CHAPTER 1

Introduction

In this chapter will separate into the following 5 main topics ;

1. Introduction
2. Educational Advantages
3. Research Objective
4. Research Scope

1.1 Statement and Significance of Problem

Nowadays the needs of organ substitutes to replace the damaged organ are greatly increase. Bone tissue is one of the most parts that need for replacement or repair material because of the bone defects from accident and bone related diseases. To solve this problem autograft is a general method used in orthopedic surgery for bone replacement. Its advantages include good biocompatibility and no immunological response. However the disadvantage of this method is the amount of risk factor to donor site, the pain and infection from surgery and the chance of failure to integration into the defect site after implantation. Therefore bone tissue engineering has been trying to provide another technique that could be implemented to solve this problem.

Bone tissue engineering is a kind of science that applies the principle of biology and engineering together to study and develop substitutes to repair or replace the damaged bone tissue. Usually, methods to repair the damaged bone tissue include autograft, allograft and metallic replacement. Recently, there is a new popular approach for bone tissue engineering which is seeding 3D highly porous biodegradable matrices with cells and culture the cells to let the cells to proliferate in the 3D matrices. After that, implant the matrices to the defect area to induce bone tissue regeneration. As shown in figure 1.1 the scaffold is playing the role on bone tissue regeneration and being degraded after bone healing.

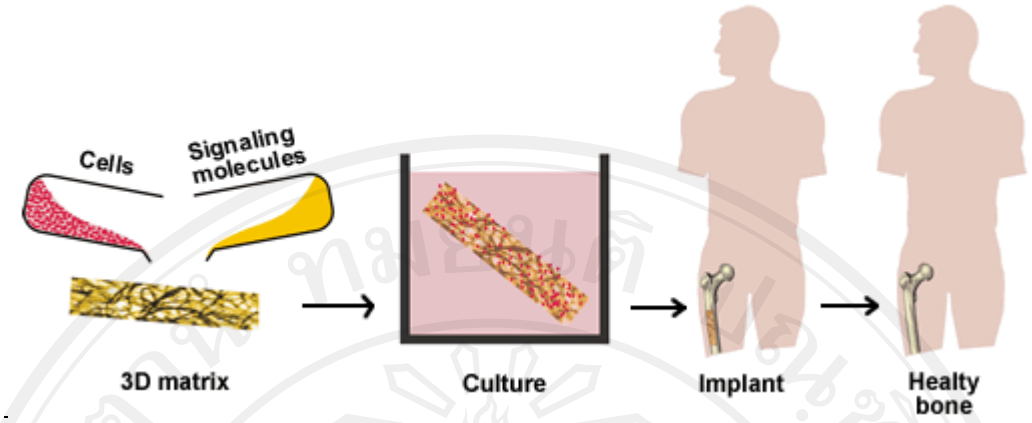

Figure 1.1 Basic principle of bone tissue engineering approaches

Bone tissue engineering creates the biological material that provides the option of implantation and prosthesis. It can be used for bone repairing in many fields including maxillofacial, orthopedic, craniofacial, and plastic surgery, which are mostly concerned with biocompatibility, non-toxicity, bioactivity, high osteoconductivity, and degradation rate.

Scaffold is a kind of biomedical device that uses to implant to the damaged tissue to help tissue regeneration. Scaffold is a 3D porous matrix that can be fabricated by three main materials including natural polymer, synthetic polymers, or ceramics. Ideally, scaffold should have the following characteristics: (1) three-dimensional and highly porous with interconnected pore network (2) biodegradability or bioresorbability (3) suitable surface chemistry for cell attachment, proliferation and differentiation (4) mechanical properties to match the tissue at transplantation sites (5) versatility to be processed into a variety of shape and size [1]. There are many ways to fabricate the scaffold such as freeze drying method, particulate leaching method, solid free form fabrication and polymer/ceramic fiber composite foam [1] each method has their own advantages.

Figure 1.2 Porous Scaffold used for tissue engineering application

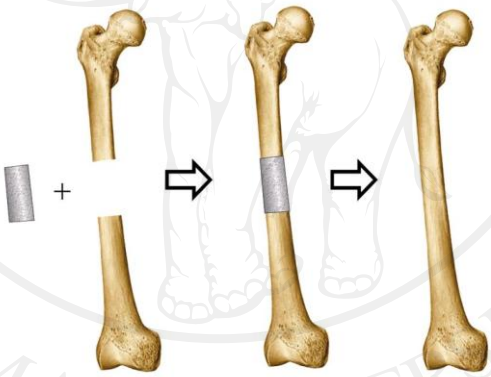

Figure 1.3 Porous Scaffold Application

Bio ceramics are widely use for bone tissue engineering recently. Hydroxyapatite ($Ca_{10}(PO_4)_6(OH)_2$) is a calcium phosphate ceramics which is the main component in inorganic part of bones and teeth. Because it has chemical composition similar to mineral in human bone tissue, hydroxyapatite is widely use in bone tissue engineering because of its good in bioactivity, osteoconductivity and biocompatibility. Moreover it is able to synthesize from CaO sources such as coral and mollusk shell which is natural and local

materials that can be found easily in Thailand. But hydroxyapatite needs to be blended with other polymer in order to form into a porous 3-d matrix due to its weakness.

The other materials that are commonly used in bone tissue engineering application are polymers. Polymers used in tissue engineering application can be divided into 2 main types which is natural polymer and synthetic polymer. There are many natural polymer that can be candidate for bone scaffold fabrication such as chitin, chitosan, collagen, and gelatin.

Chitosan is a polysaccharide derivated from chitin which is the component in structure of squid and crustacean's shell. Chitosan structure is similar to glycosaminoglycan which is the component of the extra cellular matrix of human bone and cartilage. Chitosan has potencial using in tissue engineering because its hypoallergenic, biodegradability, antimicrobial properties and can be casted in to porous structure [2] which can be an interesting candidate for bone tissue engineering application.

Figure 1.4 Squid pens (left) and Chitosan (right)

Silk fibroin is a kind of protein obtained from *Bombyx Mori,* which is a kind of domestic silkworm, which can produce silk that widely use to produce threads. In fact silk contains two kinds of proteins which are serecin and fibroin. Serecin are glue like protein which has hydrophilic properties and act as binder protein that binds fiber together [3], while fibroin which has hydrophobic properties is widely used in biomedical application

such as scaffold, suture and drug delivery [4]. Furthermore, there are many studies about on fibroin which revealed that it has good mechanical properties as well as biocompatibility. Therefore, fibroin will be the main investigation in this study, which aims to enhance scaffold properties by mixing it with HA and chitosan.

Figure 1.5 *Bombyx Mori* (up) and silk cocoon (down)

The application of the scaffold fabricated from HA/Chitosan/Fibroin mixture in this research is for bone filler because the selected materials properties are bioactive, good biocompatibility and osteoconductivity which can be a good candidate for bone tissue engineering application.

This study will focus on the preparation of porous scaffold for bone filling using natural materials which are HA from mollusk shell, chitosan and silk fibroin. With the

assumption that the combination of these three biomaterials could synergy the physical and biological property of the porous scaffold.

1.2 Educational Advantages

1.2.1 Obtain the Fibroin/HA extraction process from natural sources.

1.2.2 Obtain the properties of Fibroin/HA/Chitosan scaffold.

1.2.3 Obtain a suitable condition for fibroin scaffold fabrication by freeze drying method.

1.3 Purposes of the Study

1.3.1 To develop Fibroin/HA/Chitosan composite based scaffold for bone filler from natural sources.

1.3.2 To study properties of Fibroin/HA/Chitosan composite scaffold.

1.3.3 To find an appropriate condition for the fabrication of porous scaffold by freeze drying method.

1.4 Research Scope

1.4.1 Porous bone scaffolds from Chitosan/Fibroin/HA will be fabricated by freeze drying method.

1.4.2 Archemedes' principle will be used for characterization porosity.

1.4.3 Characterization of the physical and mechanical properties will follow bone testing standard #ASTM- F2450-10 and ASTM D5024-95a.