INTRODUCTION
Dental implant-abutment system was used as anchor for partially or fully edentulous patients. It has become an important treatment option for edentulous patients. The procedure of implantation is to first insert the fixture into alveolus and then to connect the abutment, finally the crown is attached onto the abutment. The dental implant can replace the edentulous spot without the support of adjacent teeth. The primary stability is believed to improve the osseointegration and survival rate of the dental implant. With the advancement of science and technology, dental implantation has a high success rate of over 80%. However, failure cases are still reported in clinical practice. From the biomechanical point of view, many of the failure cases were due to the fact that the current dental implant designs did not possess the loading mechanism and mobility of buffering in natural teeth [1][2]. Therefore, the aim of the present study is to develop novel resilient mechanisms that can mimic the mechanical behavior of the shock absorber. The novel resilient mechanism will be incorporated into a dental implant to provide the shock-absorption capability of a natural tooth for attenuating the loadings during mastication.

METHODS
In this study, three-dimensional finite element analysis using commercial software-MSC. Marc 2008 (MSC. Software Corporation, Los Angeles, USA) was performed to investigate three different novel dental implants with modifications on the inside structure (Fig. 1). The diameter (3.5mm), length (8mm) and pitch (0.8mm) of the implant were set to be the same for all models [3]. Young’s modulus and Poisson’s ratio of the pure titanium were set to be 102GPa and 0.35, respectively [4]. The material property of titanium was assumed to be linear elastic, isotropic and homogenous. However, the property of resilient elastomeric material of EFM (Extra Firm Material) was assumed to be nonlinear with the mathematical formula of “Foam” (Fig. 2).

The formula used for “Foam” is:

$$W = \sum_{n=1}^{N} \mu_n \left( \frac{\alpha_n}{\alpha_n} + \lambda_n \alpha_n + \lambda_n \alpha_n - 3 \right) + \sum_{n=1}^{N} \frac{\mu_n}{\beta_n} \left( 1 - J \beta_n \right)$$

, where $\mu_n$ is moduli; $\alpha_n$ is deviatoric exponent; $\beta_n$ is volumetric exponent. Table 1 shows the detail data about each parameters used for the formula. The loading of 100N was applied axially on the abutment. The models were constrained in all directions at nodes on the bottom surface of the implant. All interfaces on the implant, abutment and resilient material was set to be contact with a friction coefficient $\mu=0.4$ [5]. The von Mises stress distribution was observed to evaluate the implant stability.

Figure 1: Design of the three novel resilient dental implants. (a)model-1; (b)model-2; (c)model-3.
RESULTS AND DISCUSSION
The results showed that the force-displacement curve and stress distribution depended on the design of the novel resilient dental implant. The mechanical performance of model-1 and model-2 demonstrated nonlinear characteristics and could provide immediate displacement when loaded as seen from load-displacement curves. The displacements of the implant for 100 N loading were 0.1mm and 0.51mm for model-1 and model-2, respectively. However, the result of model-3 displayed the linear characteristic as well as a very small displacement of 4.64μm (Fig. 3). Due to the elastomer was constrained within the fixture, therefore it couldn’t allow the elastomer to deform greatly as expected. The von Mises stresses were mostly concentrated on the abutment screw for all models from the analysis results (Fig. 4). The force was transferred onto the metal that led to stress concentration on the abutment screw after loaded. Because deformation of the elastomer was smaller than the abutment screw for the novel resilient dental implant, therefore, the stress was not concentrated on the elastomer. Based on the results, the design I and II of the novel resilient dental implants may have a better performance than the traditional dental implant on the stress distribution and implant mobility.

CONCLUSIONS
The novel implant with resilient component could provide fair performance of implant stability and mobility. It is hoped that the novel resilient dental implant can increase the success rate and post-implantation endurance life. However, further modifications of the design are necessary and the biocompatibility and implantability of the implant need to be taken into account.

REFERENCES