

## Tribology of medical devices

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Received 23 November 2016; received in revised form 8 December 2016; accepted 8 December 2016

### Abstract

Importance of tribology in a number of medical devices and surgical instruments is reviewed, including artificial joints, artificial teeth, dental implants and orthodontic appliances, cardiovascular devices, contact lenses, artificial limbs and surgical instruments. The current focus and future developments of these medical devices are highlighted from a tribological point of view, together with the underlying mechanisms.

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**Keywords:** Tribology; Medical devices; Artificial joints; Dental implants; Surgical instruments

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Peer review under responsibility of Southwest Jiaotong University.

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**1. Introduction**

Medical devices are widely used in daily life, ranging from simple bandages to complex imaging equipment. Medical devices are defined in different ways from various organizations, including the Food and Drug Administration (FDA), the European Union Directive (2007/47/EC) and ISO (13485). Examples of medical devices include instruments, apparatuses, appliances, materials, etc., intended to be used in human beings for the purpose of diagnosis, prevention, monitoring, treatment, or alleviation of disease, or compensation for an injury or handicap, investigation, replacement, or modification of the anatomy or of a physiological process etc.

Medical devices are heavily regulated because of their intended uses in human beings. Generally medical devices are classified into different categories depending upon the degree of potential risks and regulated accordingly. An increasing concern has been raised recently, following on the clinical withdraw of a number of medical devices [1]. The issue to balance the safety and effectiveness of a medical device is once again called into question. Strict and comprehensive pre-clinical testing has become even more important in the evaluation of new innovative medical devices.

Many medical devices are involved with relative moving parts, either in contact to the native tissues or within the biomaterials, and often under loading. Important issues, such as friction and wear of the moving parts, not only affect the functions of these devices but also the potential adverse effects on the natural tissues. Biotribology deals with the application of tribological principles, such as friction, wear and lubrication between relatively motions surfaces, to medical and biological systems. Biotribology plays an important role in a number of medical devices.

The purpose of this review is focused on the tribology of medical devices. Specific aims include the following:

- Review important medical devices that have received extensively tribological investigations.
- Identify the corresponding gaps in research and the new directions.
- Understand the underlying tribological mechanisms that are common among different medical devices.

It is beyond the scope of the present review to include all possible medical devices in which tribology plays an important role. Instead implanted medical devices are mainly considered and only musculoskeletal, dental, and cardiovascular systems are focused. Other important medical devices for ocular and skin systems as well as medical instruments are also included. This paper is organized with an overall introduction, followed by the literature review of medical devices in each system, and finally a summary. In each section of the literature review on a biological

system, a general introduction to the use of the medical device and the potential clinical problems are firstly outlined and then the important tribological issues are discussed.

**2. Literature review**

A search was performed in Pubmed on 8th October 2016, using the following keywords “(Medical device or (Joint AND implant) or (Dental and Implant) or Contact lens or Medical instrument or Contact lens OR Cardiovascular devices OR Fracture fixation or (Artificial AND limb)) AND (tribology or friction or wear or lubrication)” and a total of 41,090 records were found. Fig. 1a shows the increasing trend of these records, particularly after the 1980s.

A narrowed down search using the keywords “Medical device AND (tribology OR friction OR wear OR lubrication)” returned a total record of 15,966, as shown in Fig. 1b.

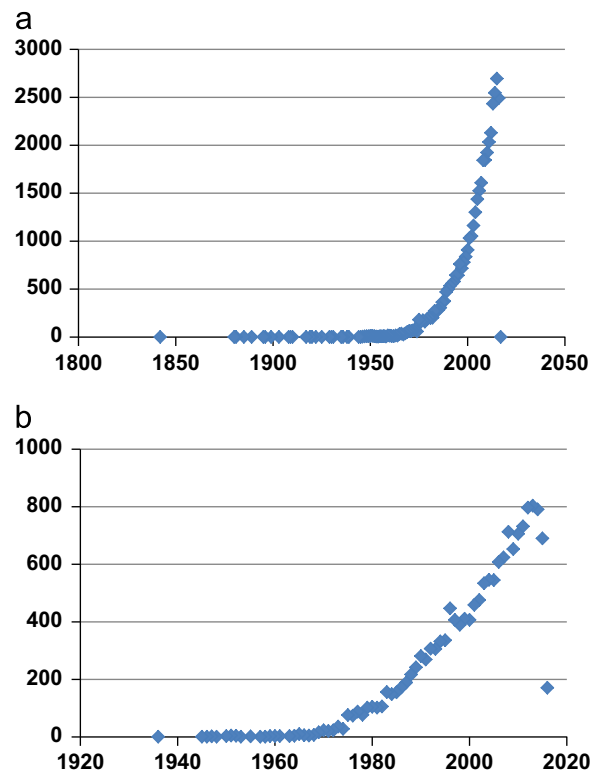


Fig. 1. (a) Number of records searched in Pubmed on 6th October 2016 against year published using keywords "Medical device or (Joint AND implant) or (Dental AND Implant) or Contact lens or Medical instrument or Contact lens OR Cardiovascular devices OR Fracture fixation or (Artificial AND limb)) AND (tribology OR friction OR wear OR lubrication)". (b) Number of records searched in Pubmed on 6th October 2016 against year published using keywords "Medical device AND (tribology OR friction OR wear OR lubrication)".

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