Rational Use of Dental Burs

DIA·TESSIN®

Introduction

Key Words:

- Abrasion
- Blades
- Surface state
- Drilling
- Grit size
- Morphology
- Rationalization

Dental burs have a very important place in basic instruments for dentistry.

Their correct choice and well adapted driving mode will determine their long lasting efficiency. Very often choosen in an empirical way. The study of the different substances and materials worked on and the results of different clinical studies allow to choose the best adapted burs.

The constant technical evolution and continuous appearance of new materials allow uninterrupted improvement in the shape and quality of these instruments. Nevertheless, elements defined by ISO* remain constant so that a necessary standardization can be assured for their international diffusion.

*ISO International Organization for the standardization

Substances and materials worked on

All the materials and substances worked on have different structures and hardness* implying the used of different types of instruments.

Tooth

1 – Enamel

- A strongly mineralized tissue compounded of hydroxyapatite crystals (96%), water (2.3%) and organic matter (1.7%).
- The hardest tissue in the whole human body, Vickers hardness between 280 and 350 H.V.
- Enamel is translucid

Use preferably diamond instruments, as tungsten carbide burs may cause enamel splinters.

2 – Dentin

- Mineralized tissue compounded of hydroxyapatite crystals (69%), water (13.5%) and organic matter (17.5%).
- Vickers hardness between 25 and 75 H.V.
- Dentin is lightly yellowish.

Use steel or tungsten carbide instruments.

* The hardness of a substance or a material is defined by the depth and the shape of the indentation left on it by a specifically calibrated rod under a specific pressure.

- Vickers's Micro-hardness H.V. it's expressed in Kp/mm^2 for hard materials (for example: enamel, metals).
- Knoop hardness is expressed in Kp/mm^2 for compound materials(for example: composites, cement).

Filling materials

1 – Silver amalgam

- Crystal structure.
- Vickers hardness between 90 and 130 H.V.
- Worked on with steel or tungsten carbide burs. Abrasives have the inconvenience of the filler.

2 – Composites

- Dental composite is composed of a resin matrix and fillers.
- Hardness between 18 and 26 Knoop.
- Worked on, depending on its composition, with diamonds, Arkansas or special tungsten carbide burs used for finishing.

3 – Cements

- The cements used in the dental state of the art are compounds of zinc orthophosphate, silicates, and sylicophosphate.
- Knoop Hardness between 40 and 80.
- Worked on preferably with diamond or silicon carbide abrasives, tungsten carbide can also be used.

Metals

- Crystal structure.
- Worked on with proper instruments according to the type of surface wanted.

1 – Gold

Type III casted or templed.
- Vickers's hardness between 145 and 200 H.V.
- Worked on with finishing tungsten carbide burs or with silicon carbide abrasives.

Type IV hardened.
- Vickers's hardness between 220 and 310 H.V.
- Worked on with finishing tungsten carbide burs or with silicon carbide abrasives.

2 – Casted Steel

- Vickers's hardness between 135 and 330 H.V.
- Worked on with tungsten carbide or corundum type abrasives.

3 – Chromeplated-nickel

- Vickers's hardness between 300 and 350 H.V.
- Worked on with tungsten carbide or corundum type abrasives.

4 – Chrome-Cobalt

- Vickers's hardness between 300 and 350 H.V.
- Worked on with tungsten carbide or corundum type abrasives.

Restoration Materials

1 – Composite Resin

- The resin most used is the polimethyl-methacrylate.
- Knoop hardness between 10 and 17.
- Worked on with steel or tungsten carbide instruments or with abrasives.

2 – Dental ceramics

- Brittle crystal structure.
- Knoop hardness between 390 and 415.
- Worked on with diamond and silicon carbide type abrasives.

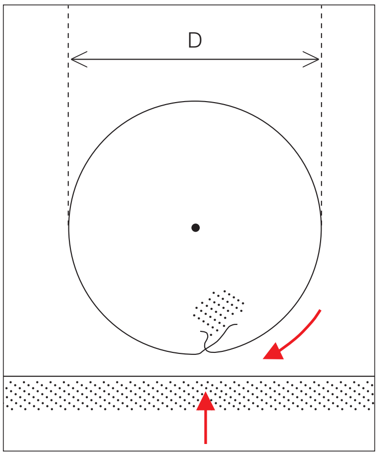
Rotation and linear speed

The instrument's rotation speed and its diameter determine its linear speed.

The linear speed is the speed in which the active part of the rotary instrument passes over the working surface.

The entire circumference's length is obtained by multipliying π by the diameter. The rotary speed beeing of n revolutions per minute, the linear speed can be found by means of a simple formula:

$$v = \frac{\pi \cdot d \cdot n}{1000} = m/mn$$



d = bur diameter mm
n = number of rotation per minute
v = linear speed

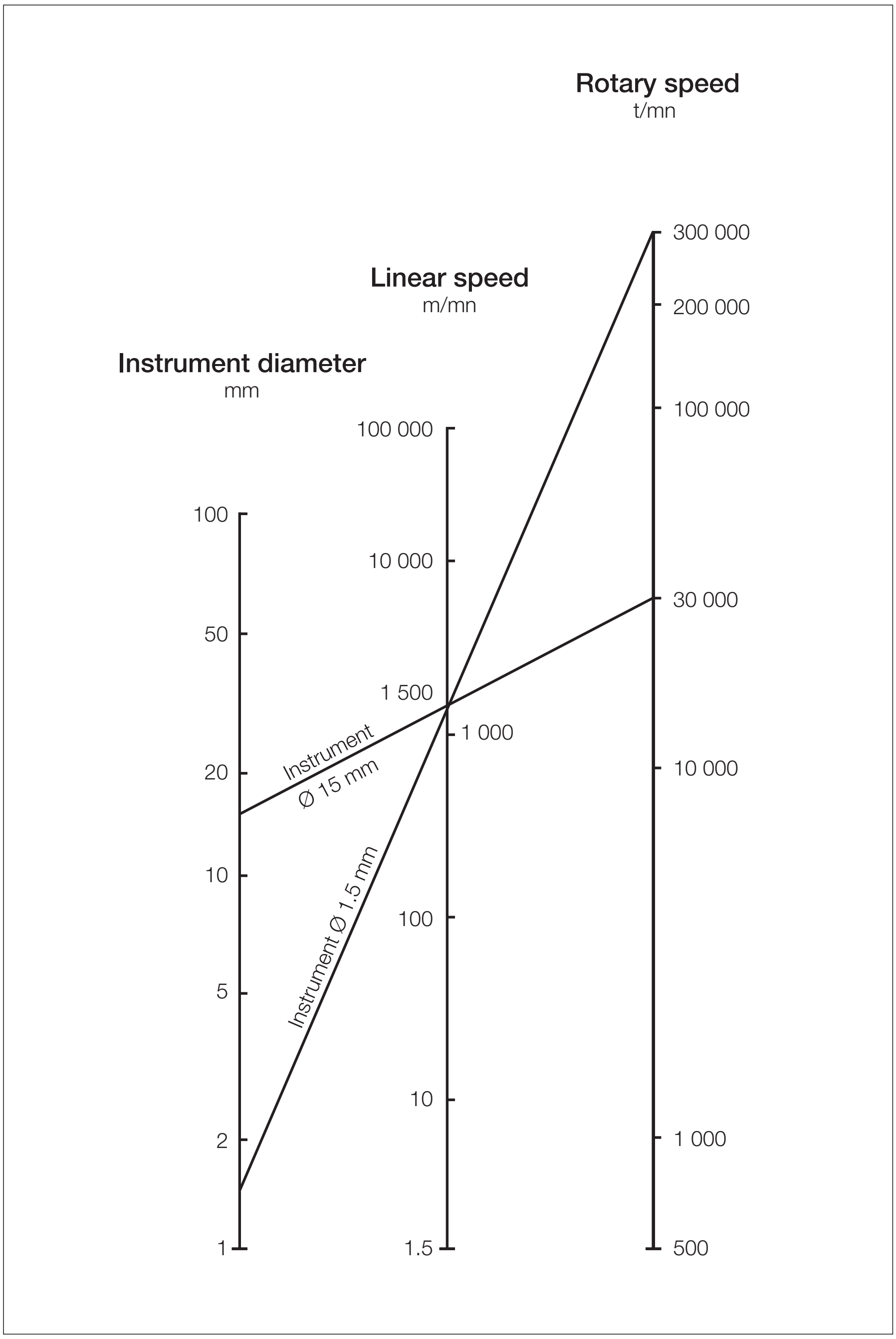
Examples:
Instrument Ø 1.2 mm
Rotary speed 400 000 rpm

$$v = \frac{3.14 \times 1.2 \times 400\,000}{1000} = 1\,507.20 \text{ m/mn}$$

Instrument Ø 4.0 mm
Rotary speed 120 000 t/mn

$$v = \frac{3.14 \times 4.0 \times 120\,000}{1000} = 1\,507.20 \text{ m/mn}$$

The same linear speed is obtained by a three times bigger diameter instrument turning three times slower.



Graph illustrating the d/n relation according to Doctor KIMMEL.

Instruments used

Steel and tungsten carbide burs

Burs' main characteristics are:

- The material the working part is made of.
- The number of blades.
- The type of blades.
- The cutting angle.
- The cutting half-life.

They are divided in two main families:

- Steel burs.
- Tungsten carbide burs.

1 – Steel burs

The typical composition of a stell bur is:

Fe	96%
W C	1-2%
Va	0,3-1%
C	1.2%

These burs are monobloc. After the drilling they undergo a thermical treatment that hardens the steel to an average Vickers's hardness of 850 H.V.

Due to their high content of stell (Fe), dental burs are very sensible to corrosion.

Dental burs' heads with a diameter between 0,5 mm and 2,3 mm have between 6 to 8 blades.

2 – Tungsten carbide burs

Most of these burs are bimetallic, the head (working part) beeing made of tungsten carbide, the shank and the neck of stainless steel.

Tungsten carbide (Wolfram) is a metallic powder amalgamated with different components by means of a sintering (heating until its particles adhere to each other) process.

The typical composition of the tungsten carbide is:

W C	94%
Co	5-6%
Ta	0.25-1%
Ti	0.25-1 %

Tungsten carbide is very hard, It has an average Vickers hardness of 1650 H.V.

As a consequence of the volume reduction during the sintering process (40-50 %) two different techniques are adopted according to the size of the instruments.

– Hot pressing technique, between 950 and 1100ºC, is applied to big volume instruments (laboratory burs). The obtained material is machined before beeing definitely sintered at near cobalt melting point, about 1350º C.

– The direct sintering technique is applied to small volume instruments, in which intermediate machining is not necessary.

Tungsten carbide head is welded onto the shank by means of a high frequency induction device. (This was a handmade process until the first years of the 1970’s). Blades are machined and sharpened with diamond grinding wheels.

Tungsten carbide burs have between 6 to 8 blades for a head’s diameter between 0,5 mm and 2,3 mm.

Contact of hydrogen peroxide with tungsten carbide causes its erosion.

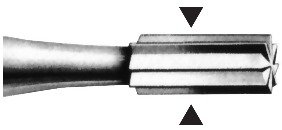
3 – Blades

There are two types of blades : axial and helicoidal.
They can be executed in regular or fine version, but only the regular one can be cross-cut.

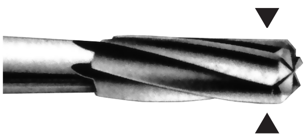
– Regular : (for trimming) between 6 to 8 blades.*
– Fine : (for finishing) between 12 to 20 blades.
: (for polishing) more than 20 blades.

*ISO Standard requires a minimum of 6 blades.

The blades are sharpened with a tungsten carbide contour bur for steel instruments and with a diamond grinding wheel for tungsten carbide burs.

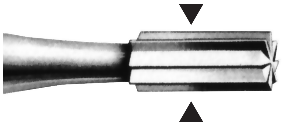


Axial burs are determined by blades parallel to the bur’s axis.



Helicoidal burs are determined by bades rotating perpendicularly to the bur’s axis.

Characteristics of the different blades

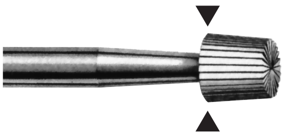


1 – Axial regular

Quality of the obtained surface: Ra = 2.5 / Rt = 12.5.

Advantages:
– Good cutting ability.

Disadvantages:
– Vibrations.
– Bad evacuation of the shavings, gets easily obstructed.
– Hight risk of bur's fracture.
– Enamel prisms' splinters.

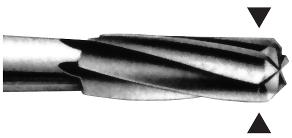


2 – Axial fine

Quality of the obtained surface: Ra = 1.5 / Rt = 7.

Advantage:
– Good surface quality.

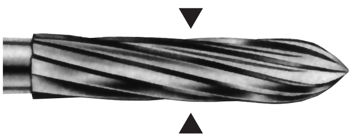
Disadvantage:
– Poor cutting ability.



3 – Helicoidal regular

Quality of the obtained surface: Ra = 1.6 / Rt = 6.5.

Advantages:
– Work perfectely at high speed.
– Great cutting ability.
– Excellent evacuation of the shavings reducing the risk of bur fracture.
– Few enamel prisms' splinters.
– No overheating.

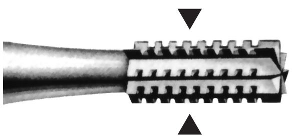


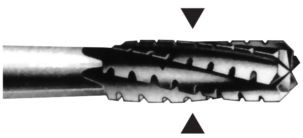
4 – Helicoidal fine

Quality of the obtained surface: Ra = 1.3 / Rt = 5.6.

Advantages:
– Soft work without vibration.
– Perfectly smooth surface.

Disadvantage:
– Poor cutting ability.





5 – Axial or helicoidal cross-cut

Quality of the obtained surface: Ra = 4.8 / Rt = 23.5.

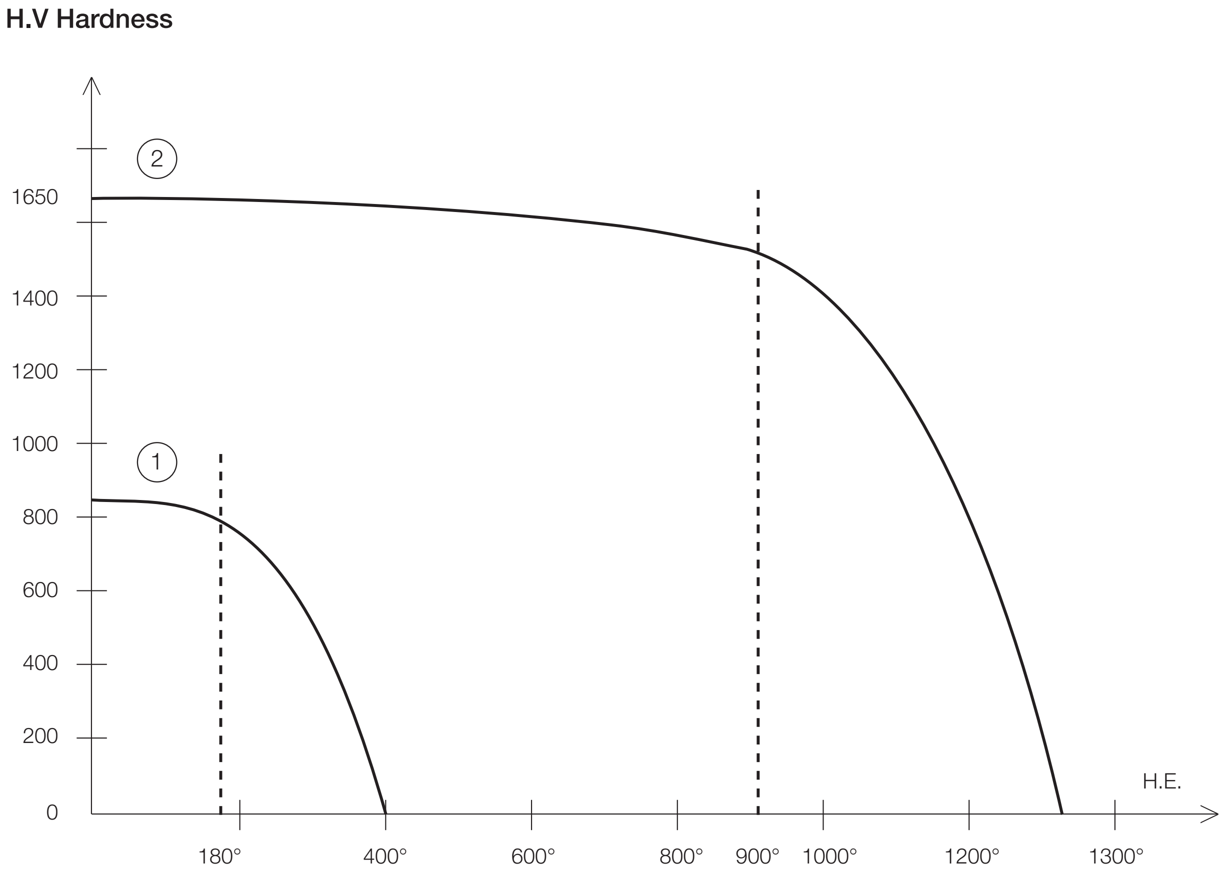
Advantages:
– Breaks the shavings of soft and homogeneous materials.
– Reduces cutting pressure.
– Less vibration

Disadvantage:
– Mere half-life than non croos-cut burs.
– Uneven surface.

Burs cutting half-life

A bur cutting half-life depends on the material it is made of and its thermical limit.

The thermical limit is the temperature point where all materials are starting to loose their characteristics, in this case their hardness.



Curve 1: Steel burs
Thermical limit 180º C

Curve 2: Carbide tungsten burs
Thermical limit 900º C.

Steel burs' colour modification at 180º (yellowish) indicates that the qualities of thermicaly treated burs are diminished.

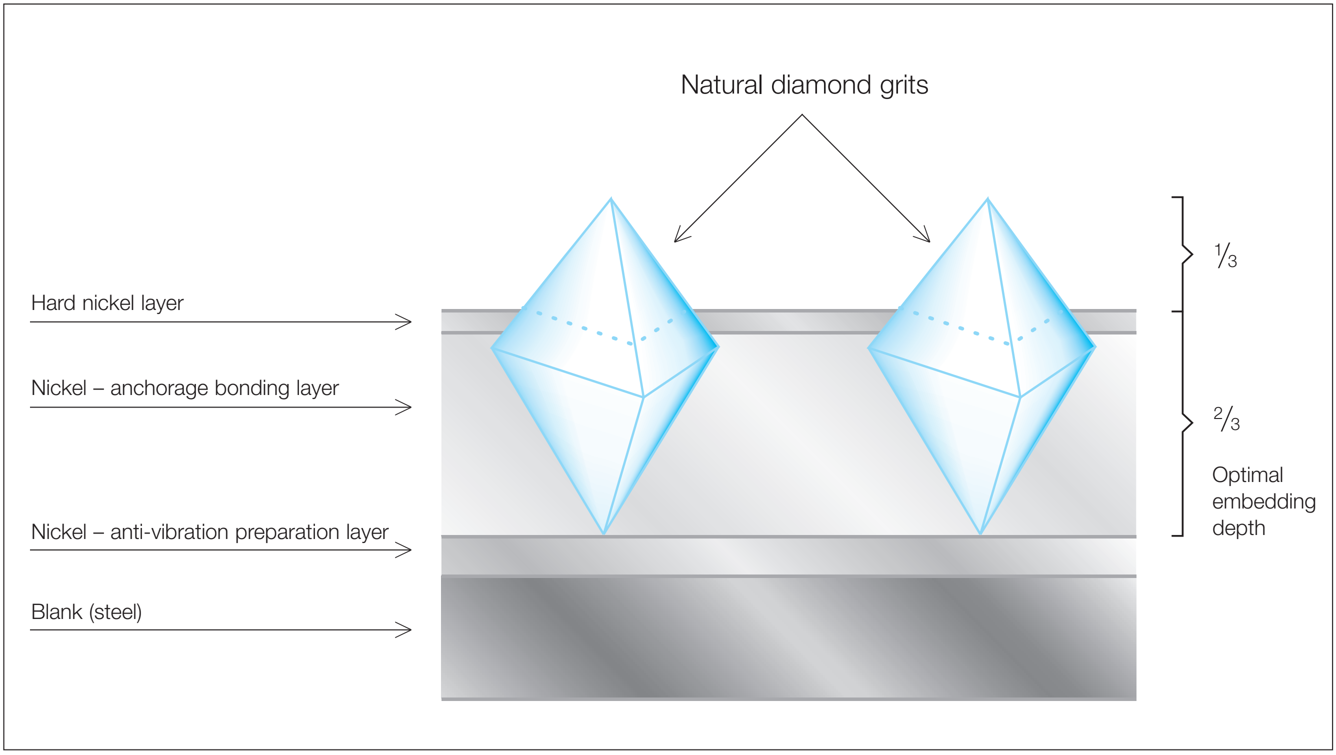
The process is the same for tungsten carbide burs when they turn to a reddish colour (900º).

Diamond Instruments

Diamond instruments are made of high-tensile stainless steel (monobloc).

The diamond grits are bonded to the blank by means of a special electroplating process.

This process has three phases:
– a preparation nickel layer playing an anti-vibration role.
– an anchorage layer, bonding the grits.
– a hard nickel layer to strongly fix the diamond grits.



They can be made with natural or synthetic diamond grits. Taking into account the natural diamond grit superiority, we will fix our eyes on them from now on.

Physical properties of these grits are:

– Their high hardness
– Their great purity
– Their shape
– Their structure

1 – Hardness

With a density of 3.5, diamond is the hardest natural mineral.

– Specific weight: 3.514
– Molecular mass: 12.01
– Hardness: 10 MOHS = 8000 H.V.

2 – Purity

Natural diamond grits have practically no magnetic impurities as nickel, cobalt or iron.

A De Beers' study compares purity of natural and synthetic diamonds.

Comparison between natural and synthetic diamonds		
	Natural diamond	Synthetic diamond specially treated for electrodeposition
Iron impurities ppm	10 – 50	1000 – 7000
Magnetic susceptibility X 10-6 cgs	0 – 4	110 – 170

3 – The shape

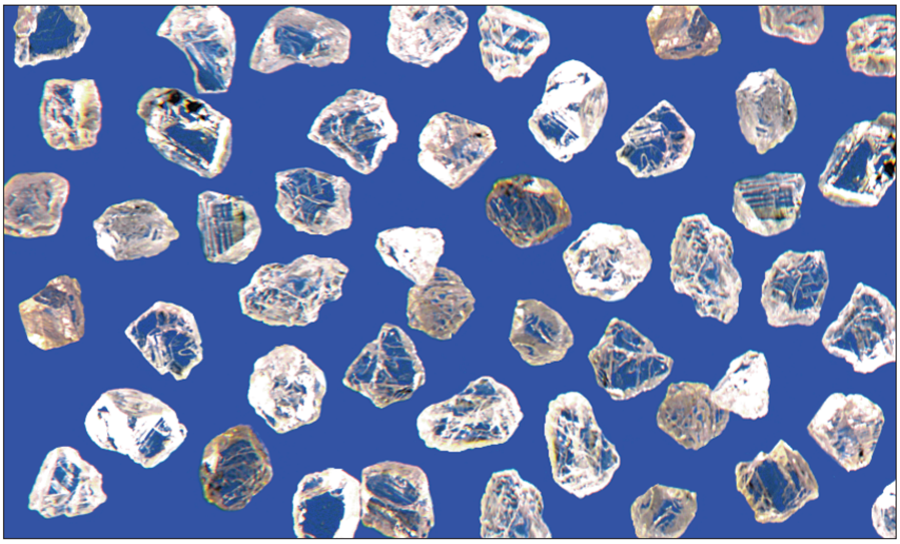
The octahedral shape of natural diamond grits, allows a high diamond density and regular inter-grit spaces, both necessary for an optimal removal of shavings.

The obtained concentration is between 50 and 60% of the surface, while the theoretical optimum concentration reached with spheres is 75%.

Diamond grits must be calibrated in order to ensure an optimal and regular concentration on the instrument. Their even distribution will guarantee a perfect concentric rotation of the bur.

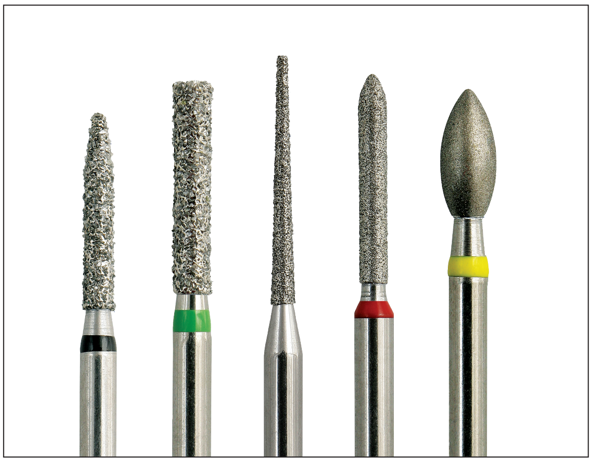
4 – Superficial structure

The irregular surface of natural diamond grits has very good retentive effects on the nickel-bonding layer and improves the abrasive performance thanks to their sharp cutting edges.



Calibrated grits are mostly distributed in five different abrasion types:

- **Extra-coarse diamond grits** (150-180 microns): black ring on the shank. (ISO 544)
- **Coarse diamond grits** (125-150 microns): green ring on the shank. (ISO 534)
- **Medium diamond grits** (106 microns): without ring on the shank. (ISO 524)
- **Fine diamond grits** (45 microns): red ring on the shank. (ISO 514)
- **Extra-fine diamond grits** (15 microns): yellow ring on the shank. (ISO 504)



Instruments with coarse and extra-coarse grits

Quality of the obtained surface: Ra = 12.5 / Rt 49.0.

Advantages:
- Support high cutting pressure.
- Great abrasion ability, very convenient for reduction.
- Long half-life.

Disadvantages:
- Surface roughness.
- Vibrations.
- Inappropriate for long and slim instruments.

Instruments with medium (standard) grits

Quality of the obtained surface: Ra = 9.5 / Rt = 42.5.

Advantages:
- Good abrasion ability.
- Nearly no few vibrations.
- Suited for enamel treatment.

Disadvantage:
- Surface roughness.

Instruments with fine and extra fine grits

Quality of the state of the obtained surface: Ra = 4.1 / Rt = 22.0.

Advantages:
- Absence of vibration.
- Surface smoothness.
- Finish quality.

Disadvantages:
- Poor abrasion ability.
- Short half-life, especially with high pressure.
- Easily obstructed.
- Heating.

5 – Abrasion half-life of the diamond instruments based on the materials and substances treated.

Half-life of abrasive diamond instruments depends on the work done and the way they are used. Their wearing out comes from the fracture or the de-set of the diamond grits.

Half-life of instruments can be increased by incorrect use.

- Enamel causes a normal wearing out.
- Healthy dentin, cements and composites alter the instrument minimally.
- Amalgam and gold obstruct the space between diamond grits more than they wear the instrument out.
- Steel, chrome-nickel and chrome-cobalt alter the instrument rapidly.
- The tip of a steel post included in a restoration may damage the abrasive surface.
- A “twisting” instrument, due to bad calibration or to a defective driving mode, has a very small sectorial active surface that will wear out fast and irregularly. The fast wear out of the fine tips of certain instruments can be associated to this phenomenon.

The wear of a diamond instrument only alters the superficial abrasive coating; the initial profile shape remains practically unchanged.

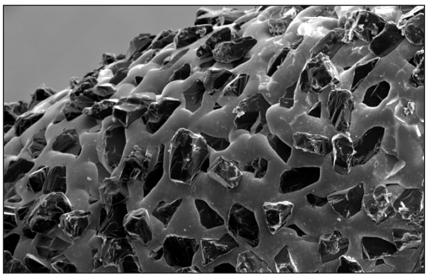
The working head of certain diamond instruments (sintered) is composed of diamond grits bonded with a bronze alloy. Wearing out the peripheral grits and the bronze alloy brings out new diamond grits, regenerating permanently the abrasive zone, and providing the instrument with a longer abrasive half-life.

Sintered diamond instruments are used for:
- Smoothing the surface of ceramics, gold, steel and all chrome-cobalt alloys.
- Separating ceramic bridges.
- Cutting crowns.
- Working on non precious metal cast models.

Factors influencing the abrasion capacity

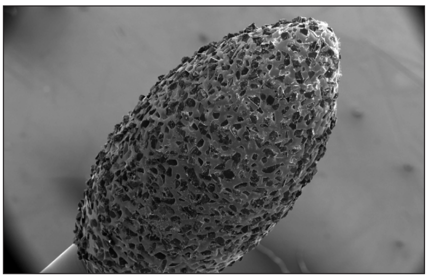
These factors are:

- Grit hardness.
- Grit size.
- Grits concentration (density of the diamond grits).
- Bonding characteristics.
- Torque transmitted by the driving mode.



Big grits
+ high concentration
+ appropriate bonding
+ high torque

= great efficiency



Fine grits
+ low concentration
+ inappropriate bonding
+ low torque

= poor efficiency

Risk analysis of dental rotary instruments

Dental burs are used in a variety of dental procedures to excavate, form or finish both natural and man-made dental materials such as tooth enamel and dentin, bone, amalgams, resins, porcelains, metals, etc.

Dental burs are driven by turbines, contra-angles or handpieces. The driving mode provides the rotation and the torque to the bur and provides the user with the necessary manual control.Driving modes come in two basic styles, slow speed and high speed. The driving modes also provide cooling water and sometimes illumination to the work area during a procedure. Driving modes are powered either by air (rotor) or by an electrical engine. Loss of power will simply stop the rotation.

Dental burs are intended to be used by trained professional dentists, orthodontists and other dental professionals. All such professionals receive training in the selection and use of dental burs and driving modes.

1 – The construction of dental burs varies as follows:

- Tungsten carbide burs are composed of a tungsten carbide working part fused onto a steel shank. The shank of the burs are sometimes nickel plated for corrosion resistance;
- Solid tungsten carbide burs are made from solid carbide blanks. This means that the shank and working part are made from a single carbide part and no weld joint exists. The shanks may be nickel plated.
- Diamond burs are stainless steel blanks with the desired shank and working part shapes. The diamond is then applied to the working part with a nickel coating.

2 – Potential Hazards

- Breakage of working tungsten carbide part. This may occur along the length of the tungsten carbide working part, or in the case of burs with weld joints, it may happen at the weld joint.
- Bending of the neck.
- Escape from driving mode.
- Bacteriological cross contamination.

3 – Estimation of risk

- **Breakage** – Failure of the weld joint of tungsten carbide material would require removal of the broken part from the patient. This broken part may be embedded in the work material or fall freely. If not removed the broken part may be a source of infection and discomfort but no negative biocompatibility effects have been recorded. Breakage is a result of poor weld strength, overload due to improper use or selection of bur by the dentist as well as corrosive deterioration of the weld joint due to sterilization processes.
- **Bending of the neck** – This implies permanent deformation of the neck. Sudden deformation would cause excessive eccentricity of the bur and could cause tooth damage. Deformation is caused by overload due to improper bur selection or application by the dentist or by improper heat treatment of the necks.
- **Escape from handpiece** – Most high speed handpieces use a ”friction grip” style of chucking system for the burs. If gripping is not adequate while the bur is rotating, it may slowly move out of the chuck and ”escape”. Again, this would create excessive eccentricity and could cause tooth damage. Escape may be caused by undersize shanks or either by oversize or worn driving mode chucks.
- **Biological cross contamination** – Burs, by their intended use and nature can be sources of biological cross contamination between patients.

4 – Risk Prevention and Reduction

- **Breakage** – In production, strength is carefully controlled. "User information's and Hygiene recommendation's" are made available to reduce overload and recommendations for sterilization to reduce effects of corrosive deterioration of the weld joint.
- **Bending of the neck** – In production, neck stiffness is carefully controlled. "User information's and Hygiene recommendation's" are made available to reduce overload.
- **Escape from handpiece** – All bur shanks are produced and controlled to international standards. Driving mode manufacturers do the same. This ensures proper gripping of burs for all styles of driving modes. "User information's and Hygiene recommendation's" are made available for proper chucking of burs.
- **Biological cross contamination** – This is insured by training of dental professionals and recommendations placed in the "User information's and Hygiene recommendation's" made available.

5 – Risk Summary

Based on the clinical safety record of the last several decades and the preventive measures taken, dental burs are considered to have adequate safety.

In 1995, burs returned for breakage complaints represented 0.035% of the total burs shipped. Since 1995, the quantity of breakage complaints and quantity of product shipped has increased at the same rate. For the other risks, minimal data has been collected for related product complaints.