

Effect of the prosthetic index on stress distribution in Morse taper connection implant system and peri-implant bone. R Wang¹, WT Zhang², KJ Cheng³, YF Liu³. 1. Case Western Reserve University School of Dental Medicine USA, 2. Department of Stomatology Hangzhou Medical College, 3. College of Mechanical Engineering Zhejiang University China

Introduction: The combination of a prosthetic index with Morse taper connection was developed, with the purpose of making prosthetic procedures more precise. However, the presence of the index may compromise the mechanical performance of the abutment. The aim of this study is to evaluate the effect of prosthetic index on stress distribution in implant–abutment-screw system and peri-implant bone by using the 3D finite element analysis.

Materials and Method: Two commercial dental implant systems with different implant–abutment connections were used: the Morse taper connection with platform switching (MT-PS) implant system and the internal hex connection with platform matching (IH-PM) implant system. Meanwhile, there are two different designs of Morse taper connection abutment, namely, abutments with or without index. Consequently, three different models were developed and evaluated: (1) MT-PS indexed, (2) MT-PS non-indexed, and (3) IH-PM (Fig.1). These models were inserted into a bone block. Vertical and oblique forces of 100 N were applied to each abutment to simulate occlusal loadings. Mandibular bone block model: CBCT images were obtained from a thirty years old healthy female volunteer with normal occlusion (Fig. 2).

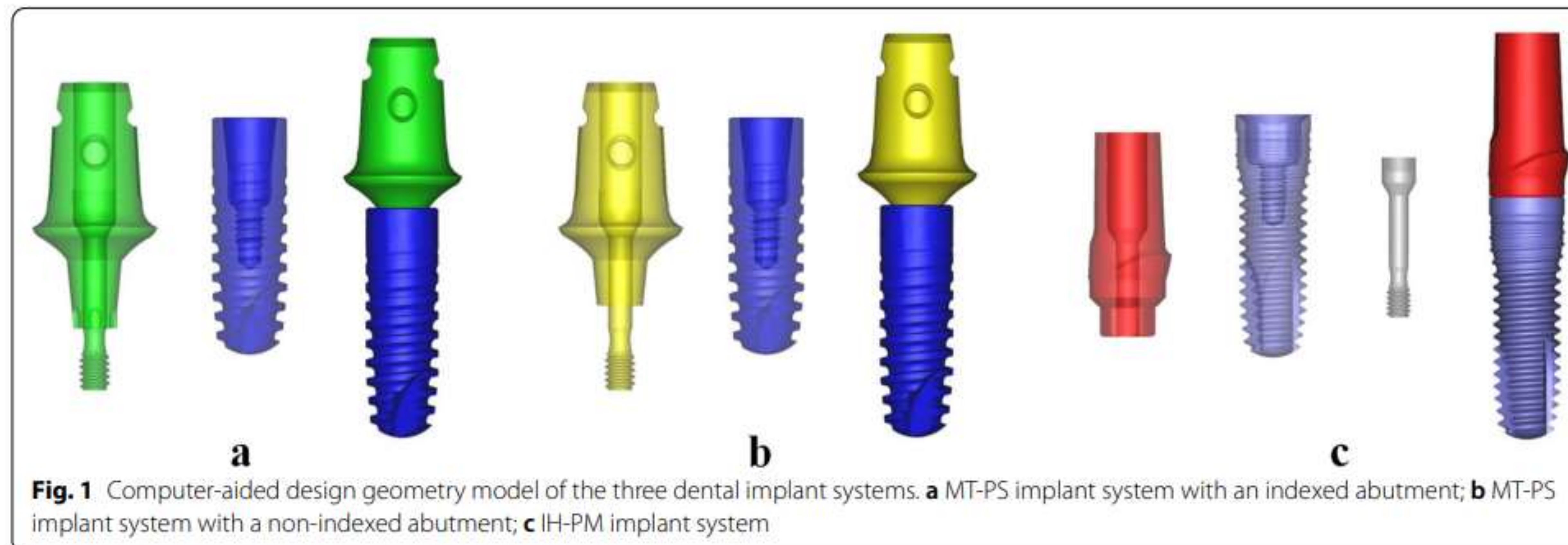
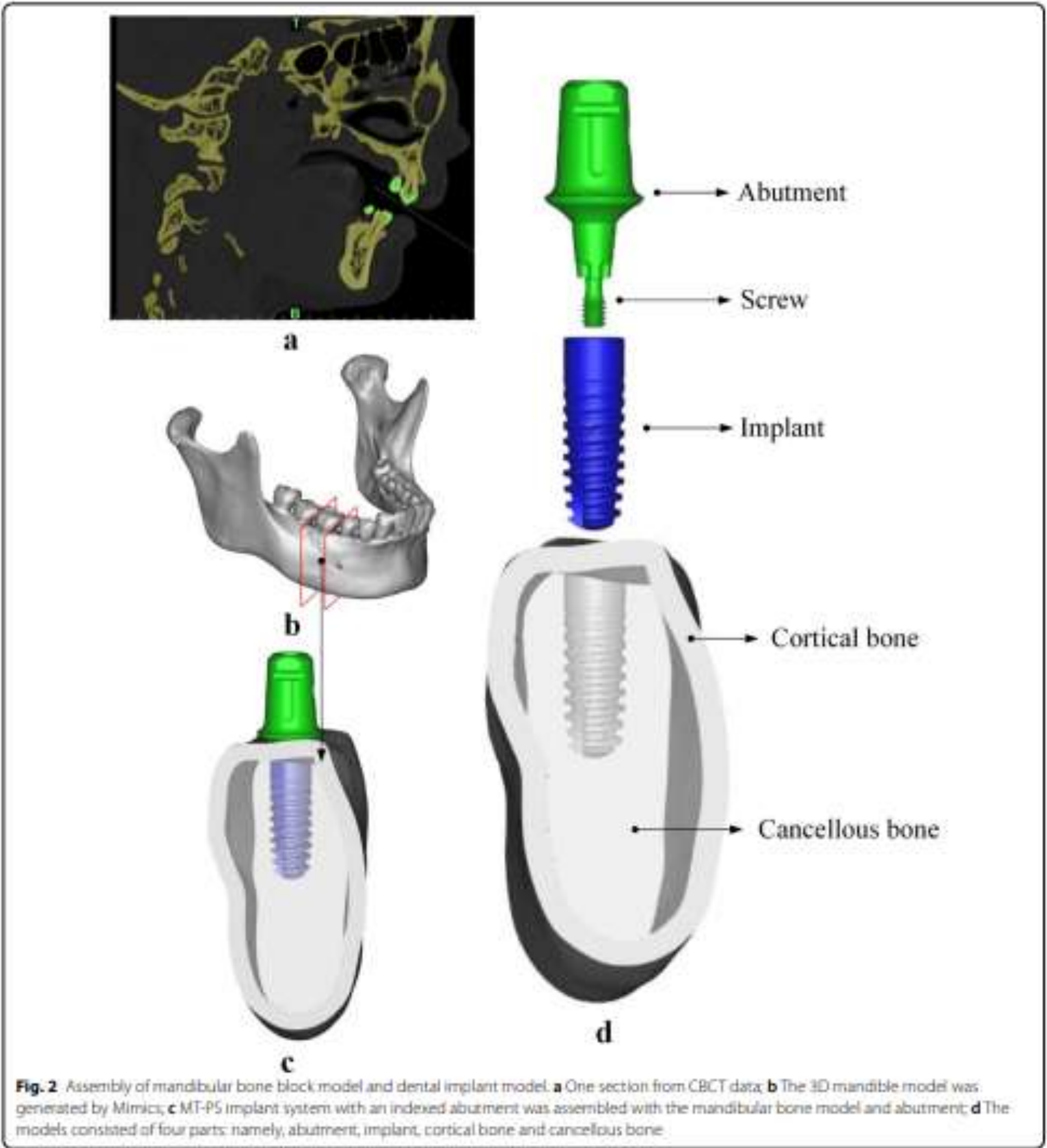
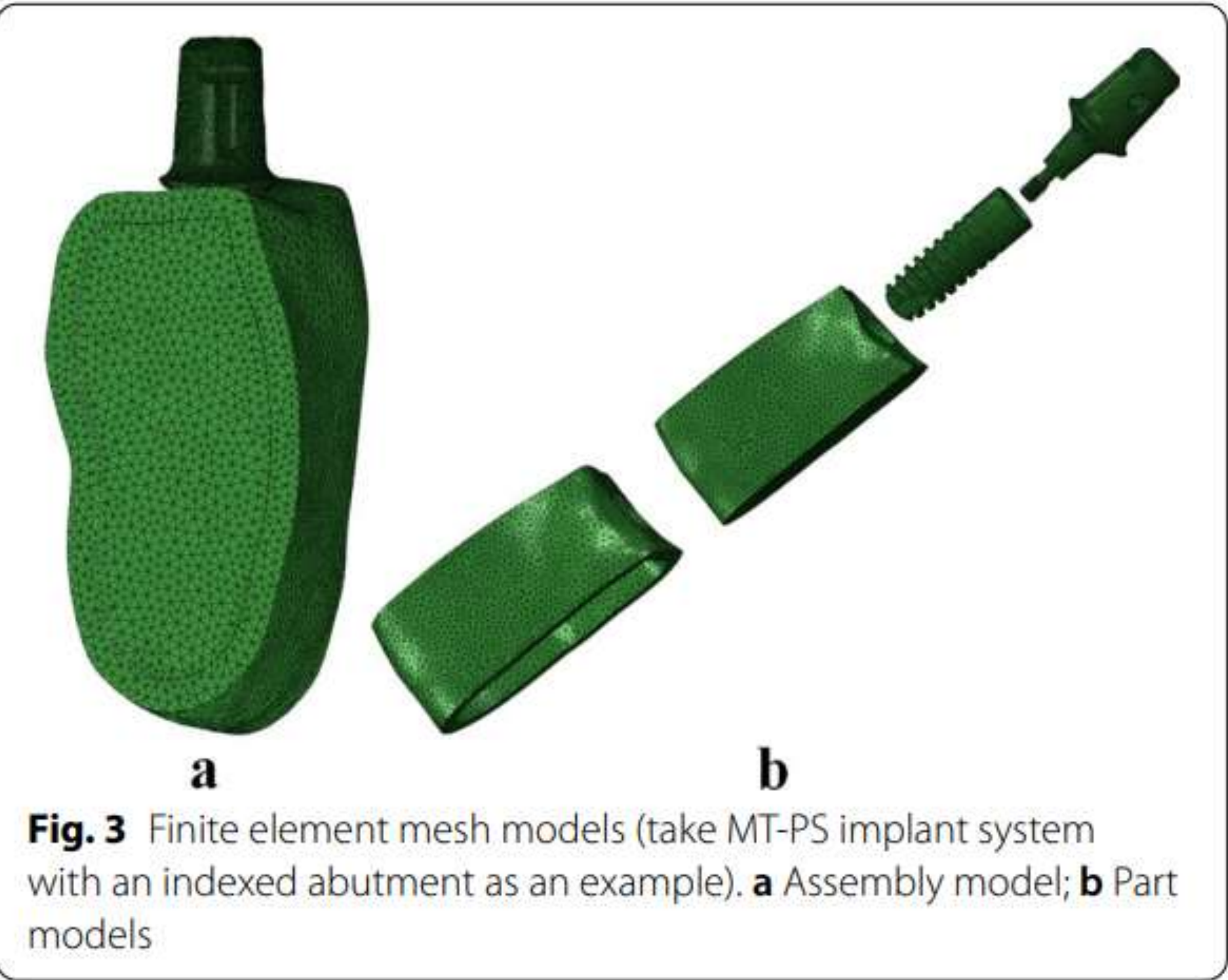
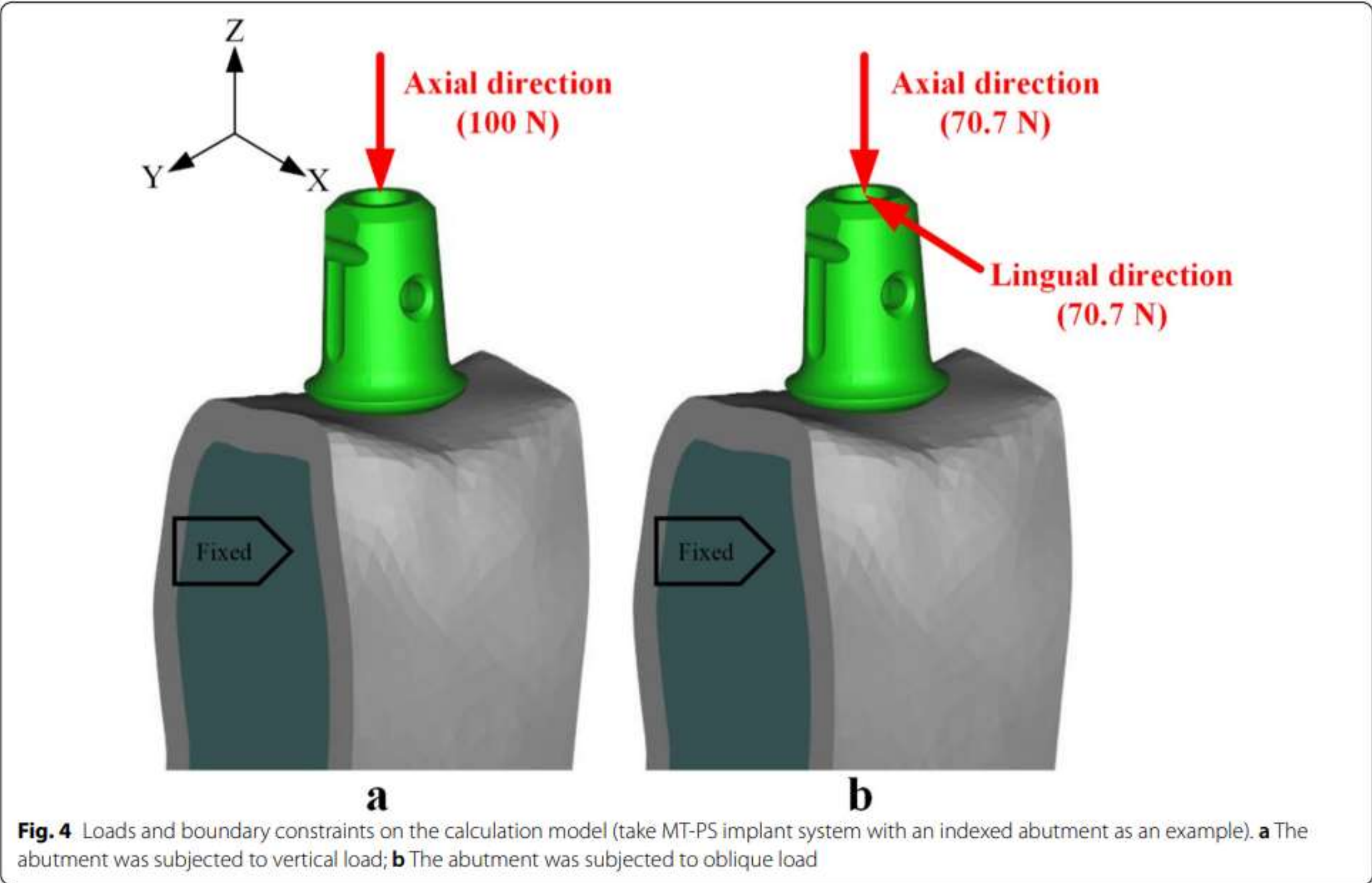


Table 1 Geometry and dimension of the two implant–abutment connections

Abutment design	Implant diameter × height (mm)	Gingival height (mm)	Abutment diameter (mm)	Abutment angle (°)
MT-PS indexed	3.5 × 11	1.5	3.84	0
MT-PS non-indexed	3.5 × 11	1.5	3.84	0
IH-PM	3.75 × 11.5	1–2	3.18	0

Table 2 Material properties used in the FE models

Materials	Young’s modulus (MPa)	Poisson’s ratios
Cortical bone	13,700	0.3
Cancellous bone	1370	0.3
Implant	112,000	0.33
Abutment	112,000	0.33
Screw	112,000	0.33



The abutment, screw, implant, cortical bone and cancellous bone were considered to be homogeneous, isotropic and linearly elastic materials. The assembly models were imported into Abaqus software (V6.13, Dassault Systèmes, Cedex, France) to generate tetrahedral meshes for subsequent simulations and calculations. The average element size of 0.5 mm was utilized as the meshing requirement for cortical bone and cancellous bone. A refined mesh (0.1 mm of average element size) was generated on the components of implant, abutment, screw, and the surrounding bone adjacent to the implant to guarantee proper geometrical and dimensional features (Fig. 3). Same loads and boundary constraints were carried out for all calculation models (Fig. 4). Mesial and distal surfaces of cortical and cancellous bone were fixed in 6 degrees of freedom (Fig. 4, black). A vertical load (along the axis of implant) of 100 N or an oblique load (along the bucco-lingual direction, inclined at 45 degrees to the axis of implant) of 100 N was applied onto the occlusal surface of the abutment (Fig. 4). Biting forces on implants are similar to those reported for natural dentition. Consequently, the 100 N vertical and oblique loads in this study were selected, which are conservative values for mean peak loads.

Results: For the MT-PS implant system, the maximum stress was always concentrated in the abutment neck under both vertical and oblique loading. Moreover, the maximum von Mises stress in the neck of the MT-PS abutment with index even exceed the yield strength of titanium alloy under the oblique loading. For the IH-PM implant system, however, the maximum stress was always located at the implant. Additionally, the MT-PS implant system has a significantly higher stress level in the abutment neck and a lower stress level around the peri-implant bone compared to the IH-PM implant system. The combined average maximum stress from vertical and oblique loads is 2.04 times higher in the MT-PS indexed model, and 1.82 times for the MT-PS non-indexed model than that of the IH-PM model.

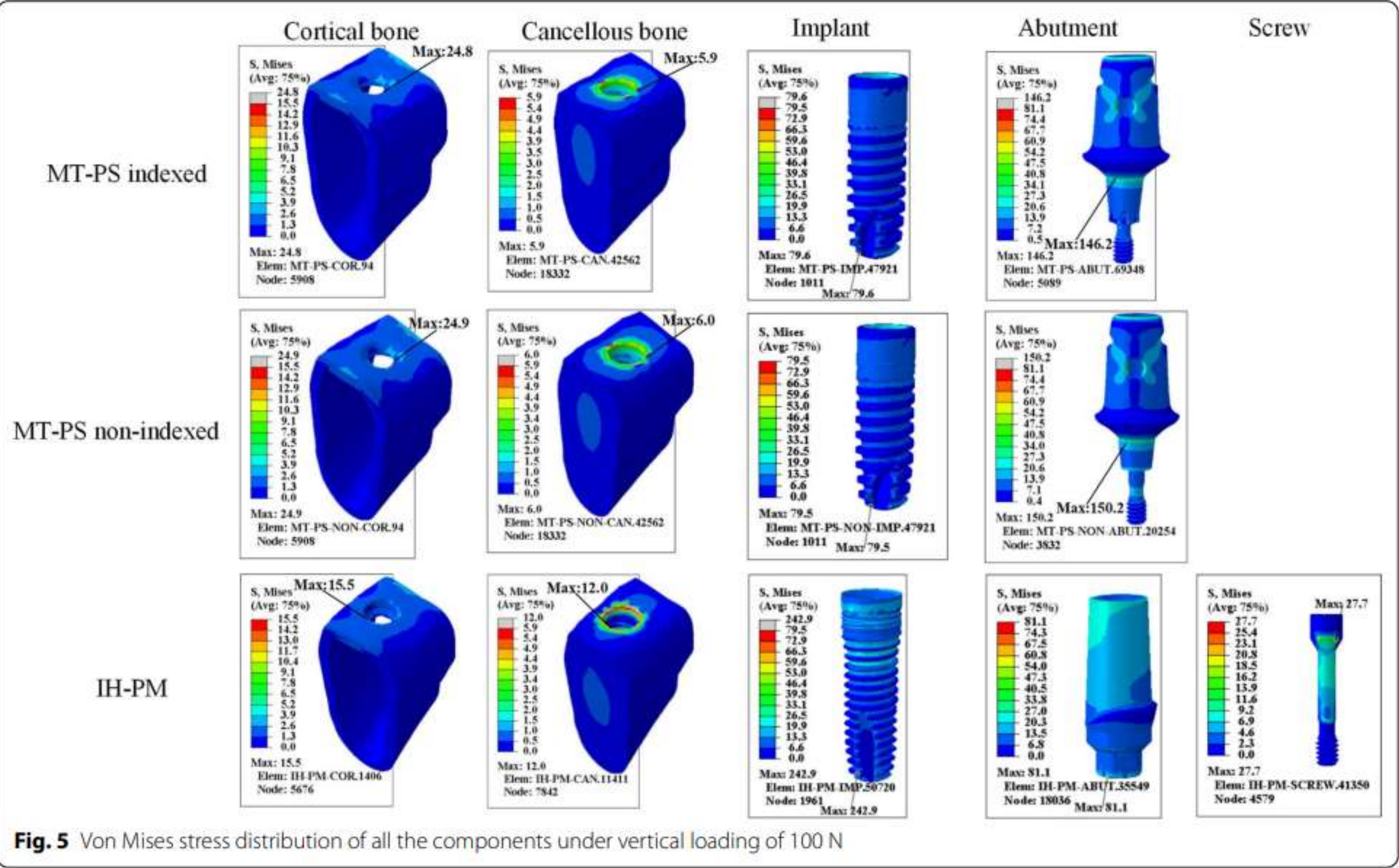


Fig. 5 Von Mises stress distribution of all the components under vertical loading of 100 N

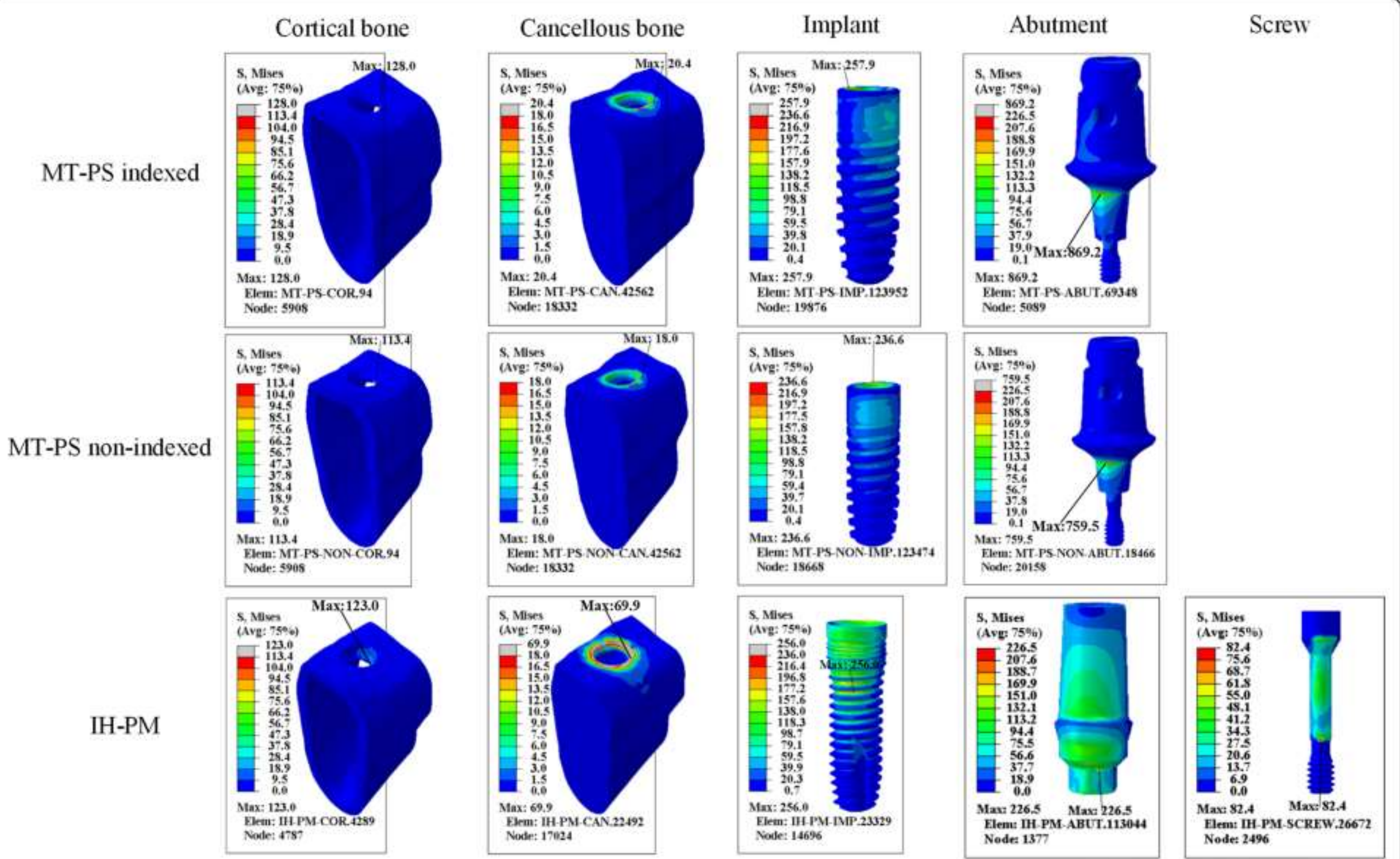


Fig. 6 Von Mises stress distribution of all the components under oblique loading of 100 N

Conclusion: MT-PS with index will cause higher stress concentration on the abutment neck than that of without index, and even exceeded the yield strength of titanium alloy, which is more prone to mechanical complications. Nevertheless, MT-PS decreases stress within cancellous bone and may contribute to limiting crystal bone resorption. This work provided computational modeling reference for clinicians to select a suitable implant–abutment connection system for different clinical situations.