

Effects of Preload on Bone Tissue around Implant : An In Vivo Study

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Introduction

Bone apposition and resorption around implants occur for several reasons. However, while the effects of the preload by tightening the torque of the abutment screw on the peri-implant bone have been investigated in vitro, there is no report in vivo so far. **The aim of this research study was to examine peri-implant bone alterations around osseointegrated implants caused by abutment screw preload stress using different tightening torque values with and without vertical dynamic load.**

There were no scientific evidences in vivo for the abutment torque value!!

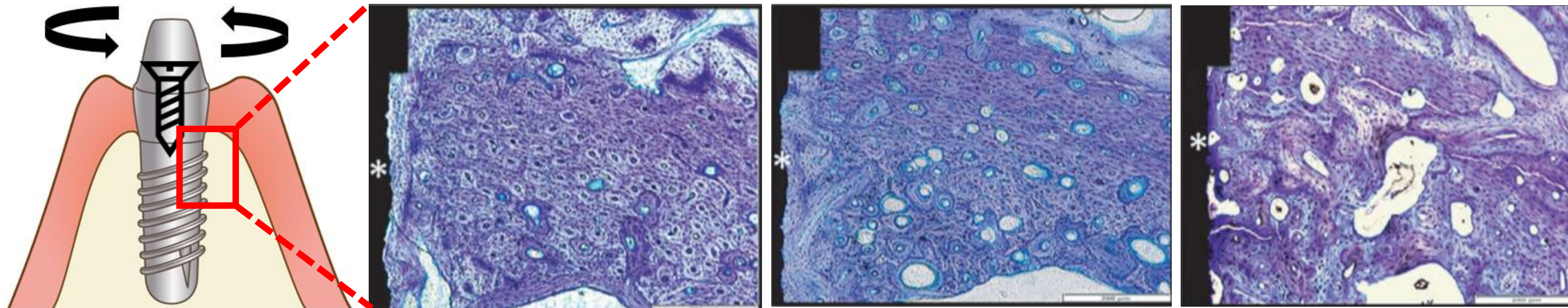
Rabbit tissue specimen after abutment screw tightening

Preload

Control

35Ncm

70Ncm

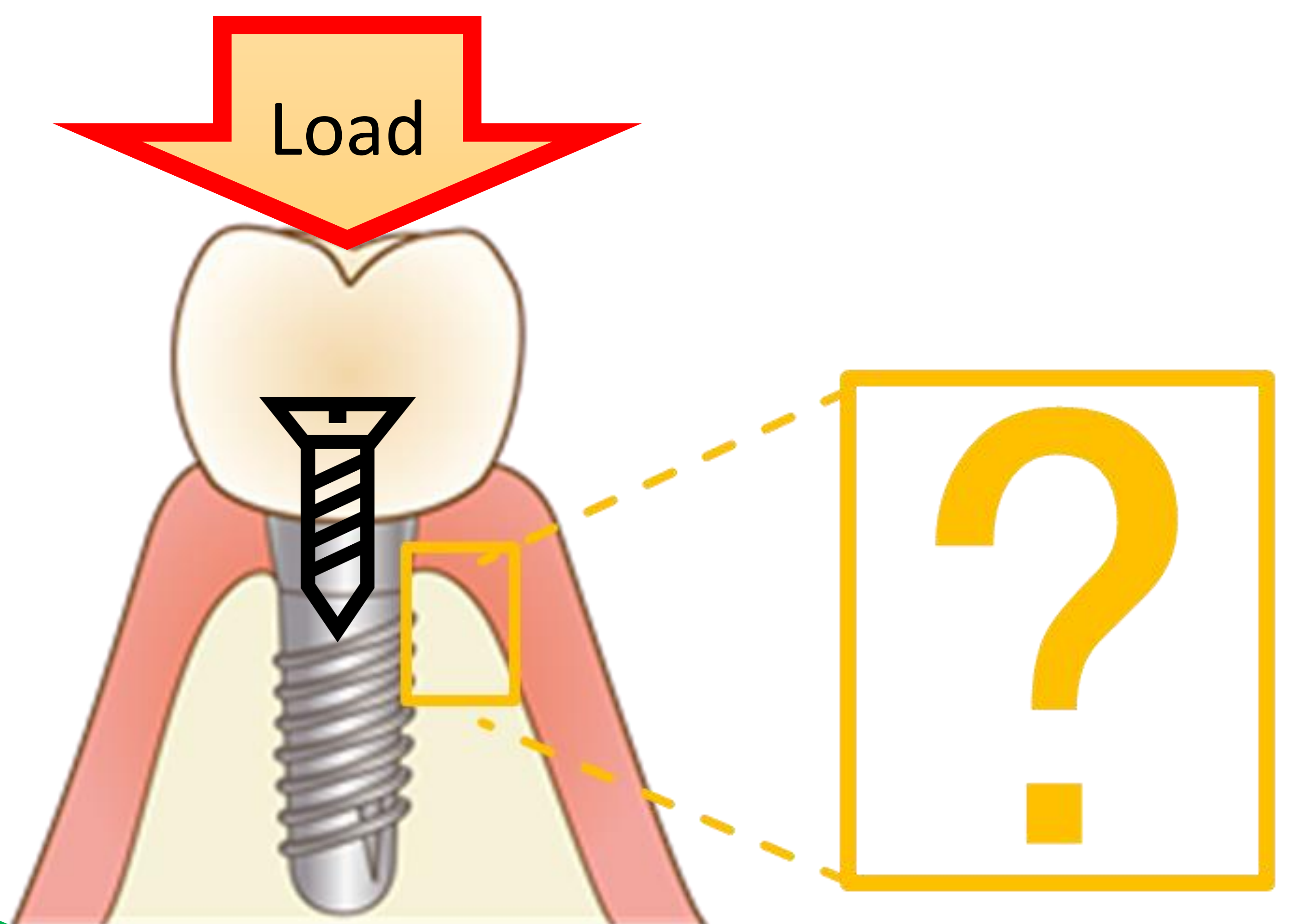


- The residual stress of the abutment screw tightening affects the bone tissue around the implant body.
- Temporary tightening does not effect bone tissues. (Farah O, et al. 2020)

Abutment screw tightening

+

Vertical dynamic load



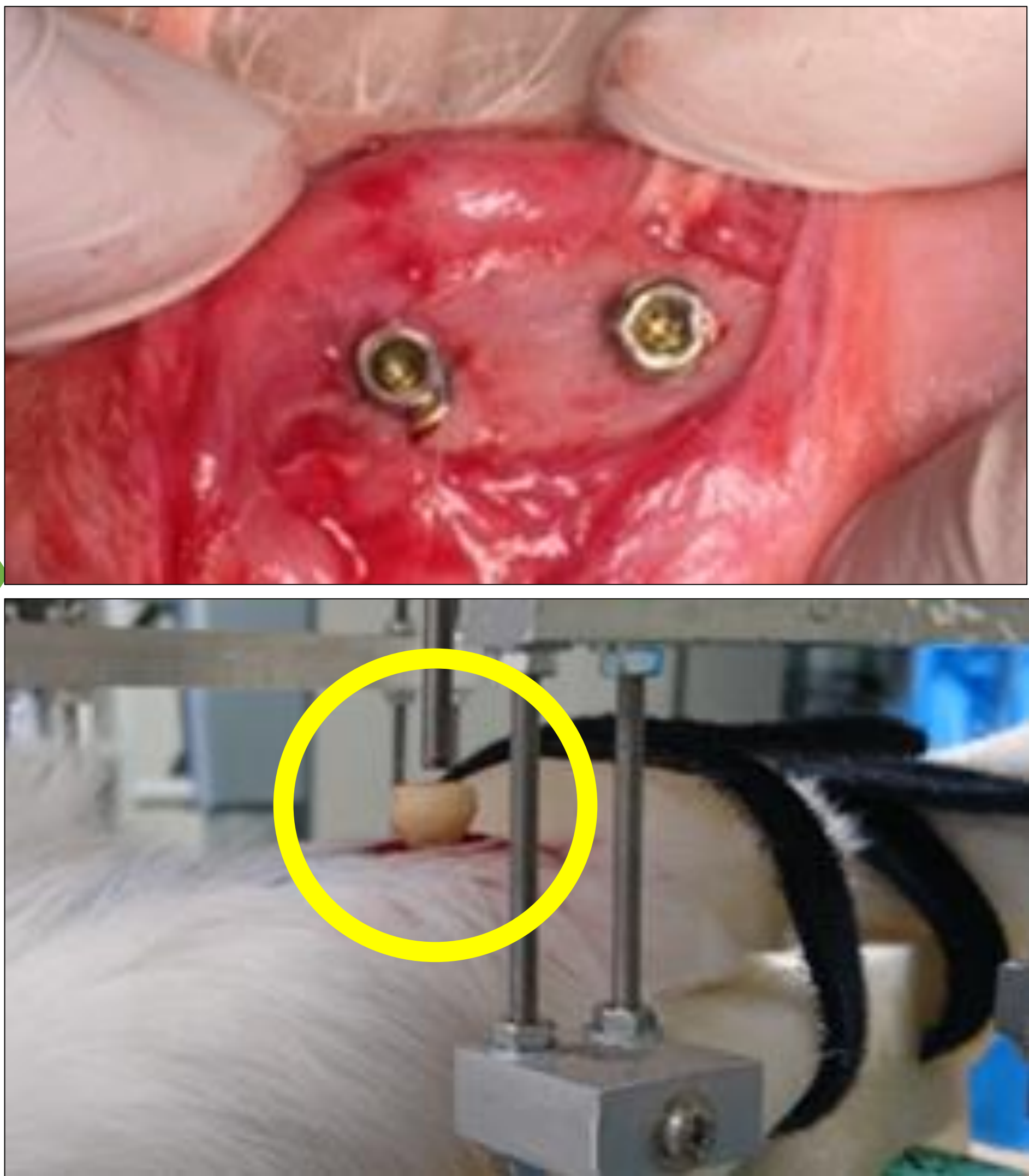
Material and Method

- 16~18-week-old Japanese white rabbits
- Implants (ϕ 3.3mm $\times$ 8mm)
- Vertical dynamic load : 50 N, 3 Hz, 1800 times
2 times/week

Implantation



Abutment screw tightening + Vertical dynamic load



8W

4W

Sampling

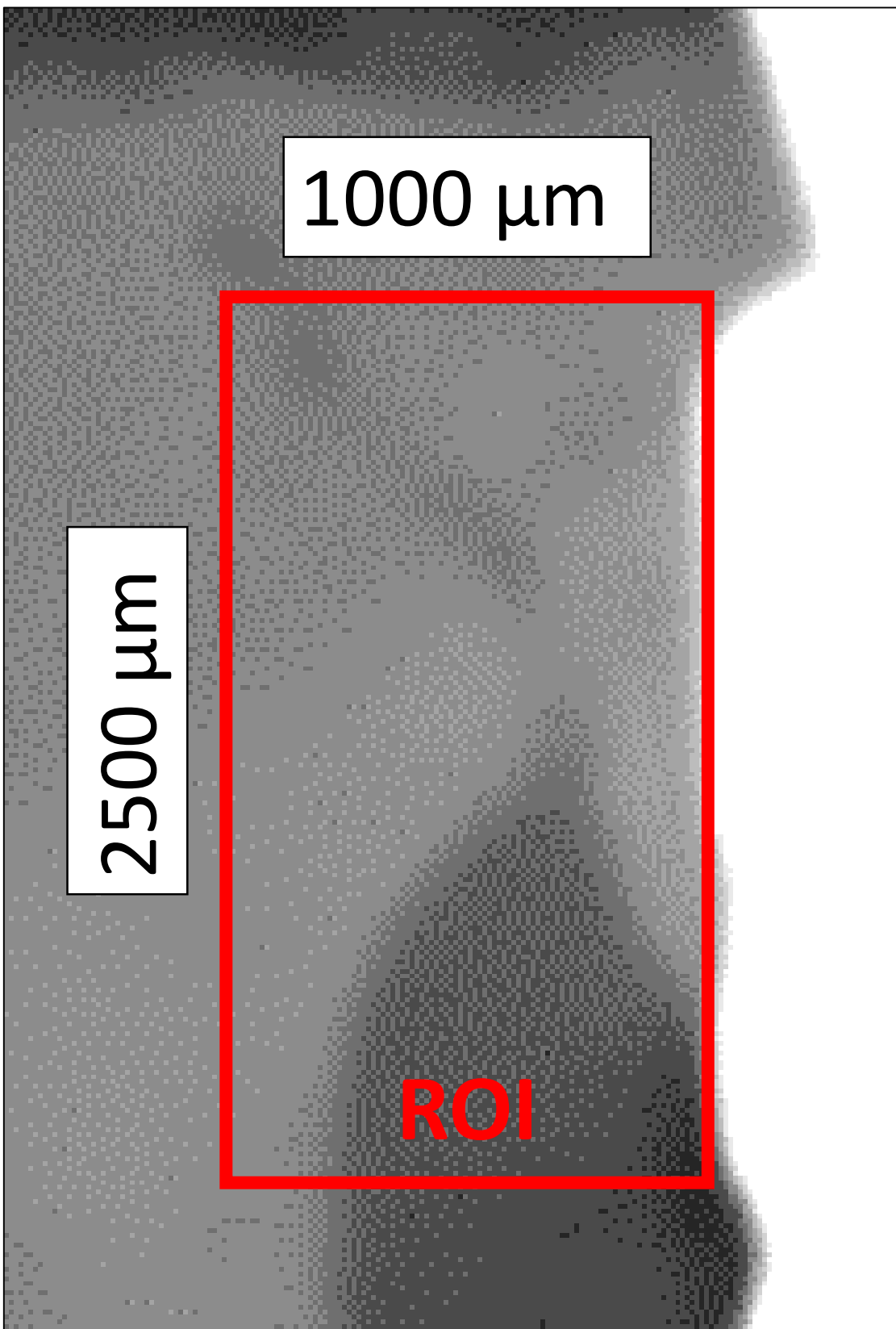
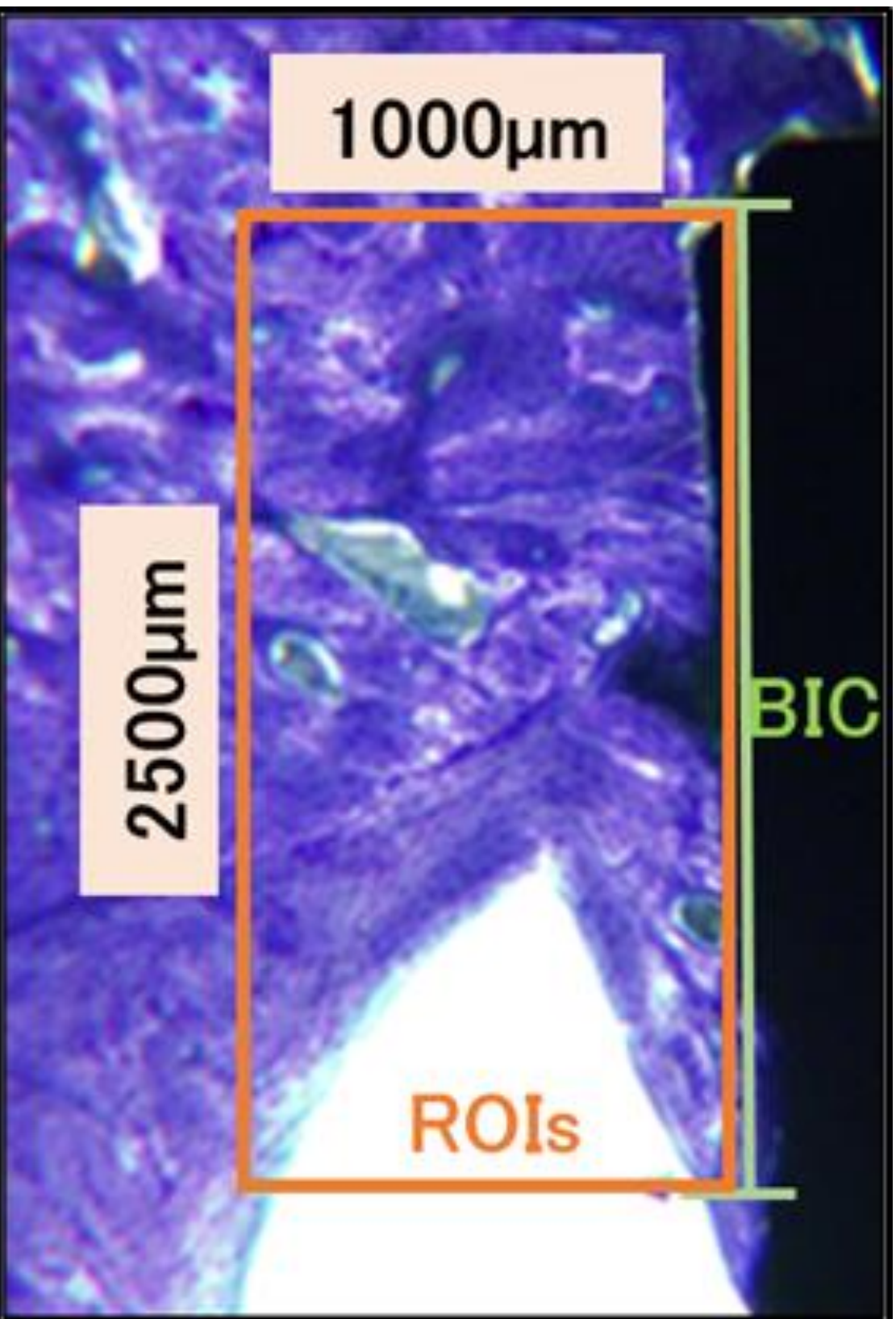
The animal care and experimental procedures were approved by the Intramural Animal Care and Use Committee (Approval no. SA01093).

Test group (each n=6)

Control group dose not have the abutments.

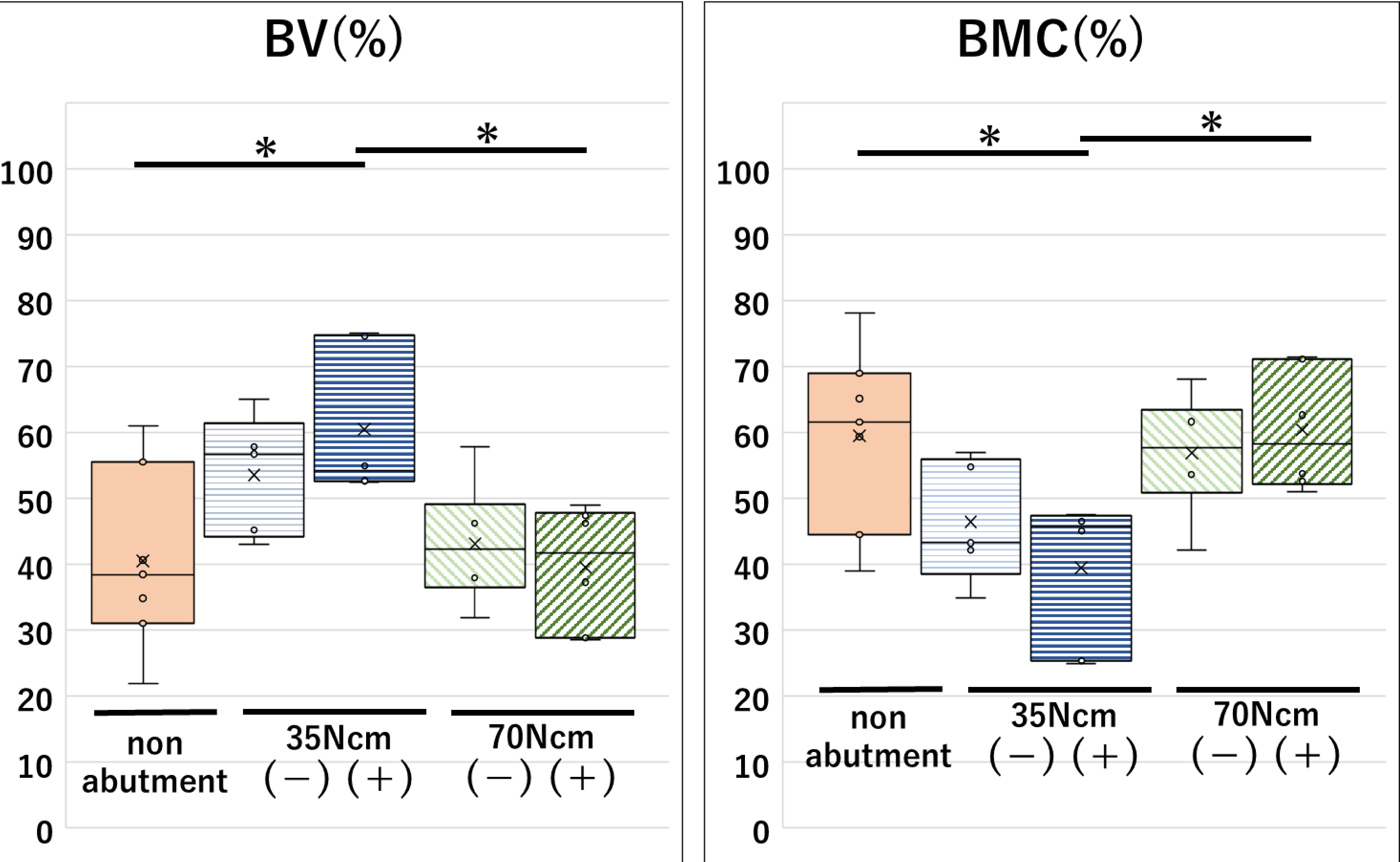
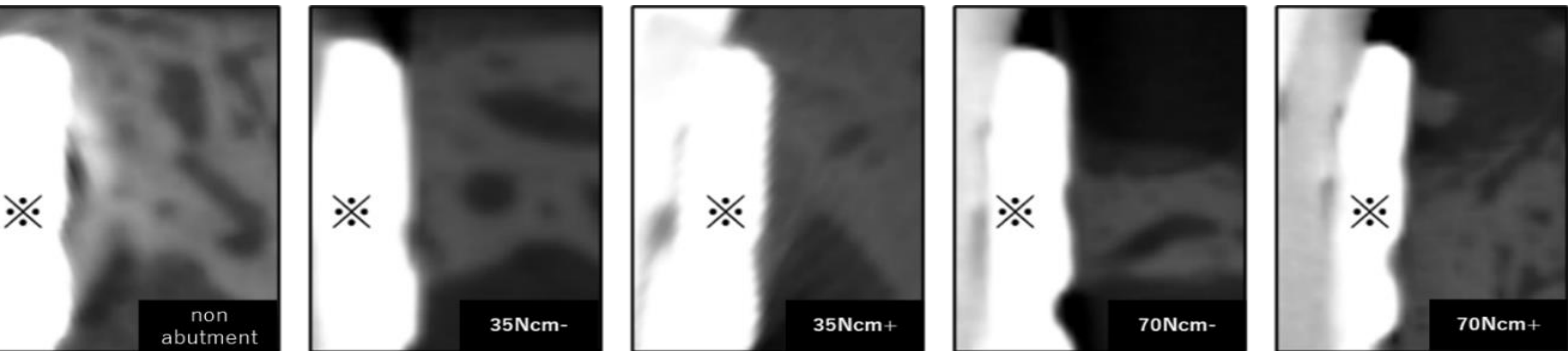
Tightening torque	Dynamic load	
	(-)	(+)
35 Ncm (Company-recommended)	35 Ncm (-)	35 Ncm (+)
70 Ncm (Excessive torque)	70 Ncm (-)	70 Ncm (+)

- **Micro-CT :**
 - **BV (bone volume) (%)** around the implant
= Surrounding Bone Volume/Perimeter Tissue volume
 - **BMC (bone marrow cavity) (%)**
= surrounding bone marrow cavity volume/surrounding tissue volume
- **Histomorphometric analysis :**
Non-decalcified sections with toluidine blue
 - **BIC (implant body bone contact) (%)**
= implant-bone contact (mm)/2500 μ m
(green line; from the shoulder of the implant longitudinally)
 - **BAF (bone area fraction) (%)**
= peri-implant bone area (mm^2)/2.5 mm^2
(orange box; 2500 μ m long $\times$ 1000 μ m wide based on the shoulder of the implant)
- **Statistical analysis :**
A two-way analysis of variance followed by Tukey-Kramer.
A significant difference was set at $P<0.05$



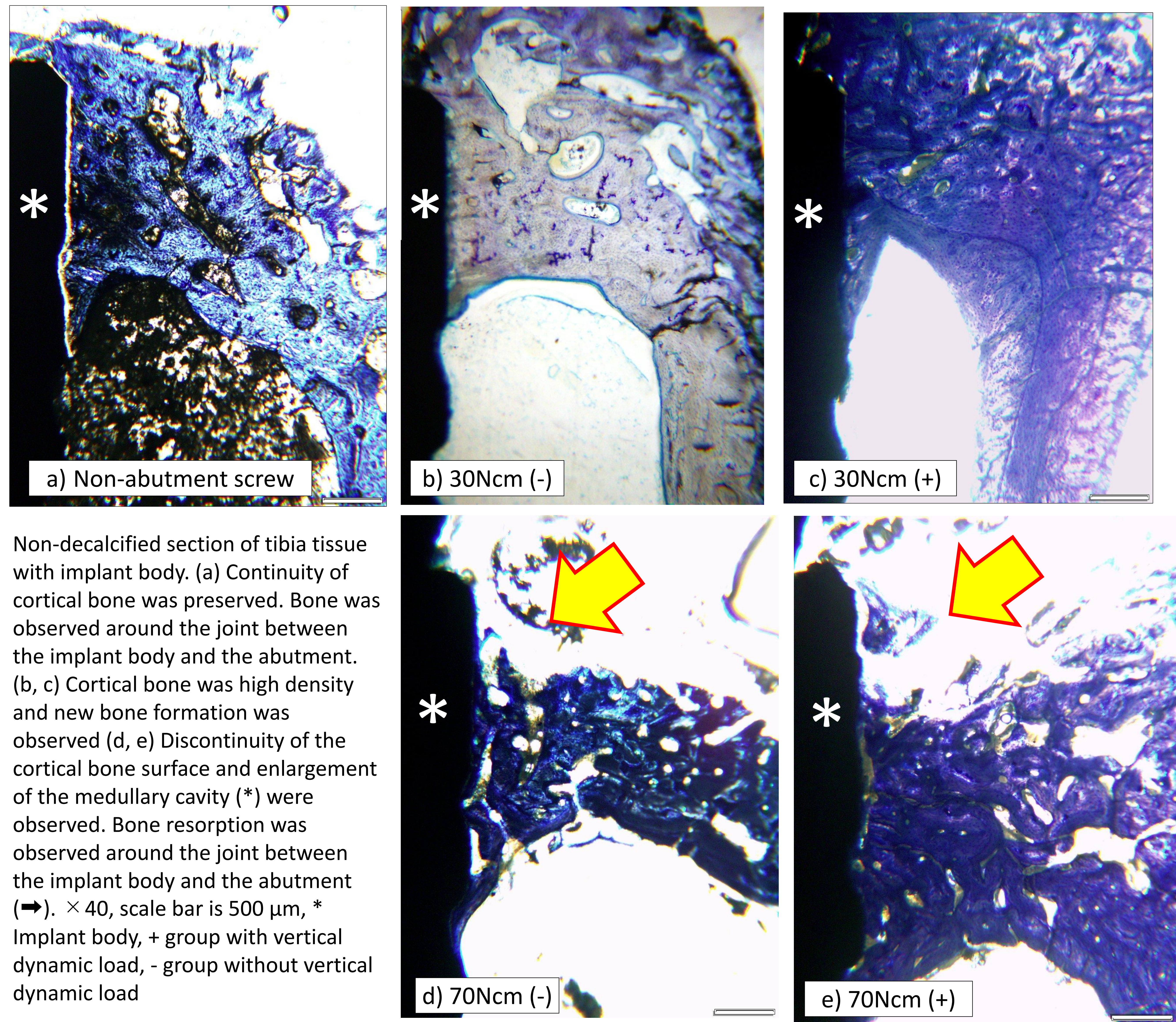
Results

1) Micro-CT

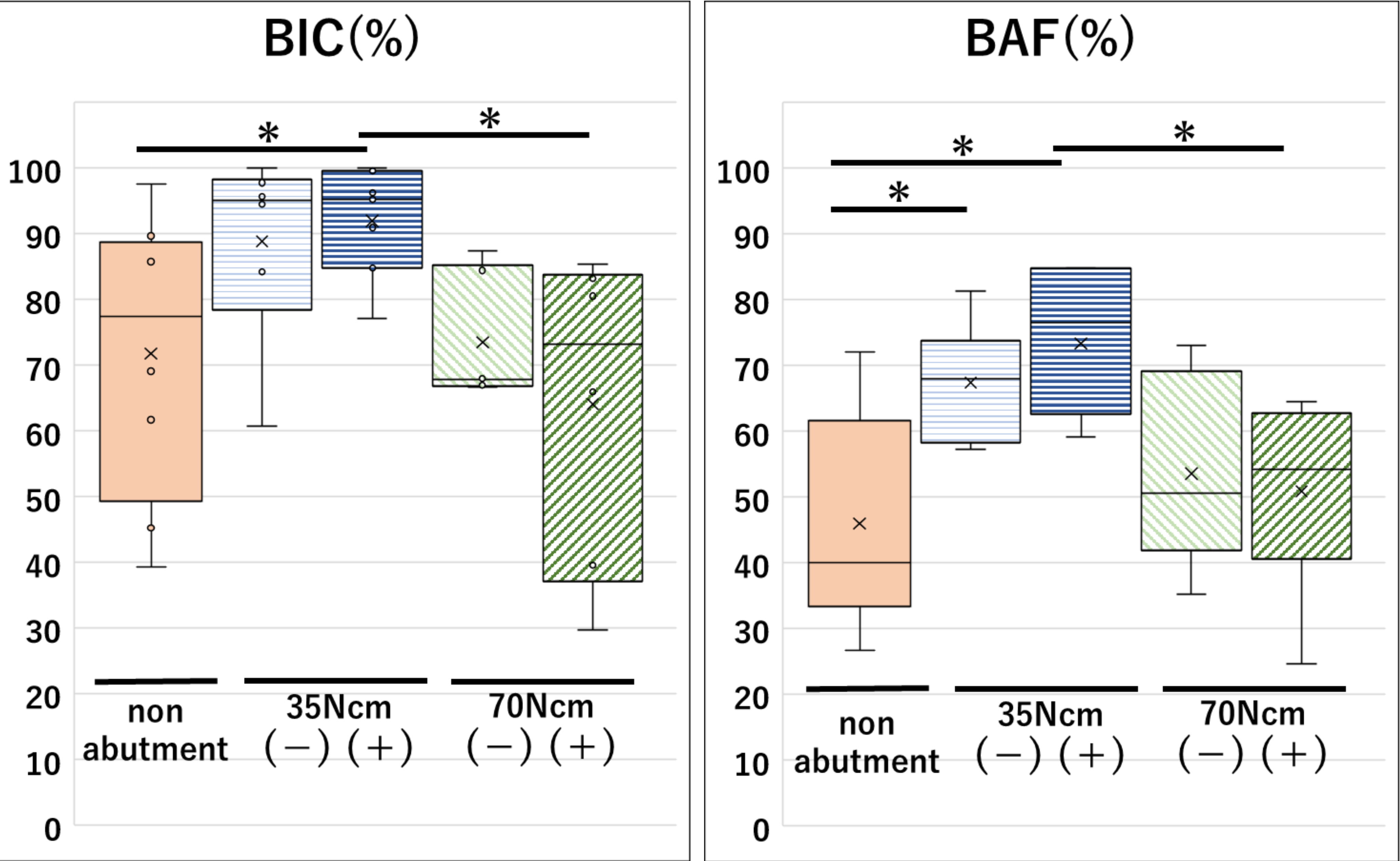


Micro CT image of implant body and Micro CT analysis of BV (bone volume) and BMC (bone marrow cavity) *P<0.05, + group with vertical dynamic load, - group without vertical dynamic load

2) Histological observation



3) Histomorphometric analysis



Histomorphometry assessment of BIC (implant bone contact) and BAF (bone area fraction) *P<0.05, + group with vertical dynamic load, - group without vertical dynamic load

Conclusion

The preload stress even without any occlusal loading might affect peri-implant bone stability and initiate bone remodeling. After vertical dynamic loading, the preload affected the peri-implant bone tissue. According to these results, tightening with the torque value recommended by the company might be biologically acceptable clinically, but an excessive torque value should be avoided.

Discussion

- Although there was no significant difference between 35Ncm (company-recommended torque) with and without dynamic loading in bone volume, 35Ncm+ tended to have larger BIC, BAF, and BV than 35Ncm-, which was significantly larger than the non-abutment group.
 - Many studies have reported that dynamic loading promote bone formation at peri-implant bone. (Yagihara A., et al.2016, Robling, A.G., et al.2009, 2006.)
 - It was suggested that **applying a moderate occlusal force on the proper torque value may work good effective in favor of the peri-implant bone clinically.**
- In the 70 Ncm torque group, there was no significant difference in BIC, BAF and BV whether there is the dynamic load or not.
- Bone marrow cavity around the implant body were observed at 70 Ncm - and + group may indicate that the possibility of bone resorption due to the preload caused by excessive tightening torque.
- Histological findings showed bone resorption at the implant neck at 70Ncm with dynamic load.
 - It was suggested that **the peri-implant bone may be effected by preload stress caused excessive tightening torque regardless of the dynamic load.**
 - **It is necessary to be careful not to apply an excessive torque value when applying abutment torque in clinical situation.**
- When a dynamic load was applied, there were significant differences between 35Ncm and 70Ncm.
 - The possibility that **the tightening torque value affects the stability of the tissue around the implant body. Moreover, clinically excessive torque should be avoid for keeping the peri-implant tissue.**