words:** burs, rotary, speed, water, spray, diamond points

## INTRODUCTION

In the initial days, tooth structure removal was done using hatchets, sharp-edged chisels, and hoes. These handheld cutting instruments were used for removing undermined and unsupported enamel resulting from dental caries. These methods were time consuming and often pose difficulty.<sup>[1,2]</sup>

The first rotary instruments consisted of drills or bur heads that could be twisted in the finger to produce cutting or abrading action. By 1957, many dentists were using rotational speeds up to 3,00,000 rpm. The introduction of air-bearing handpiece in early 1950 made possible greater rotational speeds of approximately 5,00,000 rpm.<sup>[3,4]</sup> In 1953, an ultrasonic method of tooth tissue removal was

also introduced, which used suitably shaped tips vibrating at frequencies ranging from 2,50,000 to 3,00,000 cycles - per seconds. This brief historical background reveals that the profession has been searching for a suitable method of tooth tissue removal.<sup>[3]</sup>

It is only recently around 30 years, this hunt has slowed down, but still, the dental profession is trying to refine the instruments and procedures as much as possible within the human dexterity.

## LITERATURE REVIEW

An extensive research was done in PubMed and Scopus databases from 1990 to 2015 using following mesh words such as rotary, speed, water, spray, diamond points, and burs, and a total of 88 articles were found. Of which 12 articles were finally selected, analyzed, and summarized as per the relevance to constitute this review article.

A dental handpiece is a vital tool in dental practice that performs functions such as removal of tooth decay, tooth preparation, and finishing and polishing of dental

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restorations. The first known air rotary handpiece was manufactured in 1868 by Green. Later on in 1873, electric handpiece technology evolved and it completely revolutionized dental treatment. The modern air turbine handpieces were introduced by Borden in 1957 capable of ultra-high speeds up to 3,00,000 rpm. Nowadays in North America, majority of clinical procedures in various pre-doctoral programs are performed using these high-speed handpieces. For pre-clinical training, usually low-speed handpieces are preferred as they provide the students a preliminary tactile sense.<sup>[4]</sup> Hence, it is seen that continuous development of newer methods till 1960 indicated that the earlier instruments had some or the other kind of disadvantage. In spite of the introduction of numerous tooth reduction instruments and procedures, the objectives and principles remained the same. The operator must remove minimal amount of tooth tissue, cause least injury to the periodontal tissues and pulp and with provide least discomfort to the patient. Hence, it is seen that the most popular type of handpieces is still the air-driven handpieces because of the simplicity of design, ease of control, and more patient acceptance.

### Water-Driven Types

Hydraulic-driven turbine handpiece came into use in 1953 operating at a speed of around 60,000 rpm. The first commercial model known as turbojet operated at a speed of 1,00,00 rpm. Water was supplied to the handpiece through inner small plastic tubing under high pressure to rotate turbine located in the head. Simultaneously, the larger outer tube was used to return water to the reservoir.

### Gear-Driven Types

These are one of the oldest and largest groups of handpieces and generally the conventional type. Three standard designs based on use a straight handpiece, contra-angle handpiece, and prophylaxis handpiece. Rotary power is transferred to the straight handpiece by a belt that runs from an electric over a series of pulleys and a three pieces extension cord arm. Rotary cutting instruments are inserted into a chuck at the front of the handpiece. Conventional handpieces operate at speeds under 5,000 rpm. Many now have improved bearing surfaces that allow greatly increased speeds. A long contra-angle design helps to reduce amount of vibration. It is possible to obtain speed of 1,00,000 rpm with a gear-driven angle handpiece that has an automatic lubricating system. The most recent addition of the gear-driven type of handpiece is addition of a miniature electric motor.<sup>[5,6]</sup>

### Speed Variability

The cutting efficiency of burs depends not only on the speed of rotation but also on the size of sintered abrasive particle, number of sintered abrasive particles, shape of sintered

abrasive particles, pressure applied by sintered abrasives on tooth surface, and the time elapsed between the contacting surfaces. Since 1946 continues increase in operating speeds of motor used for dental treatment have given rise (Please correct the sentence as aforementioned) Page Number- 2Line Number- 52,53 left side. Their speed ranges are generally available low or slow speeds (below 6000 rpm), medium or intermediate speeds (6000–1,00,000 rpm), and high or ultra-high speeds (above 1,00,000 rpm).

### Low Speed

It is no longer used for cavity preparation except for operations such as cleaning the teeth excavating caries, refining cavity preparations, and marinating gold restorations. Range is within 6000 rpm.

### Medium Speed

The range is between 6000 and 1,00,000 rpm. It is used for cavity preparation, finishing procedures such as placement of retentive grooves and bevels.

### High Speed

The range is above 1,00,000 rpm. It is used for clinical procedures such as removing old restorations and reducing cusps.

### Rationale of Increased Speeds

Although tooth structure can be removed by an instrument rotating at low speeds, it is a traumatic experience for both. The patient and dentist low-speed cutting is ineffective and time consuming and requires relatively heavy force of application of 2 to 4 pounds. This results in heat formation.

The main reason for increasing the speed of rotating instruments is to increase its cutting efficiency. The operator has better control and greater ease of operation. Instruments last longer. Patient is generally less apprehensive because annoying vibrations and operating time are decreased. Several teeth in the same arch must be treated at the same appointment.<sup>[7,8]</sup>

At the same time, the increased speed creates increased temperatures in the tooth. Therefore, cooling the tooth is required to prevent pulpal damage. When a dentist changes from the lower speeds to higher speeds, he must develop a new tactile sense to avoid over cutting. The end finishing is better accomplished using moderate speeds with finishing burs with fine-gritted abrasives.

### Types of High-Speed Instruments

Handpieces can be divided into four types depending on their speed limits; low speed - up to 10,000 rpm; intermediate

speed - 25,000–45,000 rpm; high speeds - 50,000–1,00,000 rpm; and ultra-high speeds - 1,00,000 rpm.<sup>[9]</sup>

## Heat Generation

The rotating cutting tools come in contact with the tooth surface, and the heat is generated. It was not until 1930 that the workers began to investigate the heat rise in the dental pulp. It has been found that the temperature rise develops within 10–12 s, after the cutting operation is started.<sup>[9]</sup> Hudson and associates in 1954 conducted a study on temperature developed in dental cutting instruments, and from their study, they have concluded that the temperatures resorb by dental burs in cutting human dentin ranged from 125°F to 275°F. Hence, it is advisable to use some form of coolant.<sup>[10]</sup> The amounts of heat transferred to the tooth from the bur decreases, at speeds above 12000 rpm, and trauma to pulp is minimized.

## Coolants

Every means should be employed to keep the temperature down as much as possible during cutting operations. There are three types of coolants usually employed in dental practice such as water, spray of air and water, and air alone.

Peyton has shown that at speeds ranging from 30,000 rpm to 1,70,000 rpm and with an application of four ounces of pressure a temperature rise within the tooth of <15°C occurred when water or air-water sprays were employed. He also found that even with a water coolant, excessive temperatures developed, when large diameter instruments or excessive pressure was applied with increased operating speeds. This indicates that the only the use of coolant is not sufficient to reduce the danger of temperature rise.

There are certain other issues with high-speed handpieces which needed to be considered. Most of the handpieces are designed with a spray of water to be directed from the head of handpiece directly onto the cutting surface.

Sometimes, the abrasive on cutting tool is away from the stream of water, so the coolant does not flood the tooth surface being cut, resulting in temperature rise. To overcome this difficulty, perforated disks have been developed. In situations where non-perforated disks are to be used, the speeds must be within 10,000 rpm.<sup>[10]</sup>

Another added advantage of coolant lies in its role to flush away the tooth debris produced during tooth cutting preventing the clogging of cutting blades/surface. Hence it maintains the cutting efficiency of stone. Nelson recommended the addition of a wetting agent to the water spray.<sup>[11]</sup>

## Vibration

Most patients associate the sensation of vibration, noise, pressure, and the slight increase in cutting temperature with

the sensation of pain. Hence, these trigger factors must be kept to minimal.

## Cross Contamination by Ultra-speed Cutting Tools

Atmospheric microbial contamination from air turbines has been an area of concern for the public health community since ages. Recent studies suggest that the extent of aerosol produced by air turbine may reach hazardous levels of microbial population. A report involving patients with pulmonary tuberculosis cultures were demonstrated on all petri dishes exposed during cutting procedures, with the heaviest concentration being at 2 feet in distances from the patient's mouth.

This indicates that the dentist and his assistant are exposed to a serious health hazard when operating with an ultra-speed exposed instrument on patients having such pathogens in their oral flora.

Patient's medical history is of utmost importance. If there is evidence of diseases such as tuberculosis, pneumonia, influenza, infectious hepatitis, or any infectious diseases including the common cold, a double protective face mask should be worn both by the dentist and the dental assistant. Alongside, protective eyeglasses must be routinely worn. We can also go for intraoral disinfection by asking for a mouth rinse for every patient before treatment to reduce the microbial load.

## BIOLOGICAL RESPONSE TO HIGH-SPEED TOOLS

### Dentin

Dentin removal leads to a reaction in dental pulp which may lead to dentinal changes. Fish in 1932 conducted an experimental investigation into the effect of cavity preparation on dentin and pulp. He found that in some cases, there was sclerosis of the cut dentinal tubules which formed a protective sealing over the pulp from the injury and there is a growth of tubular dentin. These reactions are produced by the stimulation of the odontoblasts. Other reaction resulted in the formation of dead tracts. On the pulpal aspect of these tubules, secondary dentin is laid down which also seals pulp.

### Pulp

Pulp changes associated with tooth reduction were studied by Marsland and Shovelton. The changes found were no severe than those produced at lower operating speeds provided that adequate cooling of the cutting instrument by water jet or air/water spray is ensured. The enamel showed minute cracks and dentin showed altered staining reactions as a result of localized overheating.<sup>[12]</sup>

## DISCUSSION

For efficient use of cutting tools, certain factors should be considered. Heat generated during tooth tissue removal must be kept to the minimum. Use of efficient coolants, not only eliminate the heat generated but also at the same time, keeps the operating area clean and free of any debris.<sup>[9]</sup>

High-speed cutting tools also reduce the working time and hence less patient annoyance. When the factors of pressure, temperature, and vibration are kept within the patient's tolerance limits, the comfort is improved.<sup>[2,3]</sup> Oversized cutting tools should be avoided, as they are difficult to control, and at the same time, the accuracy of tooth preparation on procedure is also adversely affected.<sup>[6,7]</sup>

Thus, it can be concluded that high-speed equipment for tooth reduction if used with proper understanding and due care provide definite advantages over the conventional low-speed cutting procedures.

## CONCLUSIONS

High-speed cutting devices, if used with a thorough understanding of their mechanism and due care to the biologic integrity of the teeth and adjacent structures are a boon to dentistry. To conclude, for effective tooth preparation, a balance must be maintained between the size of abrading particle, its shape, pressure applied by the handpiece, speed of rotation, and time of application. In the present review, a critical evaluation of high-speed cutting devices along with their biologic reactions to dentin and pulp has been briefly discussed.

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