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Carbon Nanotubes in Orthodontics

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Short Communication

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ABSTRACT

In orthodontics, almost 12-60% of applied force is lost due to friction. This can have an overall affect in the efficiency of treatment, resulting in increased treatment time and compromised treatment results caused due to loss of anchorage. Carbon nanotubes are being recently experimented in various fields of science because of their wide variety of applications. Due to its superior mechanical properties it could be employed in orthodontics in the near future. With the introduction of carbon nanotubes in orthodontics, both patient and clinician would be benefited. As a clinician, predictive treatment outcome will be possible with decreased chair side time and better treatment outcome. As a patient, the treatment duration will be considerably reduced which is always advantageous.

INTRODUCTION

Friction is one of the parameters in orthodontics which decides the performance, reliability and efficiency of the orthodontic systems. Variables that affect friction in orthodontics depend on the following factors **(Figure 1)**.

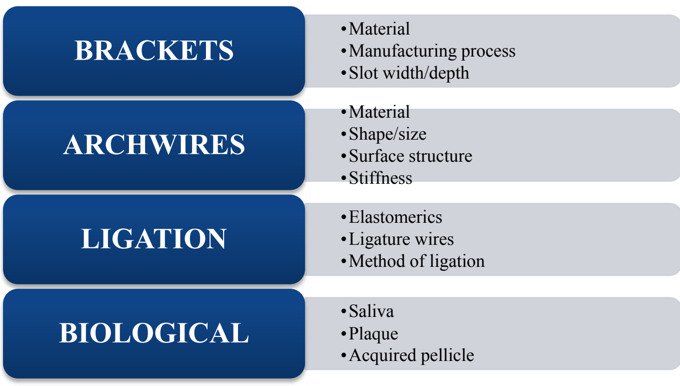

Figure 1. Variables affecting friction in orthodontics.

All these factors have helped us identify patterns of friction which can happen in dry or wet environment [1,2]. As friction increases, the treatment results are compromised and the treatment duration increased.

One of the newly explored fields to resolve this crisis is the introduction of carbon naotubes (CNTs). The discovery of CNTs by Iijima in 1991 has opened up a new era in materials science.

What is Carbon Nanotube?

A carbon nanotube is a cylindrical, tube-shaped material, made of carbon, having a diameter measuring in nanometres. CNTs are at least 100 times stronger than steel, but only one-sixth as heavy. The size, shape and exceptional physical properties

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make these large macromolecules distinctive in nature [3].

HISTORY

In 1970s Morinobu Endo, a Ph.D student at the University of Orleans, France was completing the preparation of planned carbon filaments. The growth of these filaments was initially thought to be the first CNTs. However, they failed to meet the measurement requirements for width and thus were considered as barrelenes. After 20 years, in 1991, the true first invention of nanotube was credited to Sumio Iijima of IBM.

TYPES

There are two basic types of CNTs:

1. Single-walled Carbon Nanotubes (SWNTs)

A. Cylindrical in structure.

B. Can be twisted, flattened and bent into small circles without breaking.

C. Most SWNTs have a diameter close to 1 nm, with a tube length that can be thousand times longer.

D. There are three definite ways in which this graphene sheet can be rolled into a tube:

I. Armchair

II. Zig-zag

III. Chiral

2. Multi-walled Carbon Nanotubes (MWNTs)

A. Made of two or more coaxial cylinders.

B. Has a diameter close to 50 nm.

C. There are two models which can be used to describe the structures of MWNTs:

I. The Russian Doll model: sheets of graphite are arranged in concentric cylinders.

II. The Parchment model: a single sheet of graphite is rolled in around itself, resembling a rolled up newspaper.

PROPERTIES

1. High tensile strength.
2. High electrical and thermal conductivity.
3. Acts as high quality electron field-emitter, largely due to their increased length-to-diameter ratios.
4. Highly flexible.
5. Very elastic.
6. Low thermal expansion coefficient.

Synthesis/Fabrication of CNTs

Various methods can be employed:

1. Arc discharge method
2. Laser ablation method
3. Chemical vapor deposition method

There are three different ways in which the chemical reactions are initiated:

A. Plasma enhanced chemical vapor deposition

B. Thermal chemical vapor deposition

C. Vapor phase growth

Characterization of Carbon Nanotubes

Study of these CNTs can be done by following methods:

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1. Scanning electron microscopy
2. Field emission scanning electron microscopy
3. Atomic force microscope
4. Transmission electron microscopy
5. Energy dispersive X-ray spectroscopy
6. Raman spectroscopy
7. X-ray diffraction

APPLICATIONS

CNTs have found applications in several fields such as **(Figure 2)**.

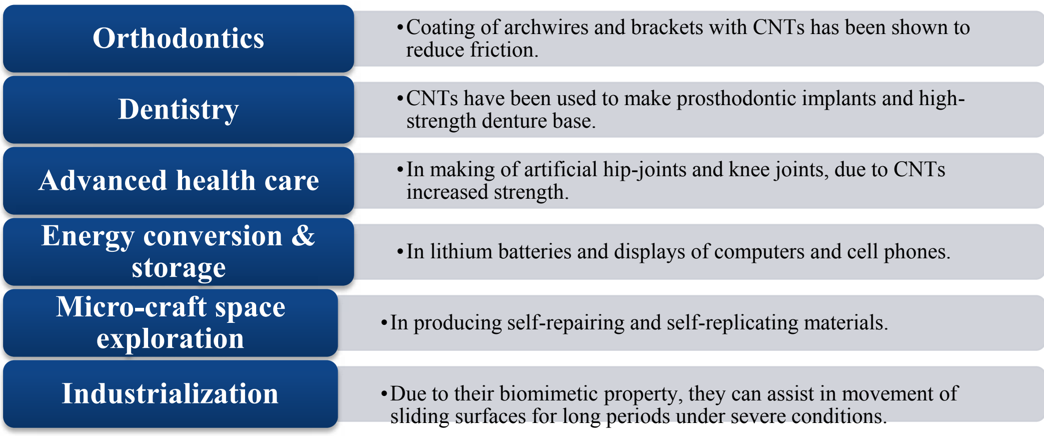

Figure 2. CNT applications.

BIOLOGICAL CONCERNS

The toxicity of CNTs has always evoked caution in nanotechnology. Variables such as structure, size distribution, surface area, surface chemistry, surface charge, agglomeration and purity of the samples, have significant impact on the reactivity of CNTs. However, available data clearly states that, nanotubes can cross membrane barriers, under some conditions. This indicates that they can induce harmful effects such as inflammatory and fibrotic reactions if the raw materials reach the organs [4,5].

CONCLUSION

Maximizing the efficiency and reproducibility of the orthodontic appliances can help to optimize friction. This can be achieved by introducing CNTs to the orthodontic system. With the CNT coated bracket and arch wire we would be able to have a predictable treatment outcome with better anchorage control and thus reduced treatment duration and better treatment outcome

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