

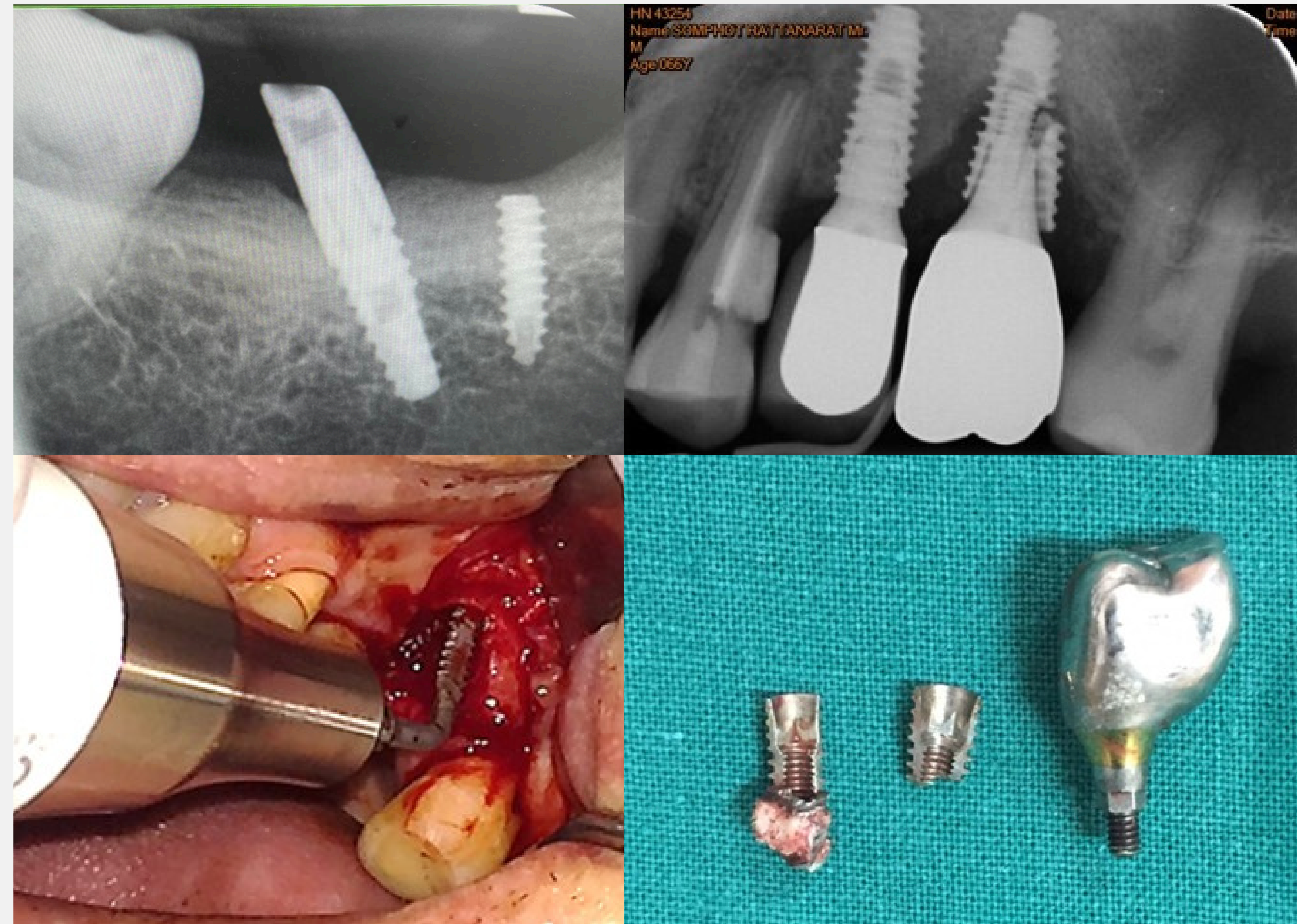
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Introduction

Narrow-diameter implants (NDIs) were originally designed for the replacement of anterior teeth, as well as premolars, to address aesthetic concerns.

In elderly patients, bone grafting to widen the alveolar ridge for larger implants can be challenging due to the need for multiple surgeries and high costs. Consequently, narrow-diameter implants are sometimes used in the molar region, although this increases the risk of fracture from high occlusal forces. Thus, evaluating the mechanical performance and failure mechanisms of narrow-diameter implants in high-load areas is essential. This study aims to assess their fatigue resistance, modes of failure, and stress concentrations using finite element analysis (FEA).



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Materials & Methods

- Ten NDIs (3.5 × 10 mm) with abutments and crowns
- Stepwise loading: 200–1200 N at 20 Hz
- Fatigue testing per ISO 14801:2016
- Failure load, cycles, and fracture modes recorded



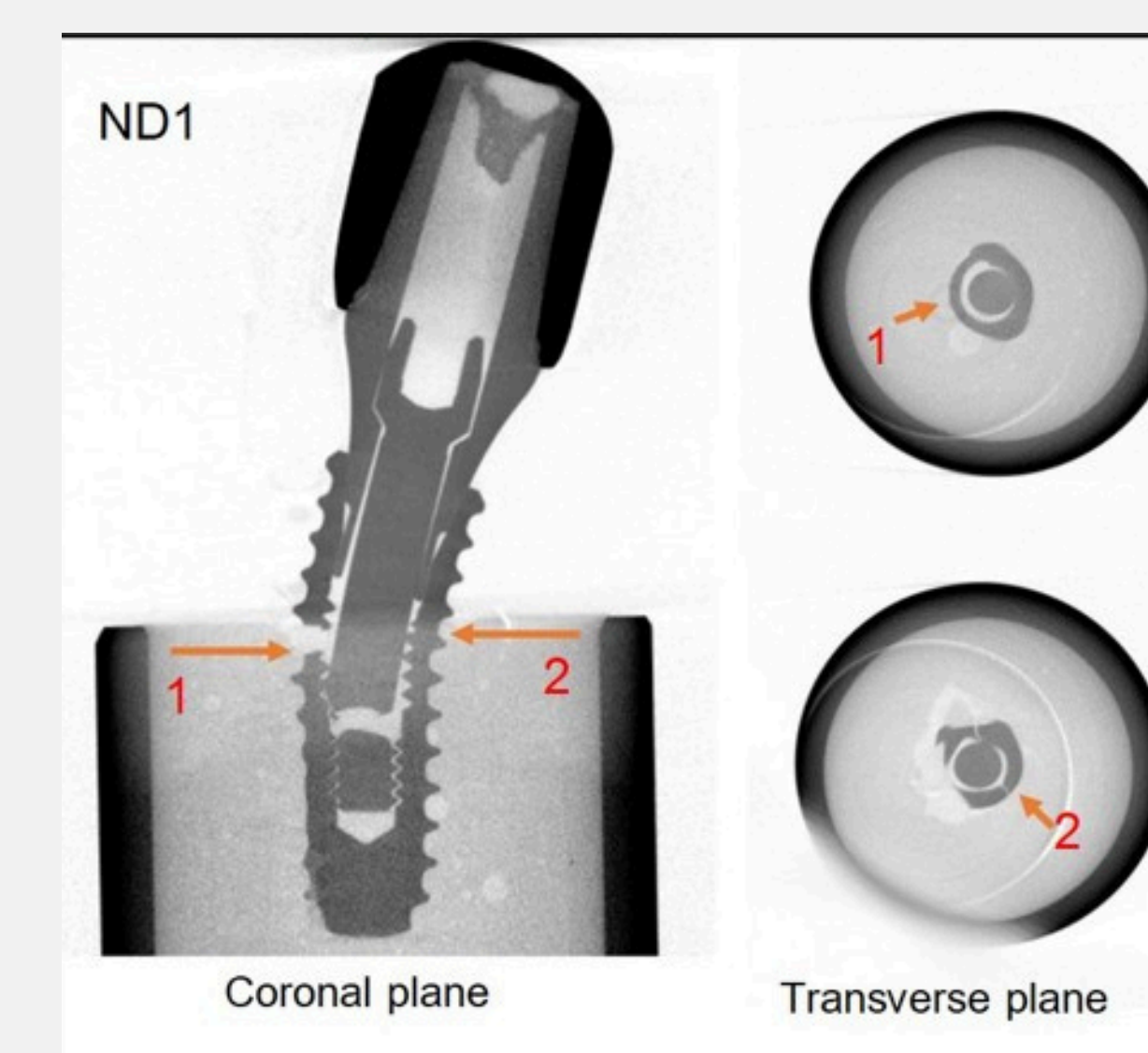
1. Sample preparation



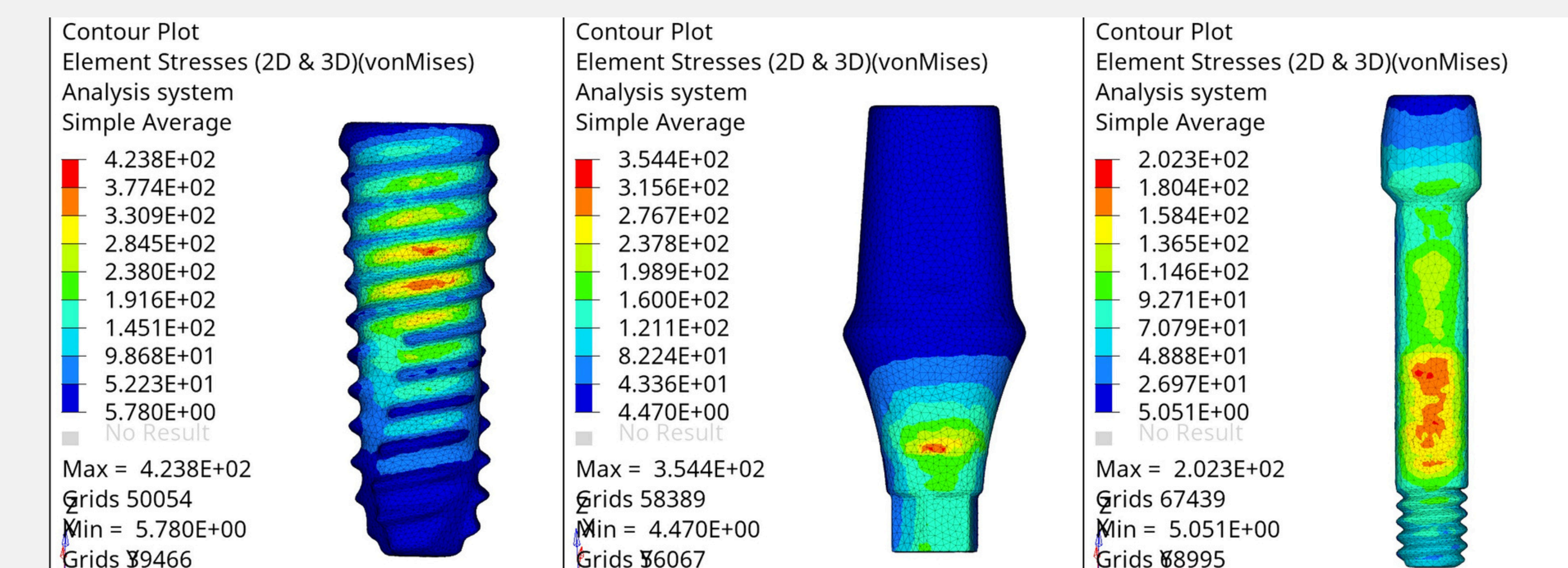
2. Fatigue testing



3. Modes of failure analysis



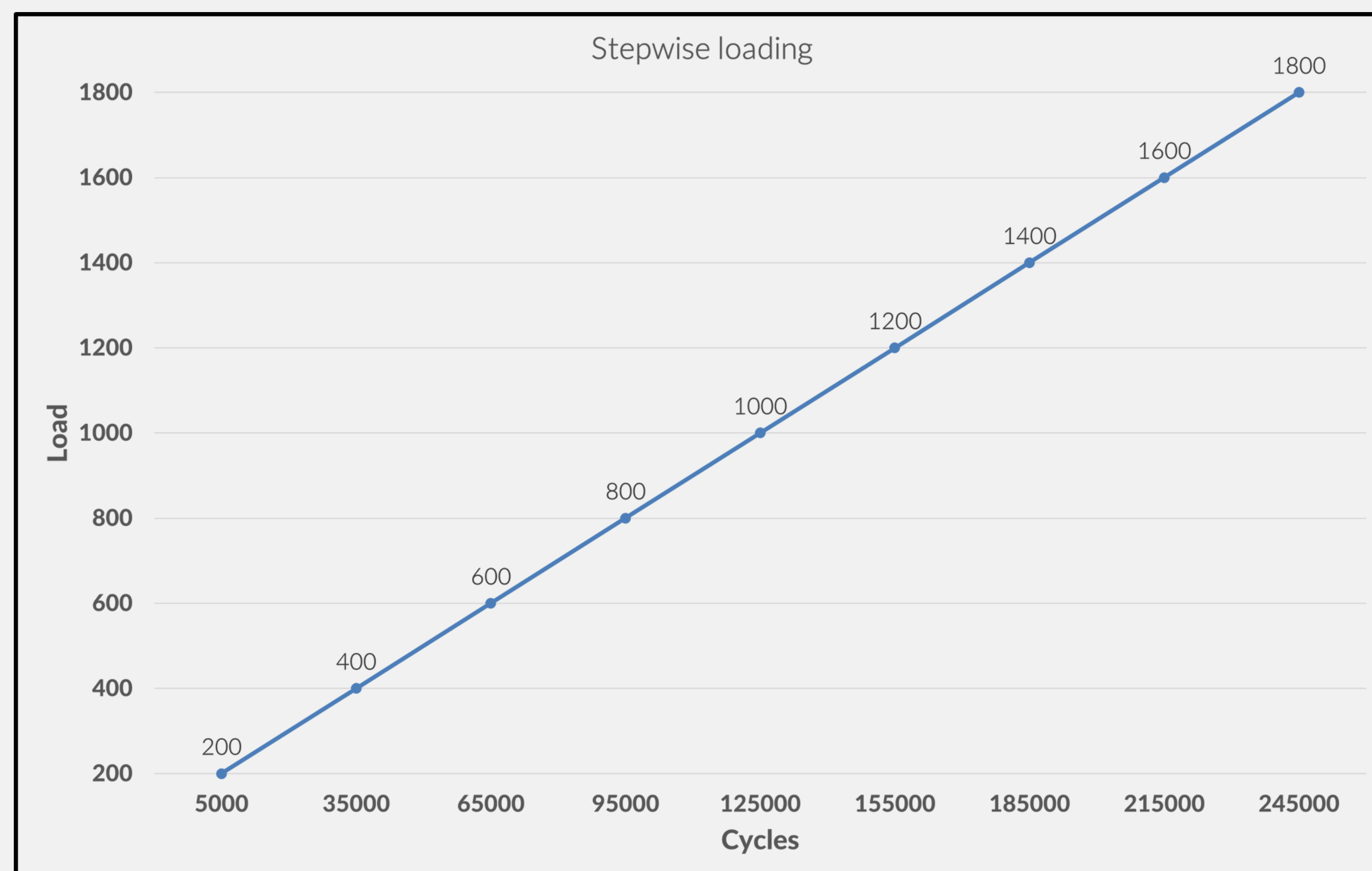
4. Finite element analysis



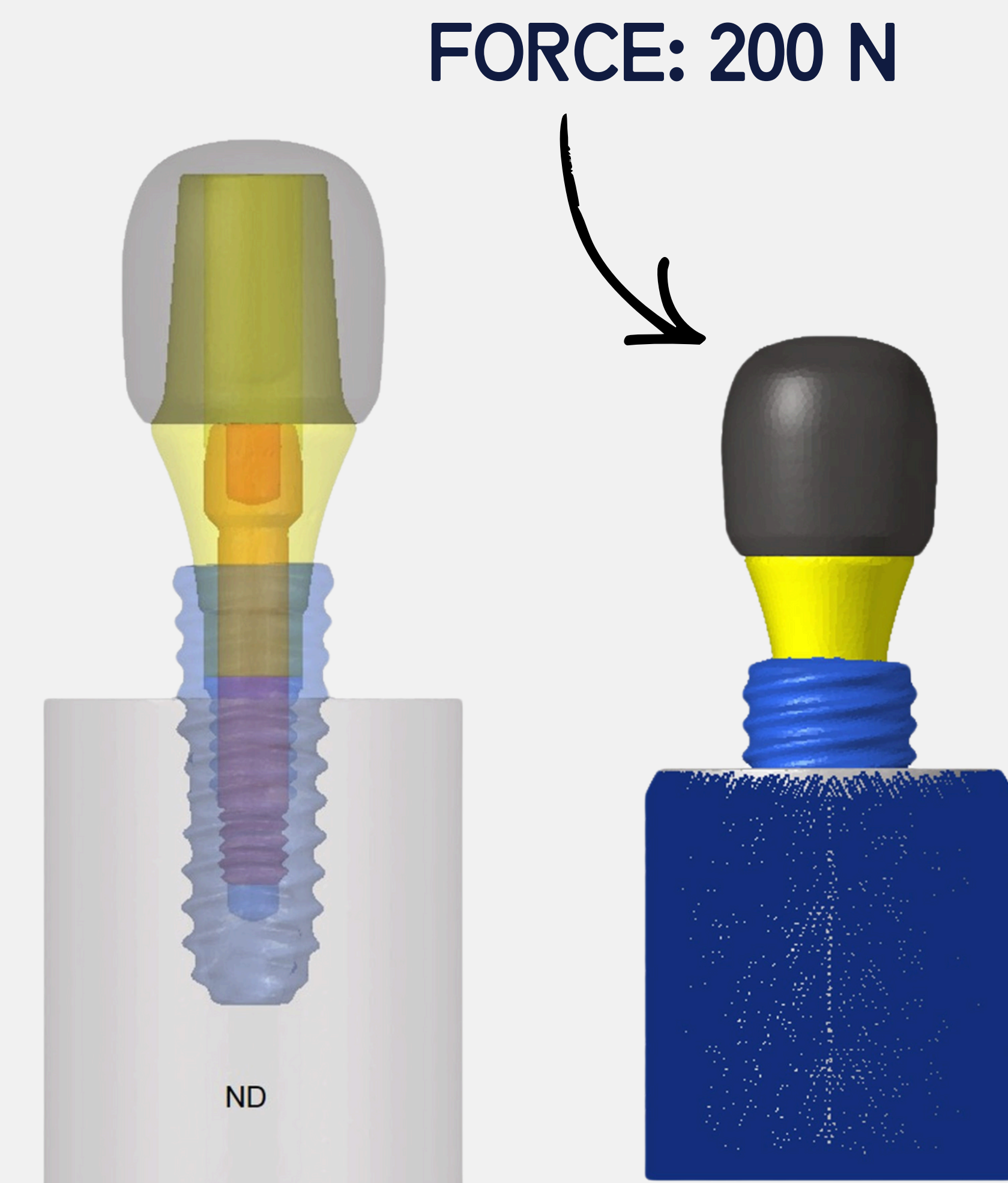
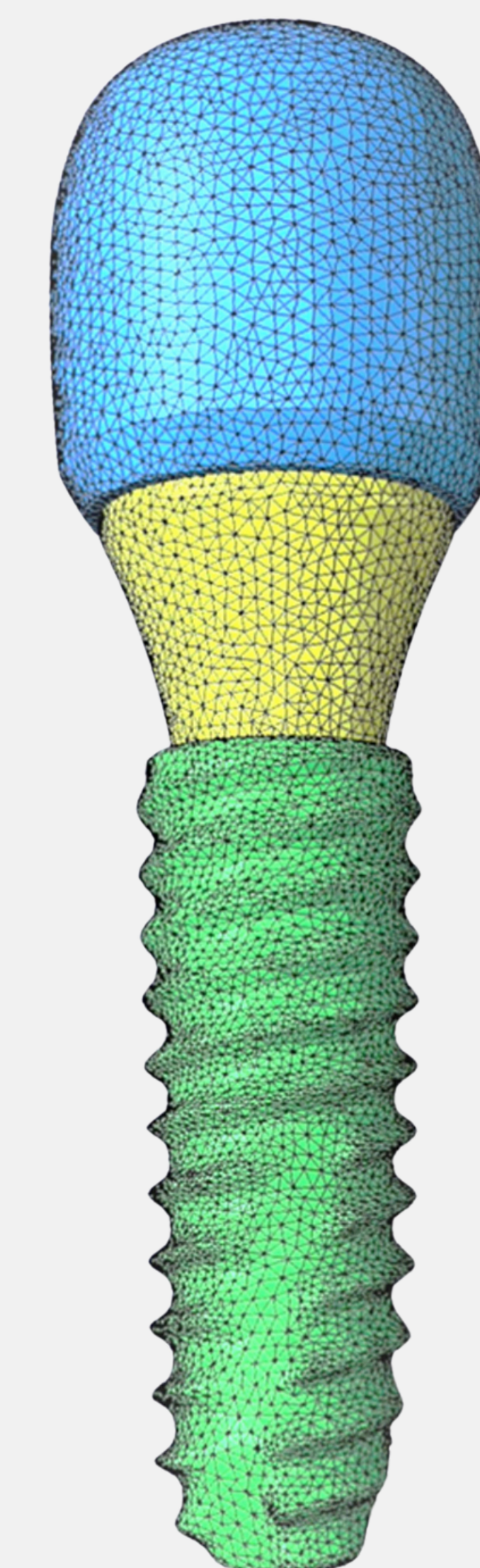
Materials & Methods

Fatigue testing

- Stepwise loading
- Frequency 20 Hz, Dry condition
- 245,000 cycles / 1.5mm displacement
- Record Failure Load, Cycles, Mode of failure



3D Finite Element Analysis



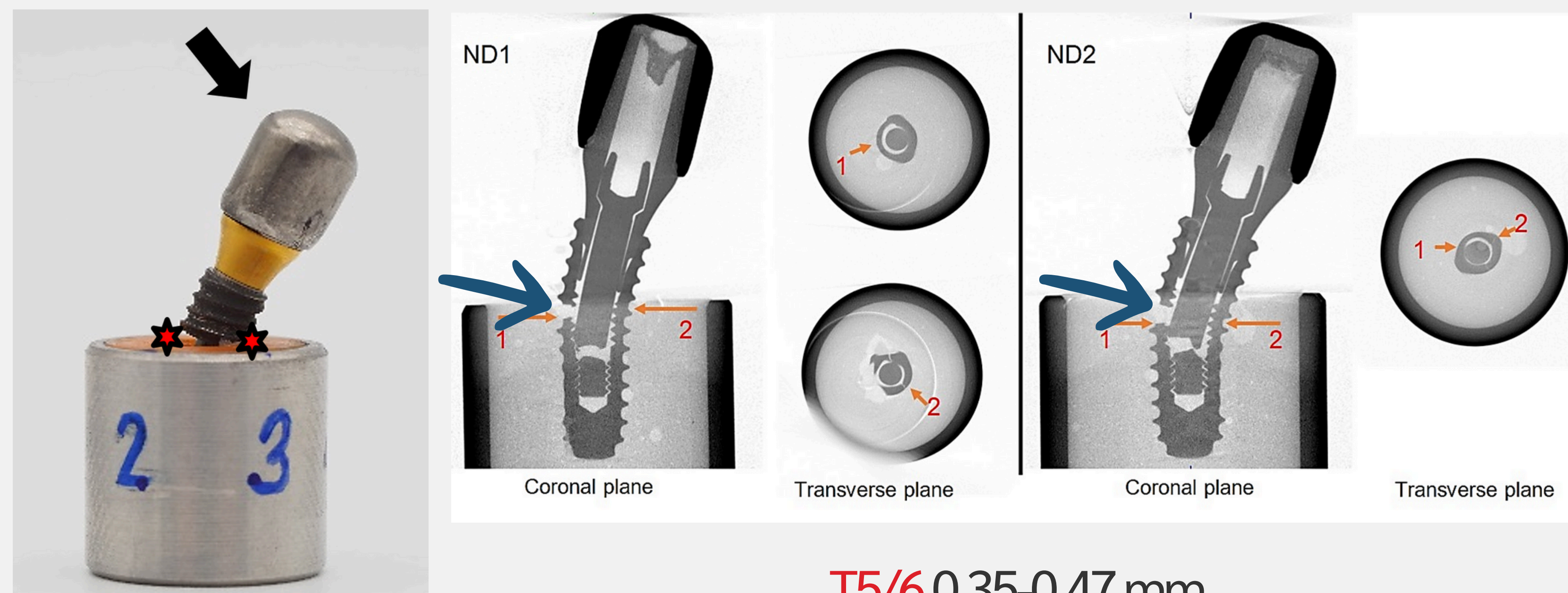
- 3D models based on fatigue-tested specimens
- Static load: 200 Newtons
- Fatigue load replicated experimental conditions
- Von Mises stress and damage calculated

Results

Fatigue Experiments

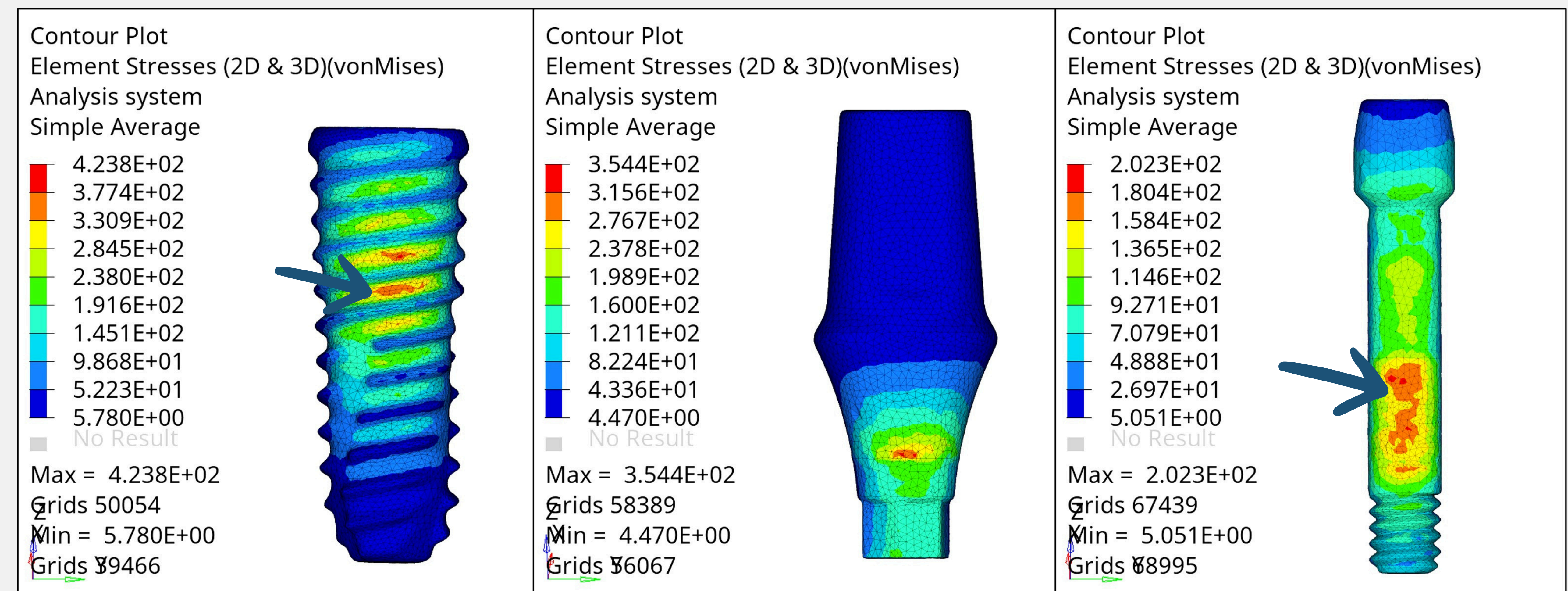
- Failure load: 960 N
- Total cycles to failure: 92,165
- Fracture at the fixture and abutment screw

Mean of failure cycles (SD)	Mean of failure load (SD)
92165 (10149)	960 (84)



T5/6 0.35-0.47 mm

3D Static Finite Element Analysis



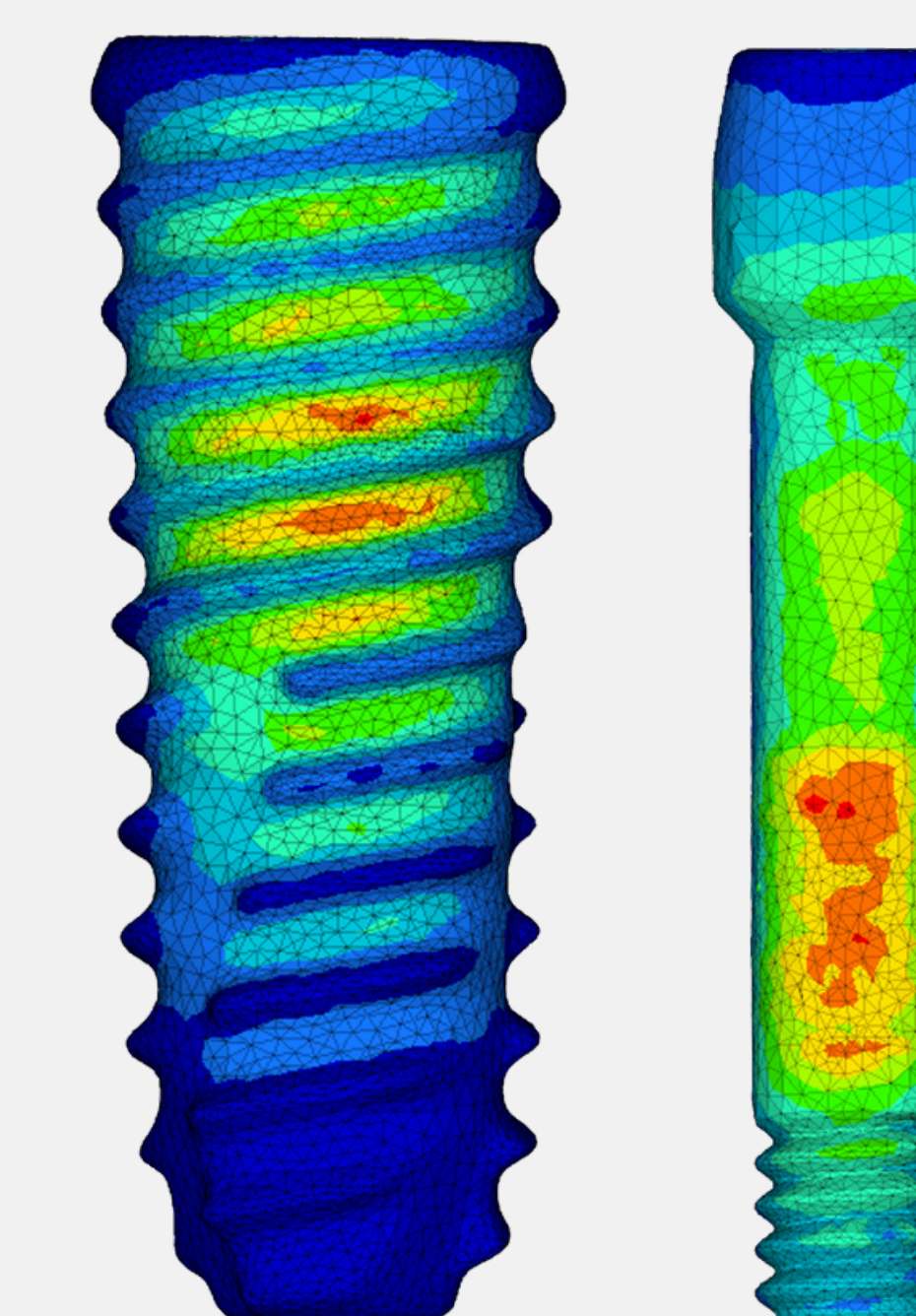
- Max von Mises stress:
 - Fixture (CPTi grade IV) 423.8 MPa
 - Abutment (Ti alloy grade V) 354.4 MPa
 - Retaining screw (Ti alloy grade V) 202.3 MPa

The positions of the fixture and the retained screw fractures in fatigue experiments align with the maximum von Mises stress in the finite element analysis model.

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Conclusions

- All specimens failed at the fixture and retaining screw
- FEA stress concentration region consistent with fracture locations assessed by fatigue experiment
- Micro-CT confirmed crack initiation sites
- FEA is effective for predicting fatigue failure in NDIs



Future Works

- Various implant dimensions and configurations, as well as clinical conditions, will be studied for the implant prediction using FEA with fatigue analysis

