CHAPTER 1
INTRODUCTION

1.1 Background

1.1.1 History of miniscrew implants

The initial reports describing the use of skeletal anchorage to perform dental movements in dogs was reported by Gainsforth and Higley in 1945. Two decades later, Linkow (1969) described the clinical application of an endosseous blade implant for prosthetic treatment that was adapted to provide orthodontic anchorage. Since then, there have been several reports describing the clinical application of dental implants for orthodontic anchorage purposes (Huang *et al.*, 2005; Roberts *et al.*, 1989; Roberts *et al.*, 1990).

Although the use of dental implants had been considered an effective approach to achieve orthodontic anchorage, the clinical application of this method was limited by the small number of possible placement sites (Wehrbein *et al.*, 1996). Further disadvantages of dental implants include high costs, large size, the necessity for surgical procedures for implantation and removal and the long waiting period for osseointegration before applying orthodontic force (Block and Hoffman, 1995; Odman *et al.*, 1988).

Subsequently, Block and Hoffman (1995) developed the “onplant”, a less invasive implant device, to obtain skeletal anchorage. The onplant is a disc-like structure placed subperiosteally on the palatal bone. However, the high costs, long waiting period before loading forces, and the necessity for special hardware to connect the onplant to the orthodontic appliance have limited the clinical application of this method.

To overcome these problems, devices temporarily fixed to bone for the purpose of enhancing orthodontic anchorage and subsequently removed after use, so-called temporary skeletal anchorage devices, have been introduced (Costa *et al.*, 1998; Kanomi, 1997; Kyung *et al.*, 2003a). The most accepted temporary skeletal

anchorage device is the miniscrew implant, on account of its reduced size, low costs, simplicity of use (Cope, 2005; Lin and Liou, 2003), and wide range of clinical applications (Kyung *et al.*, 2003b; Paik *et al.*, 2002; Park *et al.*, 2001; Yun *et al.*, 2005).

In 1997, Kanomi reported the clinical application of a surgical mini-bone screw, normally used to fix bone plates in fracture repair, and a surgical procedure to use the mini-bone screw to provide maximum anchorage in a severe deep bite case. In 1998, Costa *et al.* described the first titanium miniscrew designed for orthodontic treatment. This miniscrew may have one of two different caps, one bracket-like and the other tube-like. Two years later, Melsen *et al.* (2000) reported an experimental study in monkeys to evaluate the immediate loading of an implant that was a modification of the screw design in the study of Costa *et al*.

Miniscrew implants of various designs, sizes and composition of materials have been manufactured, and reports of clinical applications of these miniscrew implants have increased from 2003 to present time (Chang *et al.*, 2004; Herman *et al.*, 2006; Lee *et al.*, 2004; Suzuki and Suzuki, 2007; Yao *et al.*, 2005).

1.1.2 Terminology and definition of miniscrew implants

Currently, terminologies for miniscrew implants vary depending on the authors, such as; micro-implant (Park *et al.*, 2001), miniscrew (Lee *et al.*, 2004), mini-implant (Kanomi, 1997), microscrew (Chang *et al.*, 2004) and miniscrew implant (Papadopoulos and Tarawneh, 2007). According to prior studies, miniscrew implants were developed mainly from two origins, the dental implant (Roberts *et al.*, 1989) and the surgical screw (Kanomi, 1997). Consequently, the proper terminology for this temporary anchorage device should show both developmental origins and present the obvious characteristic, miniature size. Therefore, “miniscrew implant” appears to be the most appropriate and accepted terminology.

In 2003, Kyung *et al.* recommended that miniscrew implants should be slightly longer and wider than the previously available surgical screws to compensate for the larger moments applied to the miniscrew implant head. In 2005, Cope implied that the term “miniscrew implant” should be used for implants having a diameter of less than 2.5 mm. Two years later, Papadopoulos *et al.* (2007) suggested that because

the devices to which the terms “mini-implant,” “miniscrew,” “microimplant,” and “microscrew” are applied are smaller than conventional dental implants and because they provide skeletal anchorage which is discontinued after treatment, in contrast to the permanent function of conventional dental implants, the new terms should not be used interchangeably with those for dental implants. In conclusion, the miniscrew implant is defined as a temporary skeletal anchorage that is larger than the surgical screw but smaller than the dental implant.

1.2 Statement of problem and objectives

Recently, a wide variety of miniscrew implants, of several sizes and designs, have been developed for clinical use (Carano *et al.*, 2004; Chung *et al.*, 2004; Kyung *et al.*, 2003a; Lin and Liou, 2003). According to several studies of the designs of dental implant and surgical screw, the conventional skeletal anchorage, changes in the geometry had great influence on biomechanical properties of both the miniscrew implant and the surrounding bone (Himmlova *et al.*, 2004; Holmgren *et al.*, 1998). However, studies concerning the biomechanical characteristics of miniscrew implants, such as influences of the length, diameter and shape on the performance of miniscrew implants, have not been conclusive.

The purpose of this study was to evaluate the influence of the miniscrew implant diameters, lengths and loading forces on the stress distribution in bones and miniscrew implants using finite element method. We expected that this study would define clearly the biomechanical performance of miniscrew implants and would provide basic knowledge for further studies.