

The Minipig Intraoral Dental Implant Model: Histological Characteristics and Implant Outcomes

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Background & Aims

Historically, the most used animal model for pre-clinical evaluation of dental implant technologies and surgical protocols has been the canine. Minipigs have been extensively used in biomedical research and they are considered to be anatomically and physiologically similar to humans. They usually achieve skeletal maturity around 16-18 months of age, which coincides with the eruption of the permanent lower premolars. Particularly, the Yucatan minipig have full permanent dentition around 18 months of age, and each side of the jaw contains 3 incisors, 1 canine, 4 premolars and 3 molars. Although recently the intra-oral swine models have been used to study wound healing of peri-implant soft and hard tissues, the literature lacks a more detailed investigation focusing on the description of the minipig intra-oral dental implant model (MIDIM).

Fig 1a



Fig 1b

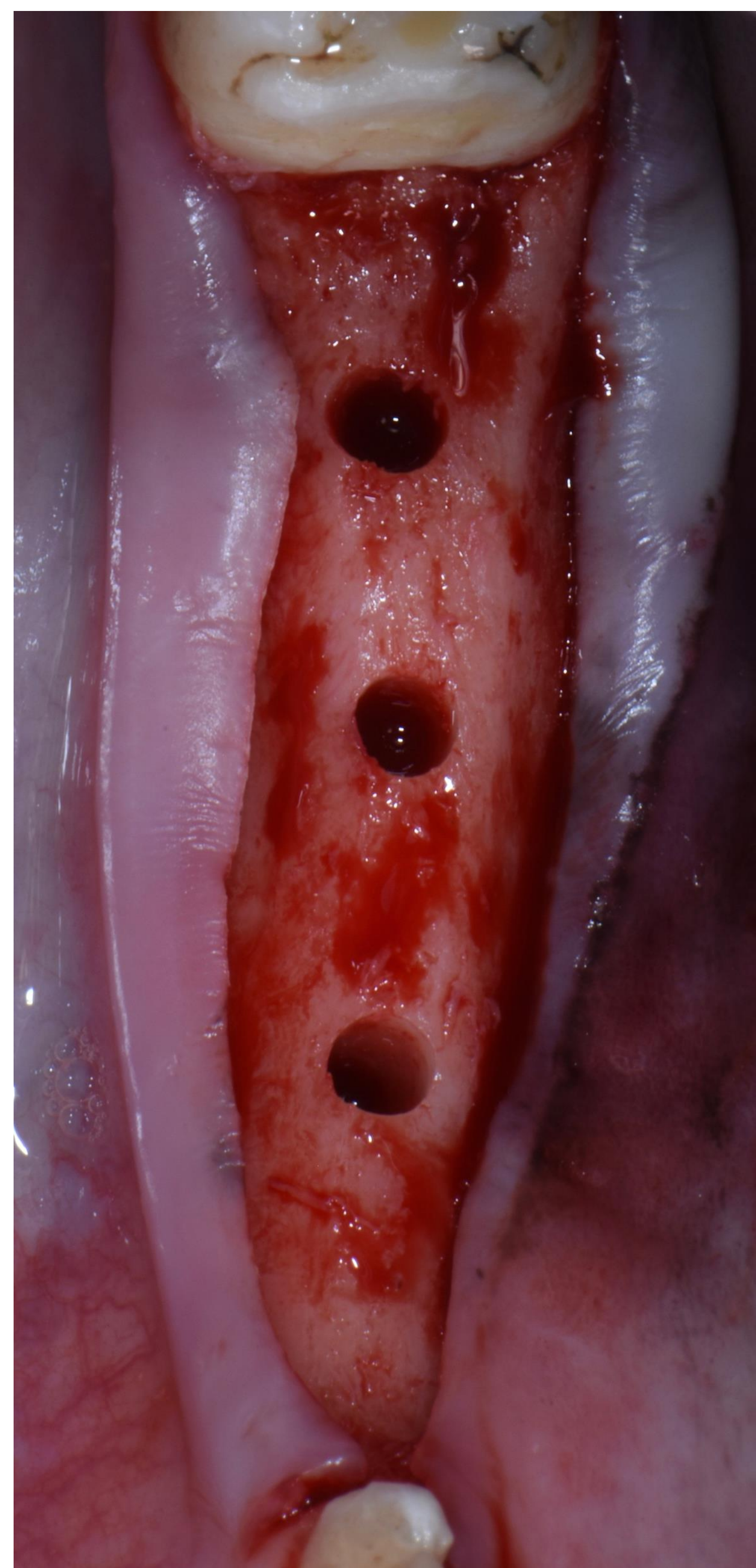


Fig 1c



Fig 1d

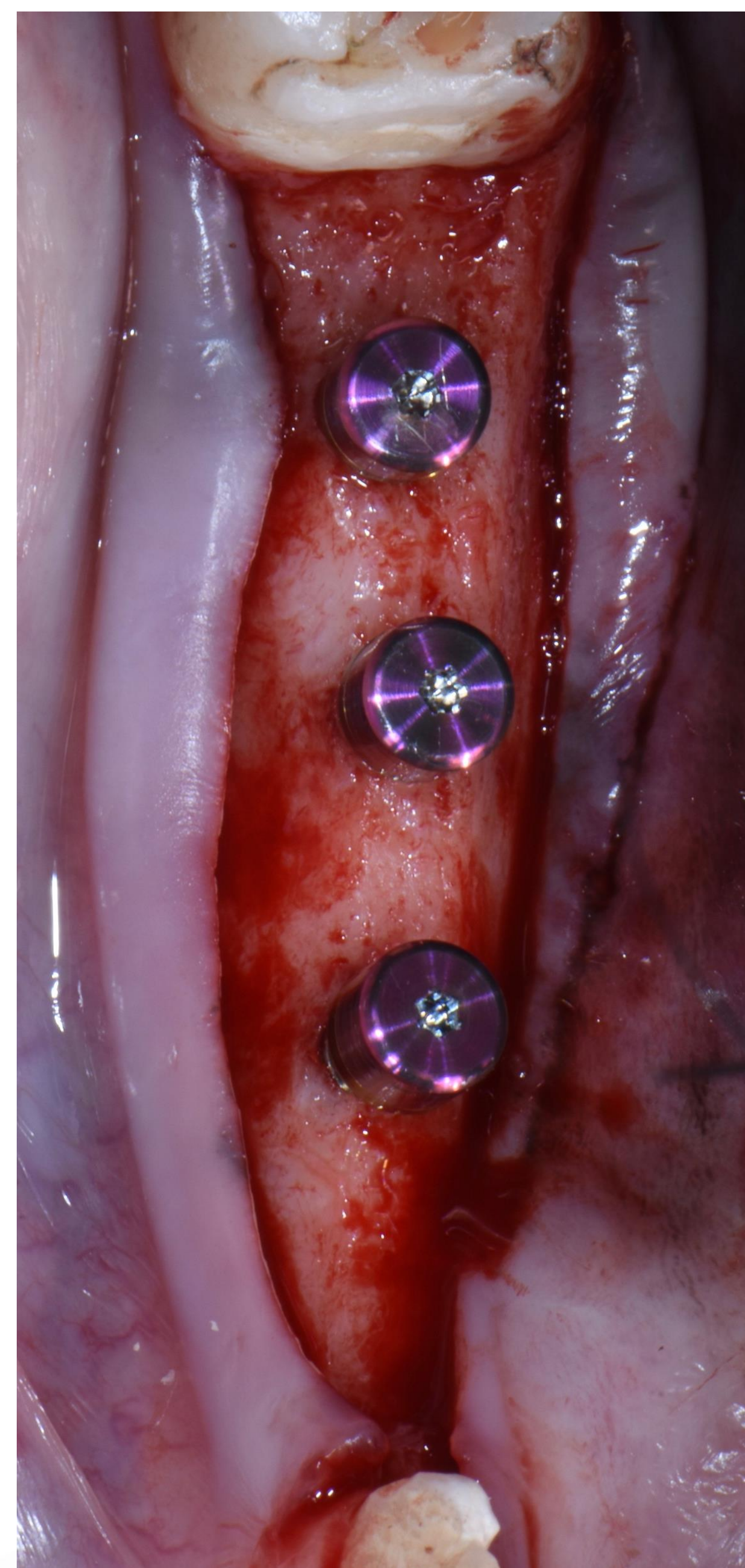


Fig 1e



The purpose of this study was to describe the characteristics and histological outcomes of the MIDIM.

Fig 1: Implant placement surgery: (a) ridge healed 3 months after extraction; (b) osteotomies; (c) implant placement; (d) healing abutments; (e) immediate post-op



Methods

Sixteen Yucatan minipigs, 24-28 months old, approximately 60kg were included. Third and fourth premolars (P3 and P4) and first molars (M1) were extracted, and tissues were allowed to heal for 12 weeks. Three dental implants were placed in each mandibular quadrant (Nobel Active 3.5x10mm). Animals were euthanized at 3 and 13 weeks after implant placement. Cutting and griding technique was used to prepare the samples, which were stained with Stevenel's Blue. Histometrics was performed using Image Pro Premier 9.2 software (Fig 3). Generalized estimating equations were used to model healing time, implant position in the arch, and implant site taking into consideration the clustering of implants within animals.

Figure 3 shows the parameters assessed:

Fig 3a: osseointegration (bone to implant contact – BIC – red), crestal bone level (orange), platform to first BIC (green).

Fig 3b: bone density within threads (right), bone density outside threads (left).

Fig 3c: epithelium length (yellow), epithelium to platform (green), mucosal height (red).

Fig 3d: Inflammation on marginal (red), abutment (green) and platform (yellow) areas.

Fig 3a

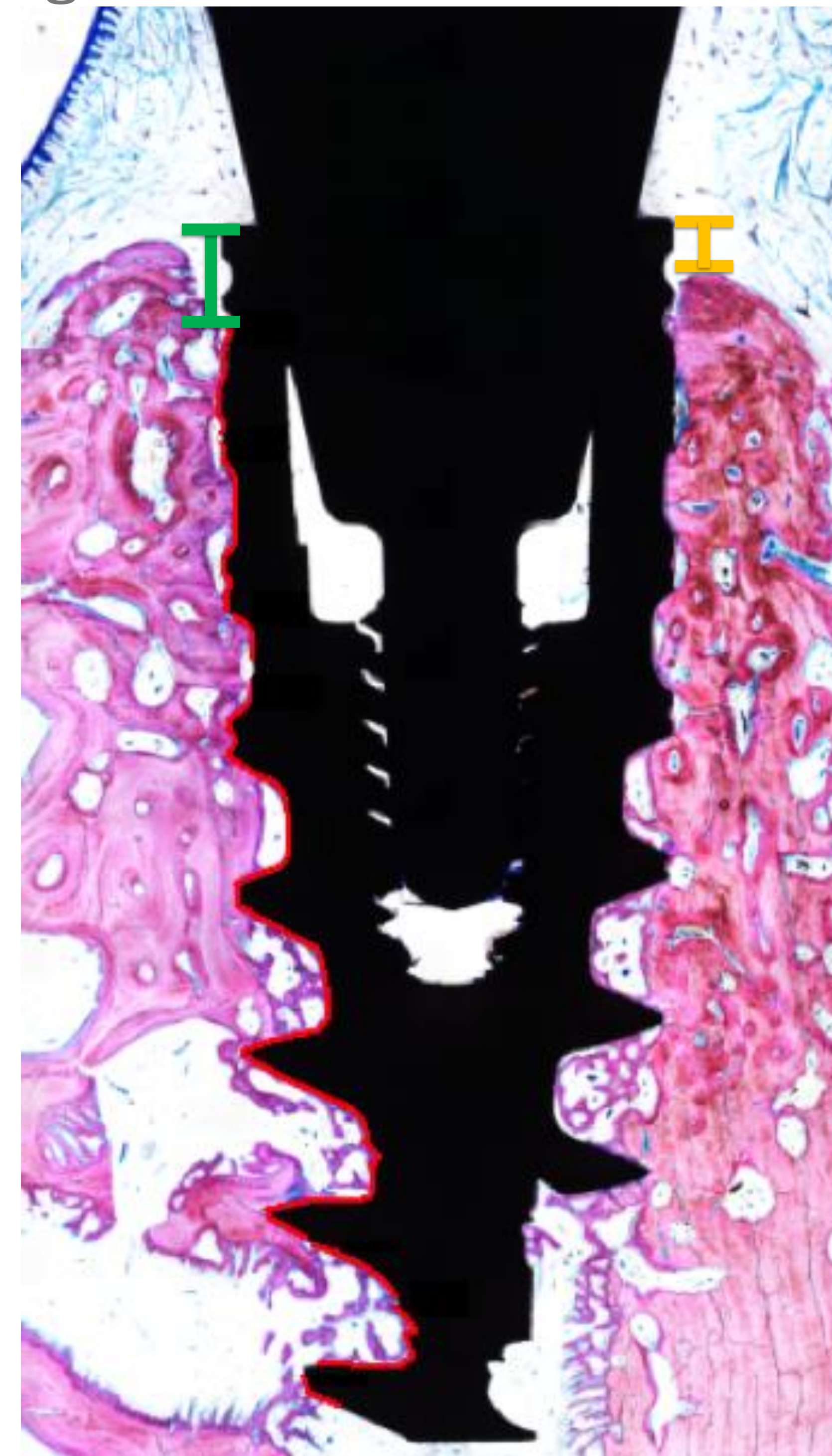


Fig 3b

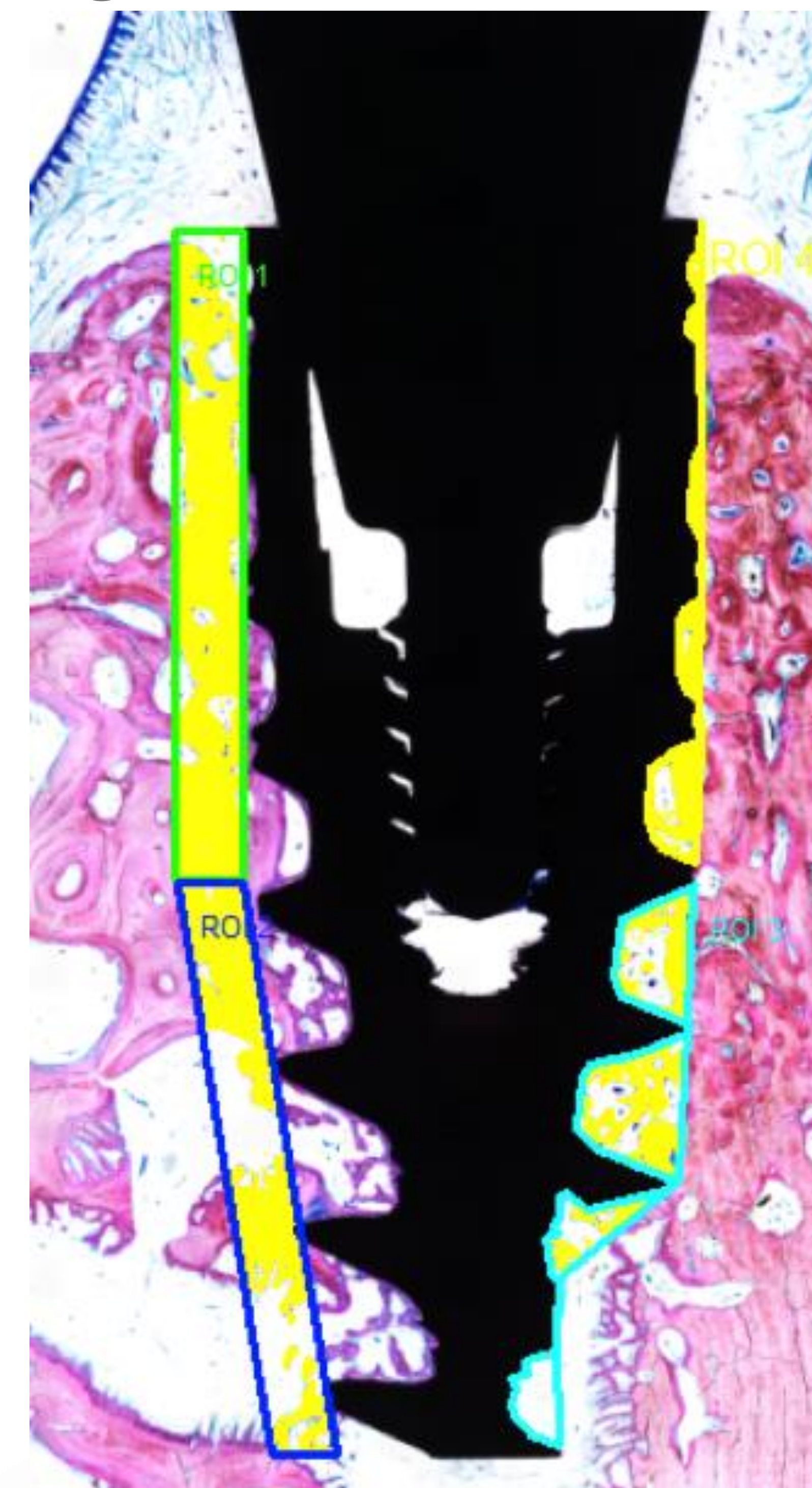


Fig 3c

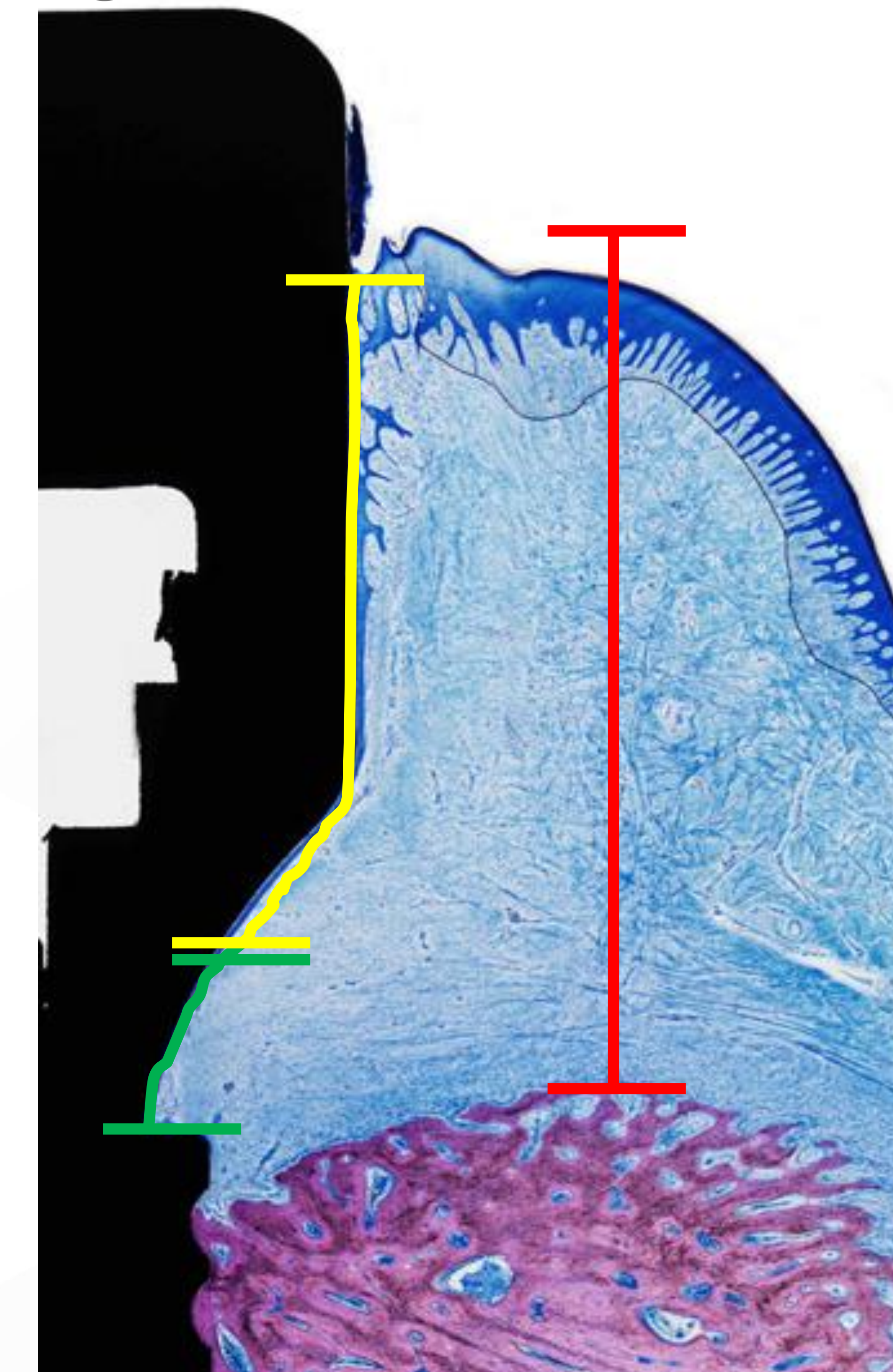
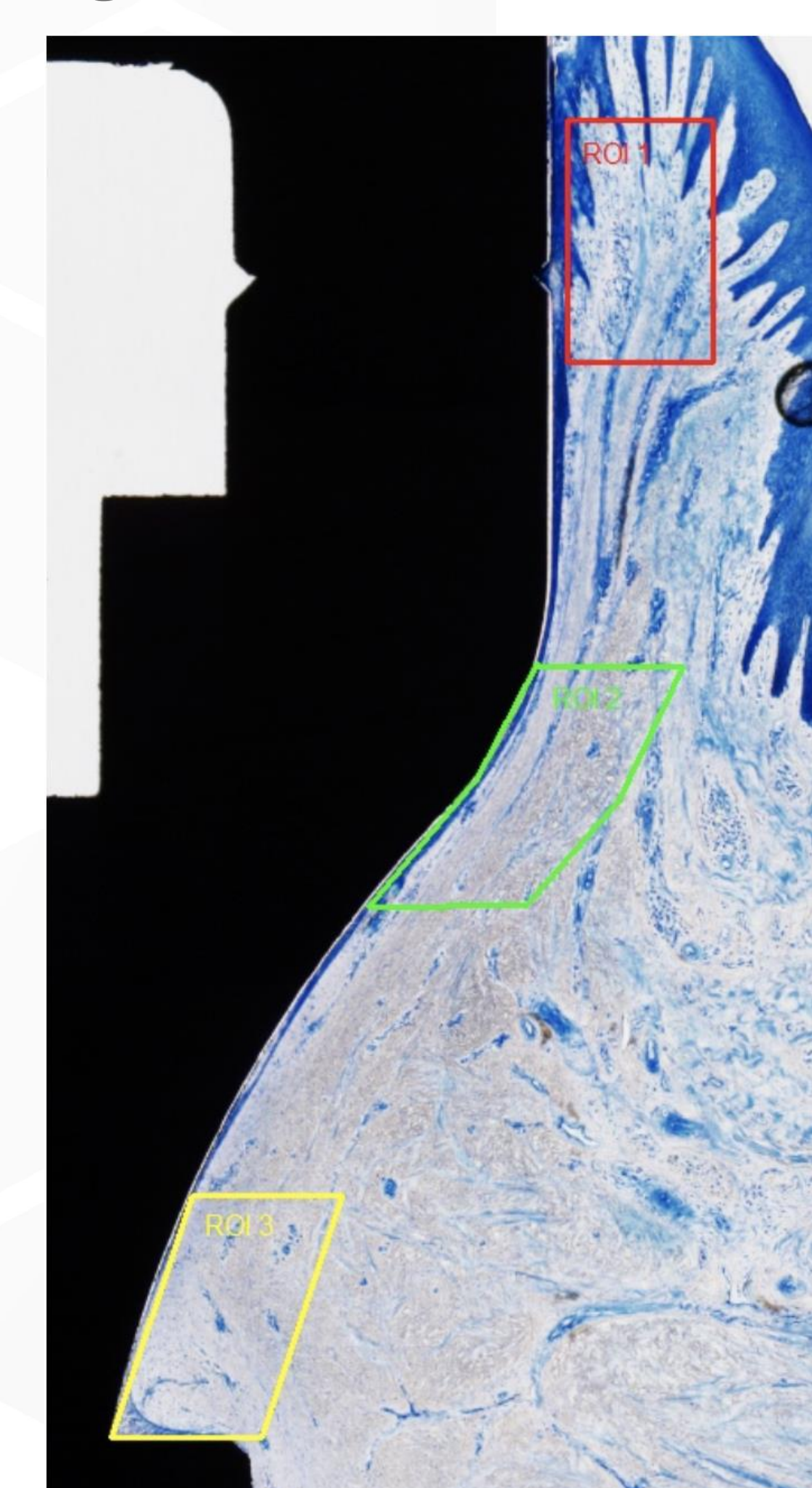


Fig 3d





Results

Table 1 show the histological measurements for hard and soft tissue parameters (mean±SD). Osseointegration significantly increased between 3 and 13 weeks of healing, and lingual sites showed significantly higher osseointegration than buccal sites. Crestal bone level was significantly higher at 13 weeks, and posterior implants had higher crestal bone level than the other implants. The distance between the platform and the first bone-to-implant contact was significantly lower in posterior than anterior implants. Bone density increase significantly overtime and it was significantly higher in anterior implants. The length of the peri-implant epithelium significantly increased overtime, and it was significantly longer on posterior implants and buccal sites. Mucosa height was significantly higher on posterior implants and buccal sites. Marginal inflammation was significantly higher at 3 weeks, in posterior implants, and buccal sites.

Table 1. Histological measurements for hard and soft tissue parameters (mean ± SD)

Means followed by same capital letter are not significantly different (p > 0.05).

	Time		Implant position			Site	
Variable	3wks	13wks	P3	P4	M1	Buccal	Lingual
Osseointegration	59.2±2.9A	68.5±1.6B	62.4±3.1A	63.7±1.7A	65.7±2.1A	61.9±1.9A	66.1±1.5B
Crestal bone level	0.4±0.1A	-0.2±0.1B	0.2±0.1A	0.2±0.1A	-0.1±0.1B	0.03±0.1A	0.2±0.1A
Platform - first BIC	0.9±0.1A	0.9±0.1A	1.1±0.2A	0.9±0.1AB	0.7±0.1B	0.9±0.1A	0.8±0.1A
BDWT	0.4±0.02A	0.6±0.03B	0.5±0.03A	0.5±0.02A	0.4±0.02B	0.5±0.02A	0.5±0.02A
BDOT	0.6±0.02A	0.7±0.02B	0.7±0.01A	0.7±0.01A	0.6±0.02B	0.7±0.02A	0.6±0.01B
Epithelium length	3.1±0.2A	4.1±0.3B	3.4±0.3A	3.2±0.2A	4.3±0.2B	4.5±0.2A	2.8±0.2B
Epithelium - platform	0.5±0.1A	0.4±0.3A	0.2±0.2A	0.5±0.2AB	0.7±0.1B	0.3±0.2A	0.6±0.2A
Mucosal height	3.5±0.1A	3.7±0.1A	3.2±0.1A	3.3±0.1A	4.3±0.2B	4.2±0.1A	3.0±0.1B
Epithelium length	3.1±0.2A	4.1±0.3B	3.4±0.3A	3.2±0.2A	4.3±0.2B	4.5±0.2A	2.8±0.2B
Epithelium - platform	0.5±0.1A	0.4±0.3A	0.2±0.2A	0.5±0.2AB	0.7±0.1B	0.3±0.2A	0.6±0.2A
Mucosal height	3.5±0.1A	3.7±0.1A	3.2±0.1A	3.3±0.1A	4.3±0.2B	4.2±0.1A	3.0±0.1B
Inflammation							
marginal	1.5±0.1A	1.2±0.1B	1.1±0.1A	1.2±0.1A	1.7±0.1B	1.5±0.1A	1.2±0.1B
abutment	0.8±0.1A	0.6±0.1A	0.6±0.1A	0.7±0.1AB	0.8±0.1B	0.9±0.1A	0.5±0.1B
platform	0.3±0.1A	0.2±0.1A	0.4±0.1A	0.1±0.1B	0.2±0.1A	0.2±0.1A	0.3±0.1A



Conclusions

3
weeks

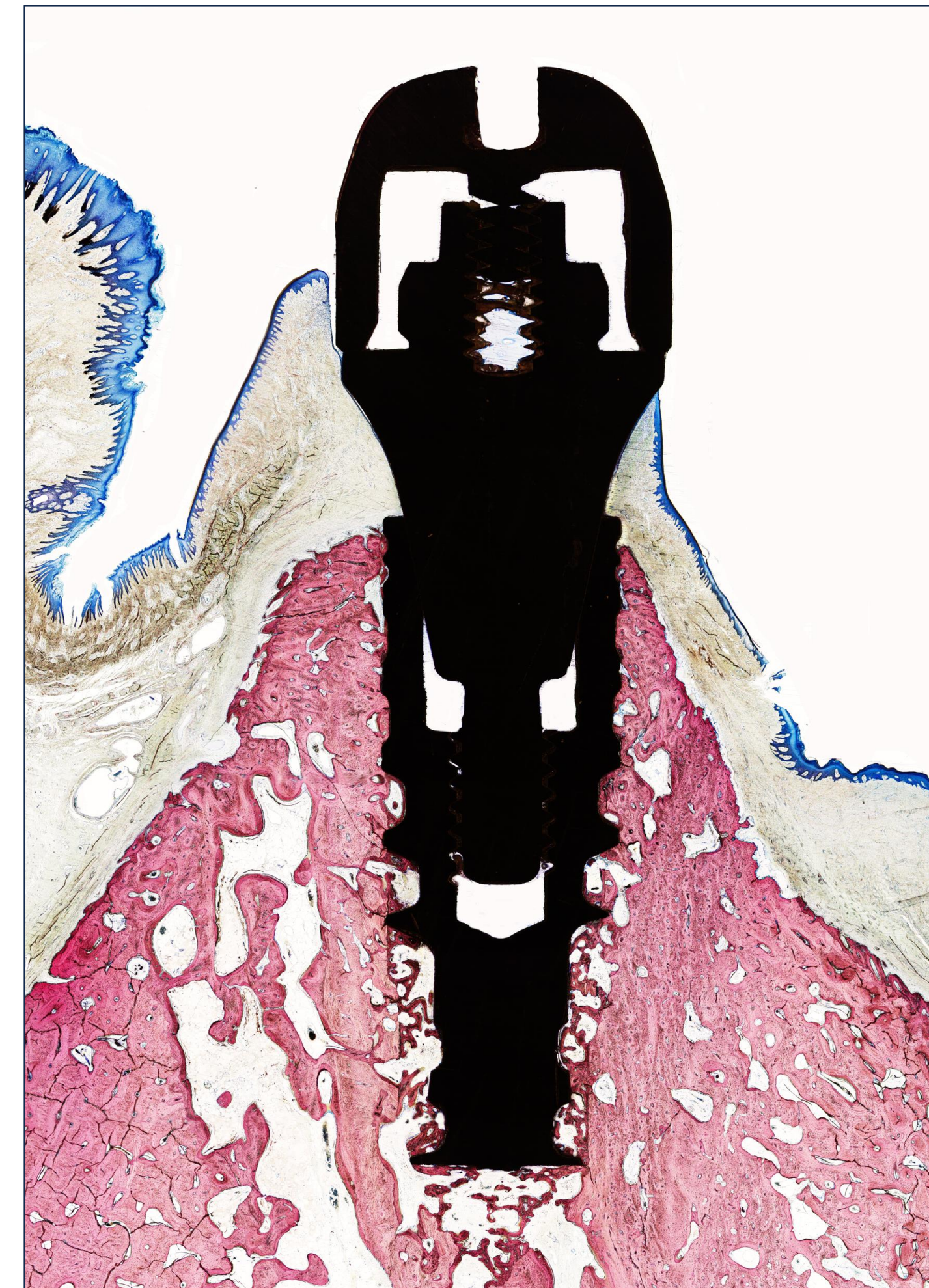
P3



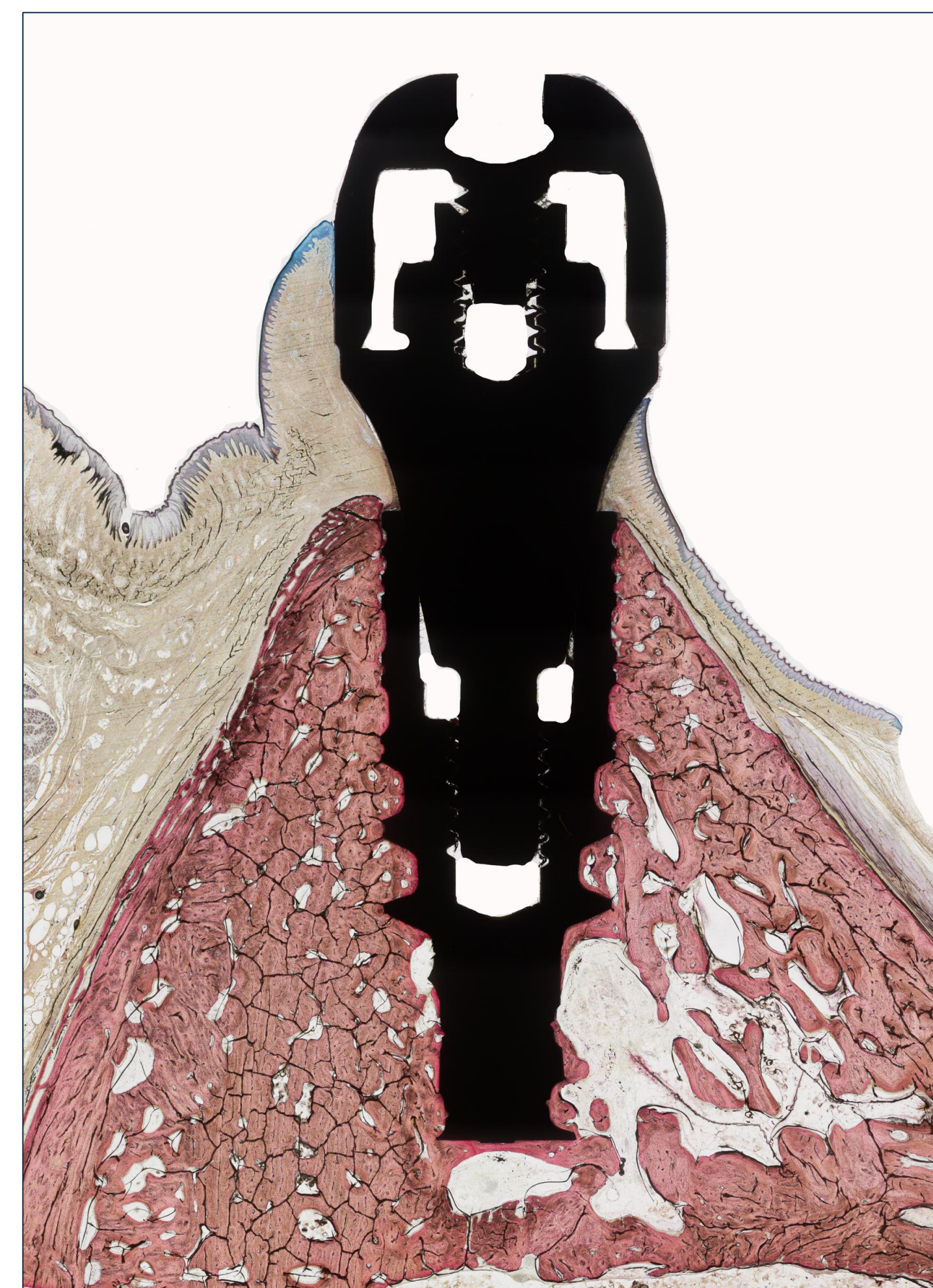
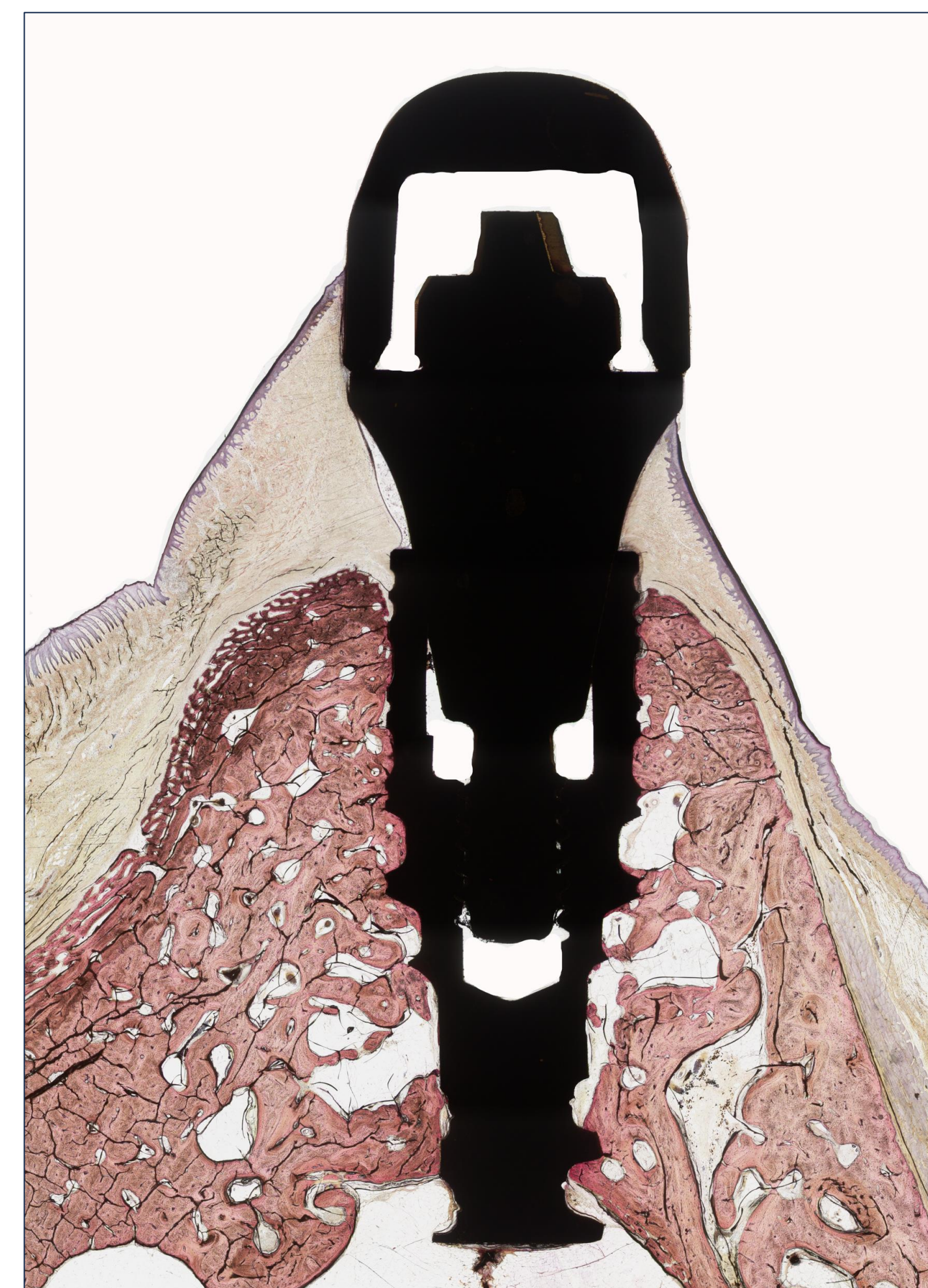
P4



M1



13
weeks



In conclusion, the minipig intra-oral dental implant model (MIDIM) can be used to reliably test dental implants technologies as intended for human use. The intra-oral and temporal variability observed appears to mimic different clinical scenarios.

Fig 4. Representative histological samples per implant position and per healing time.