# CHAPTER 1

# Introduction

## 1.1 Principles, Theory, and Rationale

Deep overbite is a frequent malocclusion characteristic.[1] Despite its frequency, it is rarely considered an important problem, although it is harmful to tooth structure, soft tissue, and the TMJ.[1, 2]

Intrusion of anterior teeth is necessary for the patient with deep overbite and gummy smile, Class II skeletal and large vertical facial height.[1, 3, 4] Conventional methods for incisor intrusion, such as the utility arch, intrusion arch, and reverse curved arches, have adverse side effects, such as labial tipping of maxillary anterior teeth and extrusion of posterior teeth.[3, 5, 6] Therefore, using mini-screws as an anchorage to intrude the anterior teeth is being widely used, because there is no side effect to the posterior teeth, it is easy to control the force and no patient co-operation is needed.[5] Previous investigations have reported successful intrusion of maxillary anterior teeth using mini-screws with variety of mechanics.[6-9]



Survival of the mini-screw mainly depends on the quality and the quantity of the cortical bone.[10-12] The space between roots is important, to avoid harming the root. Therefore, the mini-screw placement site is critical. Choi et al.[13] suggested that the best site for mini-screw placement in the anterior maxilla is between the lateral incisor and canine, 8 mm above the cemento-enamel junction (CEJ). The second-most suitable site is between the central incisors, 8 mm above the CEJ.

Nanda and Tosun[14] recommended two anchorage designs for the intrusion of the six maxillary anterior teeth that conform to the recommended mini-screw placement sites of Choi et al.[13]. The first pattern places one mini-screw between the central incisors and applies one force to intrude the teeth. The second pattern places two mini-screws between the lateral incisors and canines, left and right, and applies two forces in an oblique direction to intrude the teeth.

Intrusion of anterior teeth usually produces proclination, an unwanted side effect.(3, 5, 6) One-mini-screw anchorage design was used in cases that the incisal proclination is acceptable.(7, 8) Two mini-screws with oblique direction of force has rarely been studied; only Park et al.(15) reported that the stress distribution for the intrusion of the six mandibular anterior teeth was even, and pure intrusion occurred when the mini-screws were placed distal to the canine and the force applications were between the central and lateral incisors. Using mini-screw anchorage with an oblique force direction is of interest for the intrusion of the six maxillary anterior teeth.

The finite element method (FEM) is a simulation program which predicts how an object reacts to different stimuli based on its properties.(16, 17) It is an accurate technique for analyzing structural stress. In orthodontics, the FEM provides the orthodontist with quantitative data that can facilitate the understanding of physiological reactions happening within the dento-alveolar complex.

The purposes of this study were to investigate the pattern of von Mises stress distribution in the periodontal ligament (PDL) and the displacement of teeth, and to compare the differences between two anchorage designs for the intrusion of the six maxillary anterior teeth, analyzed by FEM.



**Research questions**

1. How do the stress distribution and the displacement of the six maxillary anterior teeth change when intrusive force applied?

2. What are the differences between two designs of mechanics for the intrusion of six maxillary anterior teeth using mini-screw anchorage?

## 1.2 Purposes of this study

1.2.1 To evaluate

1. The pattern of von Mises stress distribution in the periodontal ligament
2. The displacement of the six maxillary anterior teeth

under two intrusion mechanics with mini-screw anchorage using the finite element method.

1.2.2 To compare the results of two designs of mechanics for the intrusion of six maxillary anterior teeth using mini-screw anchorage.

## 1.3 Anticipated benefits

1.3.1 Clinical application

1.3.2 To gain knowledge for further study

## 1.4 Definitions

1.4.1 von Mises Stress

Equivalent stress of material under multiaxial loading conditions which is calculated from combining the three principal stresses (x, y, and z).



1.4.2 Linear elasticity

A linear relation between the stress and the strain. This relation is known as Hooke's law. It can also be stated as a relationship between stress σ and strain ε: $\sigma = E\varepsilon$ where $E$ is known as the elastic modulus or Young's modulus.

1.4.3 Non-linear elasticity or hyper-elasticity

Non-linear elasticity or hyper-elasticity materials is a type of constitutive model for ideally elastic material for which the stress–strain relationship derives from a strain energy density function. The stress-strain curve is a non-linear curve. Examples of materials that have this property is rubbers, fluids, and biological soft tissues.

1.4.4 Isotropy

Uniformity in all orientations. An isotropic material is a material having the same elastic properties in all directions at any one point of the body.

1.4.5 Homogeneity

The quality or state of being homogeneous. In engineering a material is said to be homogenous if the material’s elastic properties (E, μ) are the same at all points in the body.

1.4.6 Element

Basic building block of finite element analysis. There are several basic types of elements, such as, 1-D or line (spring, truss, pipe), 2-D or plane (plate, membrane), or 3-D or solid (bricks, tetrahedral, hexahedral) element.

1.4.7 Node

Interconnection of elements at points or coordinate location of elements

1.4.8 Discretization

Model body by dividing it into an equivalent system of many smaller bodies or finite elements interconnected at points