Review Article

Nano in micro – The role of nanobrush in dentistry

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ABSTRACT

Nanotechnology or nanoscience refers to a field of applied science whose theme is the control of matter on an atomic or molecular scale. In general, nanotechnology deals with structures 100 nm or smaller and involves developing materials or devices within that size. Nanotechnology entered dentistry with the advancements in diagnostics, material sciences (mainly composites and bonding agents), preventive dentistry, and dental surgical procedures. A new standard innovation in endodontics is the use of nanobrush for cleaning the root canals along with irrigating solutions. This article is a review that highlights the significance of nanobrush in dentistry.

KEY WORDS: Den brush, Endodontic irrigation, Nanobrush, Nanodentistry, Nanotechnology

INTRODUCTION

Brushes are common tools used in industry and our daily life for performing a variety of tasks such as cleaning, scraping, and applying. Typical materials for constructing brush bristles include human hairs, synthetic polymer fibers, and metal wires. The performance of these bristles is limited due to oxidation and degradation of metal wires, poor strength of natural hairs, and low thermal stability of synthetic fibers. Carbon nanotubes (CNTs) with excellent mechanical properties, high elasticity, thermal conductivity, and large surface area (50–200 m^2g^{-1}) are used for the construction of nanobrushes.

Discovery

The smallest nanotube brushes with bristles more than a 1000 times finer than a human hair were created by researchers of Rensselaer Polytechnic Institute of troy – Dr. Pulickel M. Ajayan, New York and the University of Hawaii at Manoa – Cao *et al.* from Honolulu, Hawaii, in June 2005.[1] This discovery was published in the Guinness Book of World Records in May 2008. This was first commercially introduced by Denbur, Inc. Company in December 2008.

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Construction of Nanobrush

The nanobrush consists of silicon carbide (SiC) fiber with a diameter of 16 µm as the handle and aligned multiwalled CNTs grafted on the fiber ends as bristles. CNTs of diameter 30 nm are grown by chemical vapor deposition (CVD) method. Before the CVD, the individual SiC fibers are masked by a 15 nm gold layer at the top ends placed vertically to limit the growth of the nanotubes at the fiber ends. The nanotubes grow in three prongs symmetrically distributed around the central fiber axis and have uniform length <60 µm after 40 min growth. Within the prongs, the nanotubes are well aligned with the tips exposed at the edges. The individual brush has 60 µm long nanotube bristles spanning over 300 µm, compared with current commercial brushes having bristles of 0.038–1.9 mm in diameter and a core block size of more than 3 mm. These nanotube brushes are 1000 times smaller and the overall size is decreased more than 20 times. The total weight of a single brush is <50 µg. The contact surface area per unit volume is about 11.3 μm^{-8}; this is three orders higher than a typical toothbrush 1.37×10^{-2} μm^{-8}. The actual contact area is larger when the bristles are pressed against the contacting surface.[2]

Various styles of brushes are obtained by designing the gold mask area on SiC fibers and growth conditions. The brush size including trim length (nanotube length) and bristle span (the length of the handle covered by

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the bristles) is well controlled by the CVD process. The trim length can be varied from hundreds down to few micrometers depending on the growth time. By adjusting the gold masked portion of the SiC fiber, researchers have obtained brushes with bristle span ranging from several micrometers to millimeters.

The geometry of the bristles can be different such as three prongs like a dust sweeper, two prongs resembling a handheld fan, and a one prong toothbrush. Double-ended brushes with different bristle geometry are also available.

Applications of Nanobrushes

This is a new standard innovation in endodontics used for cleaning the root canal and can be used along with irrigating solutions for improved efficacy. The nanobrush follows the natural anatomy to access the root canal. It penetrates deep into the dentinal tubules and the lateral canals. With its fibers, the nanobrush thoroughly and effectively cleanses the root canal and allows precise application of materials. With the nanobrush, the resin sealers can penetrate deep into the dentinal tubules and the lateral canals.[2]

The nanobrush is made of pliable material. The shaft of the applicator can bend to any angle. The applicator is used with its extended handle or independently with its access handle. To use nanobrush with its extended handle, there is no need to secure the applicator with a nylon string. The extended handle gives ample holding space to have thorough control of the applicator while proceeding with the treatment.

Easy shake is a revolutionary handheld dispenser. It allows to dispense one applicator at a time to the last without touching other applicators. The dispenser has a semi-cylindrical shape with a flattened area and a rounded area. The flat side facilitates guiding the applicators to a passageway. The shield covering separates the main body from the passageway. The purpose of separating the main body from the passageway is to prevent applicators to pile on top of each other in the passageway. As a result, only one applicator is touched and dispensed at a time – to the last applicator.[3-5]

A total of 120 applicators are dispensed in the Easy-Shake Dispenser. Nanobrush is available in four different types with the diameter of tip size ranging from 30 to 45 ISO size [Table 1] [Figure 1]. Depending on the length of the bristles on the shank, nanobrushes are categorized as short and long [Figure 2].

Nanobrush can be used with the access handle as well. To separate the extended handle from the nanobrush, bend the bottleneck area above the access handle, bend again then twist, and bend and twist again. The long extended handle will separate from the access handle

Table 1: Nanobrushes available with four different tip sizes

Number	Color	Length of bristles	Tip size
934 120	Green	Short	30–35
934 121	Green	Long	30–35
934 122	Black	Short	40–45
934 123	Black	Long	40–45

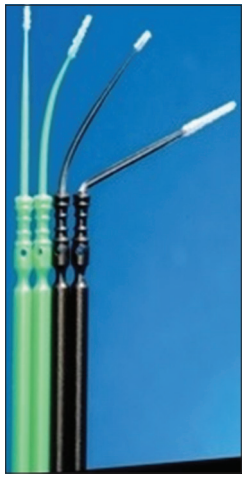

Figure 1: Four applicator sizes – nanobrush (courtesy – Denbur, Inc.) www.denbur.com

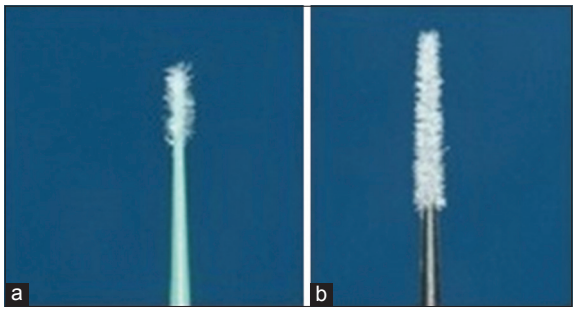

Figure 2: Nanobrush – (a) short, (b) long (courtesy – Denbur, Inc.) www.denbur.com

of the nanobrush. Thus, the nanobrush is secured the way, an endodontic file is secured to the finger.[6,7]

The nanobrush is also used for interdental cleaning. The disposable interdental tips deliver enhanced control, comfort, and precision to flush out lodged food particles while irrigating and cleaning between teeth. With its axial opening and semicircular structure, it is easily placed between teeth for thorough cleaning. Its bendable neck allows access to molars and posterior areas, interproximal areas, anterior teeth, and palate.

Nanobrush used for interdental cleaning – is called Den brush. The conventional interdental brush with a disposable triangular fibrous brush tends to sustain a thin wire with bristles cylindrically integrated within the wire. Such cleaning devices are suitable for larger interdental areas. However, due to their cylindrical design, they may irritate the gingival tissues, as the bristles extend radically from the wire, they form a

cylindrical design that does not correspond to the natural anatomy of the interdental spaces. Thus, the bristles frictionally interfere with or undesirably contact the interproximal gingival non-keratinized epithelial tissues.

Den brush is coated with biocompatible bristles on three sides: The edge and the portion of both opposing sidewalls, while the back wall is void of any bristles. The back wall corresponds to or is positioned with respect to user's gingival margin. A small indentation in the back wall prevents Den brush to place unnecessary pressure on the gingiva. At the same time, because the back wall is void of bristles, contact between the back wall and the gingival areas during the use of Den brush will not irritate the user's gingival tissues.

There are two indentations in the handle portion to allow Den brush to be bent into desired position. Both ends of the handle are rounded while the middle area consists of two flat sides for controlled and convenient holding position. Handle length allows user to easily reach all areas of upper and lower jaw. Den brush is also available in a version without bristles known as den pick.[8]

A study conducted by Al-Hadlaq *et al*., in 2006, to evaluate the efficacy of Navitip FX (a 30 gauge irrigation needle covered with a nanobrush) in removing root canal debris during the canal preparation. Scanning electron microscopic images taken from the canal wall at the apical, middle, and coronal thirds, showed low debris scores when cleaning and irrigation was done with Navitip FX in all the thirds, especially in the apical third compared to irrigation done with Navitip.[9]

CONCLUSION

Nanotechnology will transform and revolutionize the face of dentistry with advancements in dental materials sciences. Nanodentistry will make possible the maintenance of near-perfect oral health by individual specific diagnostic and treatment measures. Nanobrush commonly used for interdental cleaning is one among the most advanced scientific and technological innovations in nanodentistry. It adapts perfectly to the natural canal anatomy, penetrates deep into the radicular dentin tubules, and enables complete debridement of the root canal when used along with irrigating solutions. The role of nanobrush in dentistry is only partially understood and further clinical studies are needed until its potential applications are completely unraveled.

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