# BIOMECHANICAL ANALYSIS OF ORTHODONTIC MINI-SCREW IN DIFFERENT DIAMETER AND LENGTH

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## INTRODUCTION

Recently, the mini-screw was popular used in the clinical orthodontic treatment [1,2]. However, the contributions of the orthodontic mini-screw geometry factors still unclear. The purposes of this study were to evaluate the effects of the diameter and length of mini-screw on the stress and strain in the cortical bone and cancellous bone.

## METHODS

Four designed geometries of mini-screw (diameter: 1.5 and 2mm, length: 7 and 11 mm) and bone block (10×20×2 $mm^3$ cortical bone and 10×20×20 $mm^3$ cancellous bone) were established (Figure 1a~d) in the Solidworks software. The elastic modulus of mini-screw, cortical bone, and cancellous bone were 110 GPa, 16.7 GPa, and 1.148 GPa, respectively. The interface between the mini-screw and the bone was modeled with contact elements having a coefficient of friction of 0.4. In total, there were roughly 400,000 nodes and 280,000 elements in the mesh models. A lateral 4.9 N [3] force applied to the head of mini-screw and the exterior and bottom surface were totally fixed as the loading and boundary conditions (Figure 1e). The *von Mises* stress and strain in the cortical bone and cancellous bone were selected as the evaluation indexes. All finite element analyses were performed using the ANSYS Workbench finite element package.

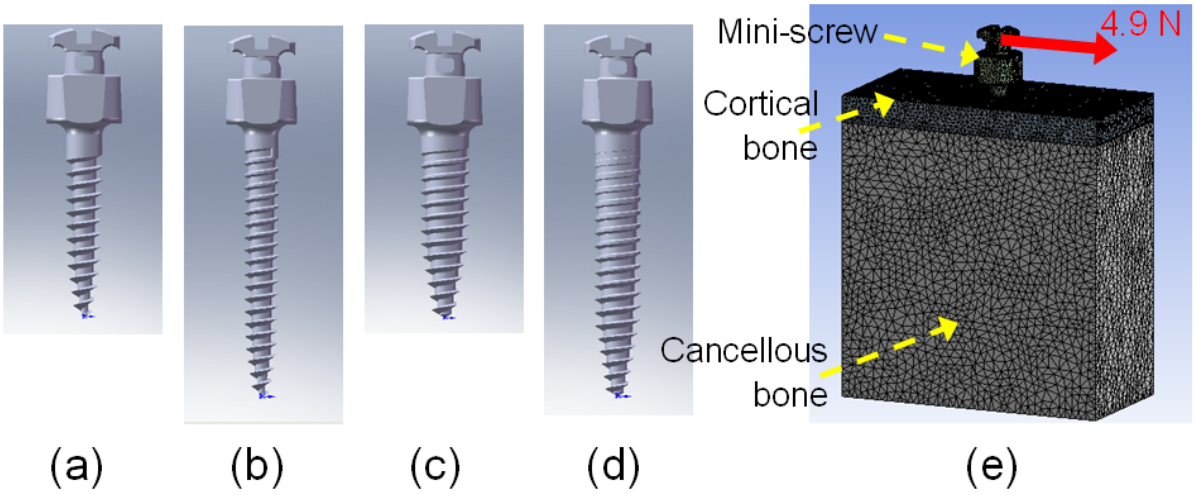


Figure 1. Four designed mini-screw used in this study: (a)1.5 mm diameter and 7.0 mm length (type I), (b) 1.5 mm diameter and 11.0 mm length (type II), (c) 2.0 mm diameter and 7.0 mm length (type III), (d) 2.0 mm diameter and 11.0 mm length (type IV), and (e)Finite element model of the mini-screw and bone.

## RESULTS AND DISCUSSION

All the deformations of the mini-screws were less than 13.0 μm (Figure 2). The largest and smallest peak *von Mises* stresses of the cortical bone were in the type I (36.58 MPa) and type IV (14.24 MPa) groups. The largest and smallest peak *von Mises* strains of the cortical bone were also occurred in the type I (2535 μ-strain) and type IV (725 μ-strain) groups. In addition, the peak *von Mises* stress and strain of the cancellous bone all less than 0.80 MPa and 700 μ-strain.

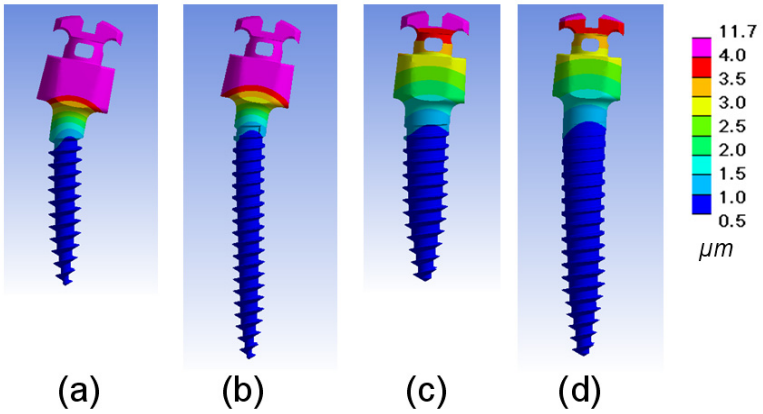


Figure 2. The deformation of the four types of mini-screw: (a) type I; (b) type II; (c) type III; and (d) type IV.

Table 1. The stress and strain in the cortical and cancellous bone.

| Mini-screw Type | *von Mises* stress in cancellous bone (MPa) | *von Mises* strain in cancellous bone (μ-strain) | *von Mises* stress in cortical bone (MPa) | *von Mises* strain in cortical bone (μ-strain) |
|---|---|---|---|---|
| I | 0.59 | 584 | 36.58 | 2535 |
| II | 0.75 | 659 | 28.40 | 1769 |
| III | 0.49 | 443 | 16.33 | 982 |
| IV | 0.61 | 518 | 14.24 | 725 |

## CONCLUSION

From the simulation results, the peak *von Mises* stress and strain in the cortical bone reduced as the diameter of mini-crew decreased and the length of mini-crew increased. The diameter and length of mini-screw only have minor impact to the stress and strain in the cancellous bone.

## ACKNOWLEDGEMENTS

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