Chapter 1 briefly introduces the background of the study. The previous studies section discusses the related literatures on corrective forces acting on the implant rod and spine during the scoliosis treatment and the delimitations in relation to the current level of research in the area. The main objectives of this study are also presented.

Chapter 2 provides a general background, biomechanical and clinical aspect of scoliosis as a disease. This chapter presents also the principles of management of scoliosis, i.e. how it is being treated by implant fixation, and the existing problems in which this research study is trying to address from a biomechanics point of view.

Chapter 3 presents a method to analyze the corrective forces acting on the implant rod and vertebra using finite element modeling. The implant rod before the surgical implantation was reconstructed
using an elasto-plastic finite element model. This chapter also presents the three preliminary clinical cases that were used to conduct finite element deformation analysis.

Chapter 4 deals with the development of a dual-camera system and numerical method to measure the three-dimensional implant rod geometry intraoperatively for scoliosis deformity surgery. The results of the validation experiment to establish the accuracy of the dual-camera system using the actual implant rod utilized during scoliosis surgery are presented.

Chapter 5 presents the effect of various screw placement configurations on the magnitude of corrective forces and degree of scoliosis deformity correction. This chapter discusses the consequences of using more screws and putting screws nearer to each other (screw density) to the magnitude of corrective forces and degree of scoliosis correction. The magnitude of forces did not have significant relationship with the degree of scoliosis correction. The corrective forces tended to reduce when more screws were used indicating that the loads acting on the spine were more distributed. The magnitude of corrective forces increased with higher screw density.

Chapter 6 presents the deformation behavior of implant rod using the changes of implant rod geometry before surgical implantation and after surgery. The influence of the changes of implant rod curvature on scoliosis correction was also presented. A significant relationship was found between the degree of rod deformation and implant rod curvature before surgical implantation indicating that the rod curvature after surgery or the clinical outcome could be predicted from the initial implant rod shape. The changes of implant rod curvature greatly influenced the scoliosis correction because the spine curve can be over or under corrected after scoliosis surgery.

Chapter 7 deals with the clinical application of the dual-camera system to measure the intraoperative three-dimensional geometry of implant rod during scoliosis surgery. The three-dimensional geometry of implant rod at the different phases of scoliosis treatment (i.e. preoperative, intraoperative and postoperative) was measured. The intraoperative forces were also computed.

Chapter 8 summarizes the findings and conclusions of the work, their clinical and biomechanical significance is also discussed.

The work presented in this thesis provides clinicians and bioengineers a new method to measure the magnitude of corrective forces acting on the vertebrae of the spine and implant rod using finite element modeling. The dual-camera system that has been developed gives in-depth insights on the deformation behavior of implant rod at the different phases of scoliosis treatment, i.e. from preoperative, intraoperative, and postoperative phases. The effects of screw placement configuration to the magnitude of the corrective forces and degree of correction will help clinicians to objectively decide which surgical strategy is likely to attain a desirable outcome. The deformation behavior of the implant rod observed in this study revealed that the postoperative implant rod geometry could be predicted from the initial implant rod shape. This is essential for the preoperative planning of the surgical parameters such as decision-making of the initial implant rod geometry. This study brings forward new insights on the effects of spinal instrumentation to the biomechanics of scoliosis correction.