The International Journal of Advanced Manufacturing Technology
https://doi.org/10.1007/s00170-018-1973-2

ORIGINAL ARTICLE

Machining of biocompatible materials: a review

Kushendarsyah Saptaji[1] · Mebrahitom Asmelash Gebremariam[1] · Mohd Azmir Bin Mohd Azhari[1]

Received: 11 September 2017 / Accepted: 2 April 2018

Abstract

The need for more effective and efficient manufacturing processes to transform the biocompatible materials into high standard artificial human body components (implants) is rapidly growing. Machining of biocompatible materials as one of the key processes in manufacturing of implants need to be improved due to the significant effects of machined surface quality to the compatibility and osseointegration with human organs such as tissues, bones, and environment of the human body. The challenges of machining biocompatible materials due to their applications as bio-implants in the human body and the nature of materials properties and microstructures have been explored and solved by various researchers. This article reviews the trends and developments of the machining of biocompatible materials. A range of possible machining technologies and strategies on various biocompatible materials using conventional (milling, turning and drilling) and non-conventional or advanced (abrasive water jet machining (AWJM), ultrasonic machining (USM), ion beam machining (IBM), laser beam machining (LBM), electrical discharge machining (EDM), and electron beam machining (EBM)) are presented and discussed. This review also examines the emerging new technologies such as additives manufacturing and hybrid processes as potential solutions and future research trends in order to fulfill the high standard requirements for a wider range of applications of the biomaterials.

Keywords Biocompatible materials · Machining · Machinability · Conventional machining · Advanced machining · Micro-scale machining · Finite element analysis · Additive manufacturing

1 Introduction

The demand for biomedical implants is rapidly growing in order to improve the quality of human life. The bio-implants are mainly the bio-mimicry of natural and artificial biomaterials used for body components. Such artificial components (implants) can be used for a short period of time, long-term, or even permanent in the biological tissue if not removed surgically [1]. Currently, implants are being used in many different parts of the body for various applications such as orthopedics, pacemakers, cardiovascular stents, neural prosthetics, or drug delivery system [2, 3]. The biomedical components such as shown in Fig. 1 generally must have good corrosion resistance, suitable surface properties, sufficient mechanical strength, biocompatibility with tissues and bones, naturally degraded and disappeared in tissue, and also reliable chemical stability and safety [4]. The materials selections and design have significant effects on the implant lifespan [3].

In this case, metallic alloys such as stainless steel, titanium and its alloys, cobalt–chromium alloys, nickel–titanium shape memory alloys, and magnesium alloys are the most preferable biomaterials. Though ceramics and polymers can also be used as an implants such as in the artificial hip joints [5]. In general, the ceramic and polymer implants are used individually or assembled with other metallic materials. Titanium and its alloys are widely used in joints replacement, spine and trauma systems, dental implants, and pacemaker casings. Magnesium and its alloys are also potential metallic materials to be used as a degradable implant materials because it is less expensive [4]. It is known that magnesium is an essential element of the human body and naturally found in bone tissues and harmless excreted in the urine. However, magnesium is known for its low corrosion resistance especially in saline media that is an environment of the human body. In order to alter the corrosion resistance, surface and subsurface qualities of machined magnesium alloys are normally improved using additional finishing processes such as electrical discharge machining (EDM), electrical chemical machining (ECM), and deep rolling [6].

✉ Kushendarsyah Saptaji
kushendarsyah@ump.edu.my

[1] Faculty of Manufacturing Engineering, Universiti Malaysia Pahang, Pekan, Pahang, Malaysia

Published online: 10 May 2018