This Journal has free content and no advertisement since many years. Even if commerce is fine, here we prefer to have no company pressures. If everyone reading this Journal would donate a few euros or dollars, we could publish more, and more often. We know that not everyone can, or will, donate, but that is fine.

Please, if you find these pages useful, consider making a donation of €5, €20, €50, or whatever you can, to sustain Virtual Journal of Orthodontics.

Thanks,
Gabriele Floria
VJO Founder
TRIBOLOGY: A NEW FRONTIER IN ORTHODONTICS

AUTHORS:

1. Dr. Anitha. A (B. D. S, M. D. S.) Ph. D Scholar and Assistant Professor Department of Orthodontics and Dentofacial Orthopaedics. A. J. Institute of Dental Sciences, Rajiv Gandhi University of Health Sciences, Mangalore - 575004, Karnataka, India.

2. Dr. Akhter Husain (B. D. S, M. D. S., Diplomat, Indian Board of Orthodontics.) Ph. D Scholar, Professor and Head Department of Orthodontics and Dentofacial Orthopaedics. Yenepoya Dental College, Yenepoya University, Mangalore - 575018, Karnataka, India.

3. Dr. Raghuvir Ballambat (B. E, M. E, Ph. D) Director of Research Department of Mechanical Engineering Manipal Institute of Technology, Manipal University - 576104, Karnataka, India.

4. Dr. Raghavendra Kini (B. D. S, M. D. S) Senior Professor Department of Oral Medicine and Radiology, A. J. Institute of Dental Sciences, Rajiv Gandhi University of Health Sciences, Mangalore - 575004, Karnataka, India.

5. Dr. Nillan Shetty (B. D. S, M. D. S) Senior Professor Department of Orthodontics and Dentofacial Orthopaedics, A. J. Institute of Dental Sciences, Rajiv Gandhi University of Health Sciences, Mangalore - 575004, Karnataka, India.

6. Dr. Rohan Mascarenhas (B. D. S, M. D. S., Diplomat, Indian Board of Orthodontics.) Ph. D Scholar and Senior Professor Department of Orthodontics and Dentofacial Orthopaedics. Yenepoya Dental College, Yenepoya University, Mangalore - 575018, Karnataka, India.

7. Dr. Rohan Rai (B. D. S, M. D. S) Professor and Head Department of Orthodontics and Dentofacial Orthopaedics, A. J. Institute of Dental Sciences, Rajiv Gandhi University of Health Sciences, Mangalore - 575004, Karnataka, India.

Address of Correspondence:

Dr. Anitha. A (B. D. S, M. D. S.)
Ph. D Scholar and Assistant Professor Department of Orthodontics and Dentofacial Orthopaedics. A. J. Institute of Dental Sciences, Rajiv Gandhi University of Health Sciences, Mangalore - 575004, Karnataka, India.
Phone No: +91-7259191971; +91-8242458403; Email: anitha_4485@yahoo.in
Fax: 0824-2224968; 0824-2225541

Abstract:

Tribology is the science and engineering of interacting surfaces in relative motion. It includes the study and application of principles of friction, lubrication and wear. Friction is a force that retards or resists the relative motion of two objects in contact. In Orthodontics, friction is a clinical challenge which is generated by an archwire and bracket and is influenced by interaction of many variables like the bracket composition, bracket width, interbracket distance, slot size, arch wire, second order angulation, degree of torsion, ligation, and wet and dry environment. The ability to quantify and control friction will lead to less anchorage loss, more predictable tooth movement, and the use of ideal force levels to overcome friction and optimize physiological tooth movement.
An understanding of this mechanism is imperative as this insight enables the Orthodontist appropriate utilization of orthodontic biomechanical principles, as well as how it pertains to the orthodontic appliances.

**Keywords:** Tribology, Friction, Nanotribology, Biotribology, Archwire-Bracket interface.

**Introduction:**

The word “Tribology” is from the Greek word tribein, meaning to rub. Tribology is the science and engineering of interacting surfaces in relative motion. It includes the study and application of the principles of friction, lubrication and wear\(^1,2\) (Fig.1).

Leonardo da Vinci who is considered as the Father of Modern Tribology is credited with formulating some of the first fundamentals of friction and also apparently sketched designs for anti-friction bearings.

**Friction:**

Friction is a force that retards or resists the relative motion of two objects in contact. Friction is the product of coefficient of friction and normal force. As the two surfaces in contact slide against each other, two components of total force arises. The frictional force component (F) and the normal force (N) perpendicular to the contacting surface and to the frictional force component (Fig 2).\(^3\)

![Figure 1: Components of Tribology](image1)

![Figure 2: Relationship between friction and contact surface area.](image2)

Frictional force is directly proportional to the normal force such that, \( F = \mu N \) where,

- \( \mu = \) Coefficient of friction i.e. surface roughness of material.

- \( N = \) Normal force i.e. the force acting perpendicular to the object.
**Lubrication:**

Lubrication is the process or technique employed to reduce wear of one or both surfaces in close proximity and moving relative to each other, by interposing a substance called lubricant between the surfaces to carry the load between the opposing surfaces. The interposed lubricant film can be a solid (ex: graphite), a solid/liquid dispersion, a liquid/liquid dispersion (ex: grease) or exceptionally, gas.\(^4\)

**Wear:**

Wear is erosion or sideways displacement of material from its "derivative" and original position on a solid surface performed by the action of another surface. Some commonly referred to wear mechanisms include:

- Adhesive wear
- Abrasive wear
- Surface fatigue
- Fretting wear
- Erosive wear

What is Nanotribology?

Nanotribology can be defined as the investigations of interfacial processes, on scales ranging in the molecular and atomic scale, occurring during adhesion, friction, scratching, wear, nano-indentation, and thin-film lubrication at sliding surfaces.\(^5\) The need for Nanotribology can be summarized as follows:

- For advanced health care: to modify surfaces in order to create structures that control interaction between materials and biological systems.

- For energy conversion and storage: nanoscale carbide coatings, self-assembled layers for friction control, materials performances at nano- and MEMS scale as a function of aging. For in-situ lubrication study and control.

- Microcraft space exploration and Industrialization: to make self repairing materials and self-replicating, biomemmetic materials and nanoscale devices which can sustain any need for movement of sliding surfaces for long periods under severe conditions.

What is Biotribology?

In the human body many tissues move in relation to one another, and the body has to allow for that movement or
the tissue will split and break down. It is a multidisciplinary field of research involving biology, orthopaedics, biomaterials, science and tribology and thus a study of friction, wear and lubrication of biological systems.\textsuperscript{6} Presently its significance lies in the following fields:

- Making hip replacements last.
- Maintaining the blood flow with the help of LVAD device.
- Ocular tribology
- Dental tribology

\textbf{Role of Tribology in Orthodontics:}

In Orthodontics, Tribology plays a very important role in the performance, reliability, efficiency and optimization of the orthodontic systems. Studies of the myriad of parameters, such as bracket composition, bracket width, interbracket distance, slot size, arch wire type, arch wire size, second order angulation, degree of torsion, ligation, and wet or dry environment, have helped our understanding by identifying trends or patterns of friction.\textsuperscript{7,8} The orthodontic literature notes numerous variables that affect the levels of friction at the bracket-archwire interface. In addition, experimental protocol and design often affect the outcome of in vitro frictional studies.\textsuperscript{9,10} The nature of friction in orthodontics is multi-factorial, derived from both a multitude of mechanical or biological factors. Numerous variables have been assessed using a variety of model systems with nearly equally varying results.

Methods to evaluate the Tribological characteristics of the existing Orthodontic systems:

- Pin on Disc Tribometer: It consists of a stationary "pin" under an applied load in contact with a rotating disc. The pin can have any shape to simulate a specific contact, but spherical tips are often used to simplify the contact geometry.\textsuperscript{11} Coefficient of friction is determined by the ratio of the frictional force to the loading force on the pin. The pin on disc test has proved useful in providing a simple wear and friction test for low friction coatings.

- A Universal Friction Tester\textsuperscript{12} can also be used to draw conclusions on ideal requirements for improving the effectiveness of Orthodontic systems.

- Finite element analysis (FEA) is a computer based numerical technique for calculating the strength and behavior of materials. Until the early 1970's FEA was limited to aeronautics, automotive, de-
fense and nuclear research. However, the present day computers are now able to handle FEA for different applications. In Orthodontics FEM\textsuperscript{13} has been used for studying stress distribution in the teeth, periodontal ligament and in the Orthodontic appliances. Orthodontic bracket systems and appliances have been modeled and studied to understand how the materials would act under various biological conditions.

- A scanning electron microscope (SEM) is a type of electron microscope that produces images of a sample by scanning it with a focused beam of electrons. The electrons interact with electrons in the sample, producing various signals that can be detected and which contains information about the sample’s surface topography and composition.\textsuperscript{14} This principle can be used to study the surface roughness and surface changes of the given materials.

**Conclusion:**

Friction is not likely to be eliminated from materials, thus the best remedy is to control friction by achieving two clinical objectives: maximizing both the efficiency and the reproducibility of the orthodontic appliances. Efficiency refers to the fraction of force delivered with respect to the force applied, while reproducibility refers to the ability of the clinician to activate the orthodontic appliance so that it behaves in a predictable manner. Therefore, the clinician should be aware of the characteristics of the orthodontic appliance that contribute to friction during sliding mechanics and the extent of the amount of force expected to be lost to friction. This will help allow efficient reproducible results to be achieved.

**References:**


