



Evaluation of Low crystalline apatite (LCA) bone grafts in the mandibular socket preservation : An experimental study in the mongrel dog

YongJun CHO DMD / Deok-Kyu KANG DDS / Hye-Sun KIM DDS, MS /
Jae-Young KIM DDS, MS, PhD / Jong-Ki HUH DDS, MS, PhD

*Department of Oral and Maxillofacial Surgery, Gangnam Severance Hospital,
Yonsei University College of Dentistry, Seoul, Korea*



Introduction

- Recently, Low Crystalline Apatite(LCA) has been introduced as a novel non-heat-treated alloplastic bone graft material with not only osteoconductive properties but also significant osteoinductive potential.
- LCA is characterized by a unique nano-scale microstructure and macropores, which distinguish it from conventional synthetic bone graft materials (CSBs) such as hydroxyapatite (HA), beta-tricalcium phosphate (β -TCP), and octa-calcium phosphate (OCP) (Fig. 1).
- Additionally, LCA demonstrates superior blood wettability and fibrin clotting compared to BCP37, enhancing its potential for effective bone regeneration (Figs. 2 and 3).
- This study aims to compare the physicochemical properties of LCA with CSBs and assess its in vivo performance in a mongrel dog mandibular socket preservation model.

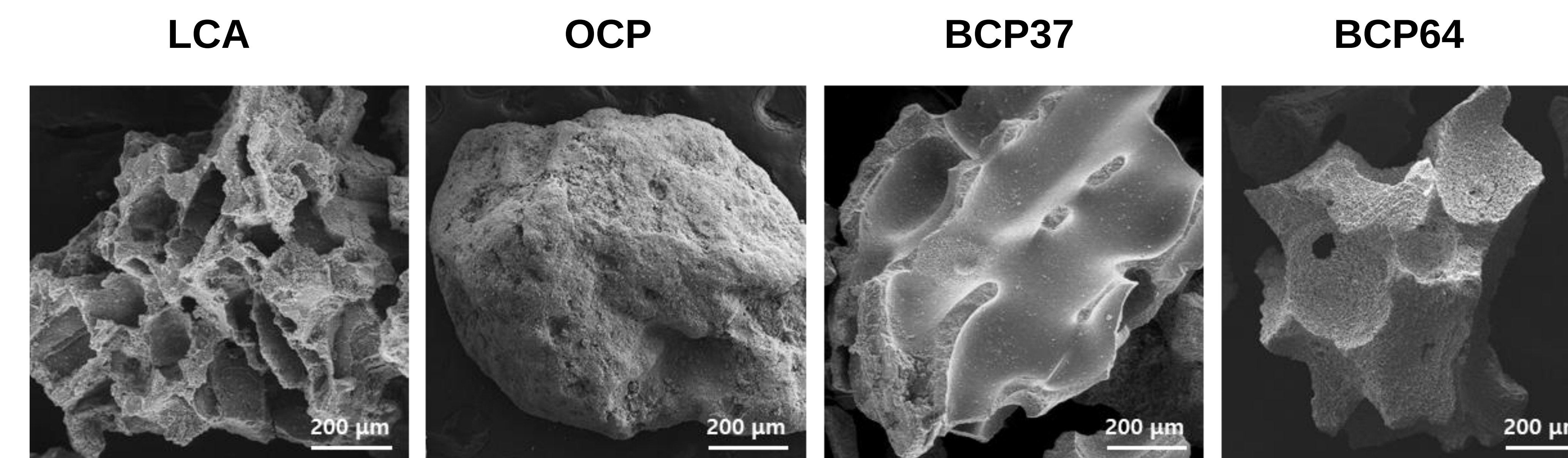


Fig.1 SEM images of each bone material (magnification of x100), LCA presents porous structure.

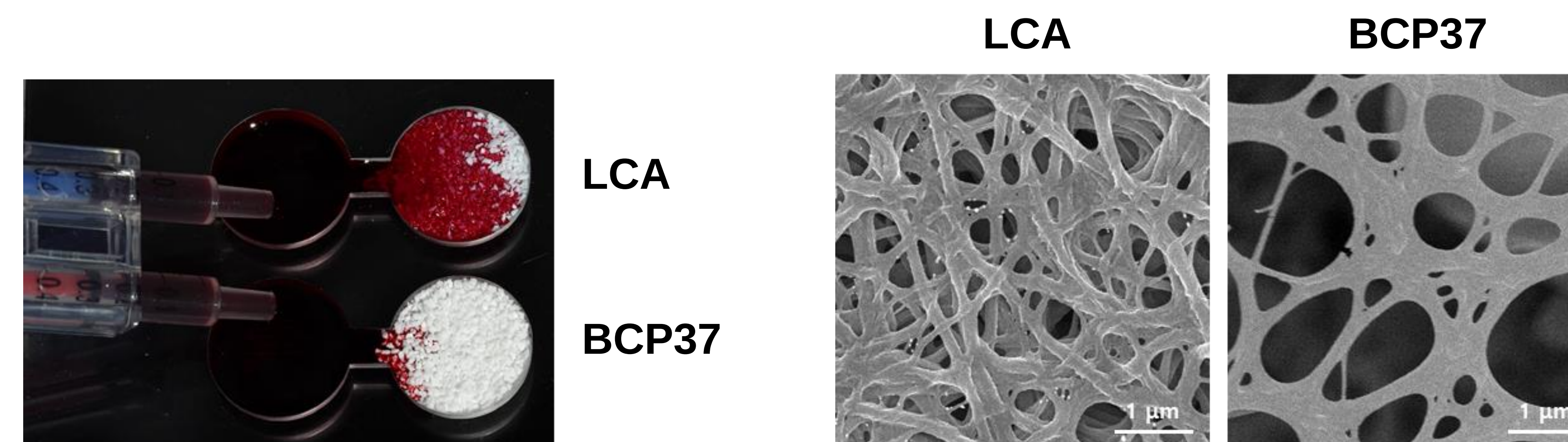
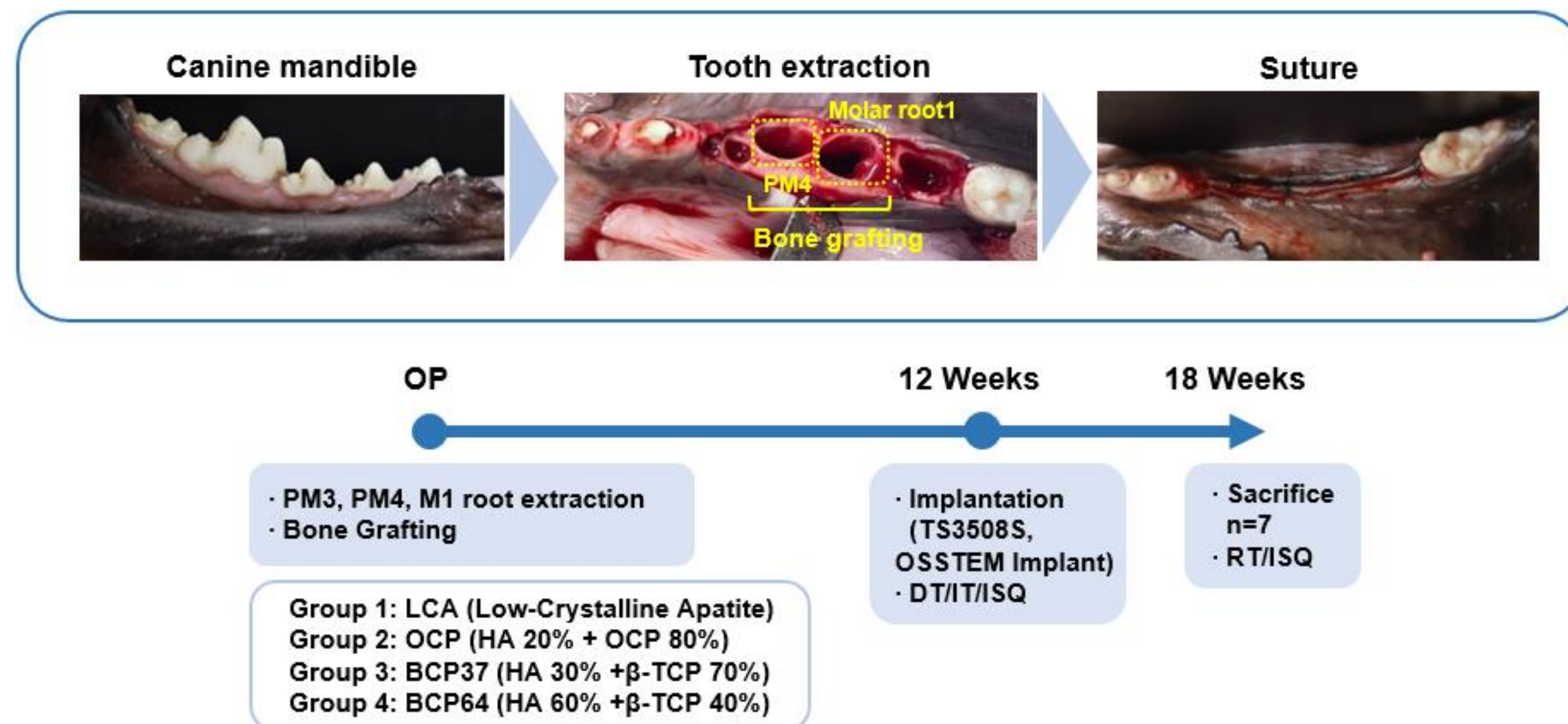


Fig.2 Blood soaking comparison between LCA and BCP37.

Fig.3 Fibrin clotting at the surface of LCA and BCP37 (magnification of x10,000).

Materials & Methods



- All experimental procedures were approved by the Institutional Animal Care and Use Committee (IACUC) under protocol number OST-IACUC2304.
- This study initially involved 8 mongrel dogs, each with bilateral mandibular premolars and molars designated as experimental sites. However, one dog expired at 9 weeks, resulting in a final sample size of 7 dogs. A total of 28 extraction sockets were used for the experiment.
- In each dog, four different graft materials were applied to individual sites, categorized into four groups: LCA (Low crystalline apatite), OCP (octa-calcium phosphate), BCP37 (HA 30% + β -TCP 70%), and BCP64 (HA 60% + β -TCP 40%).
- To prevent dehiscence, the PM3 was extracted, and graft materials were placed in the extraction sockets of PM4 and the mesial root of the molar (M). After thorough trimming, the flap was repositioned and sutured.

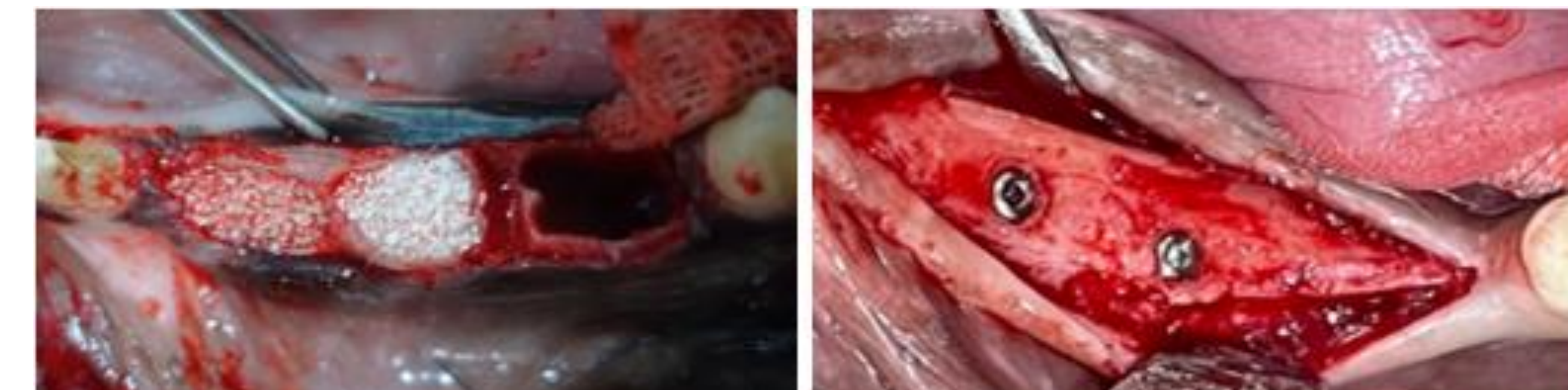


Fig.4 Bone graft was performed in the extraction sockets. After 12 weeks of healing, implants were inserted, and at 18 weeks, the animals were sacrificed.

- After 12 weeks, dental implants(TS3508S, OSSTEM Implant, Korea) were placed in the grafted areas, and drilling and insertion torque measurements and implant stability quotient (ISQ) were recorded.
- Six weeks after implant placement, the mongrel dog were euthanized, and removal torque and ISQ were subsequently measured.
- Additionally, micro-computed tomography (mCT) and histological analysis were conducted to assess new bone formation and graft material resorption.

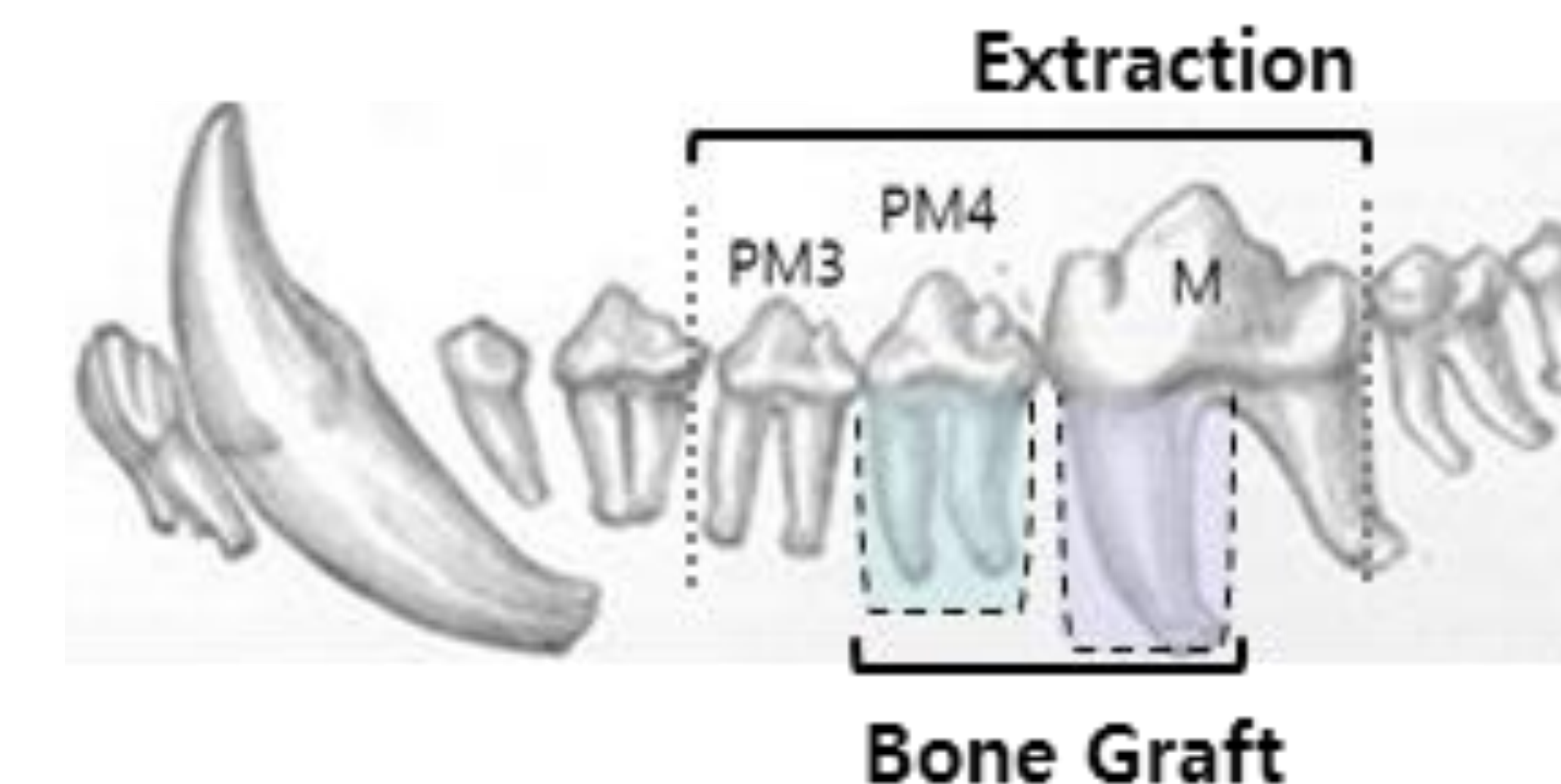


Fig.5 Schematic of the mandibular dentition of a mongrel dog. In the experiment, bone grafting was performed in the extraction sockets of the PM4 and the mesial root of the M.

Results

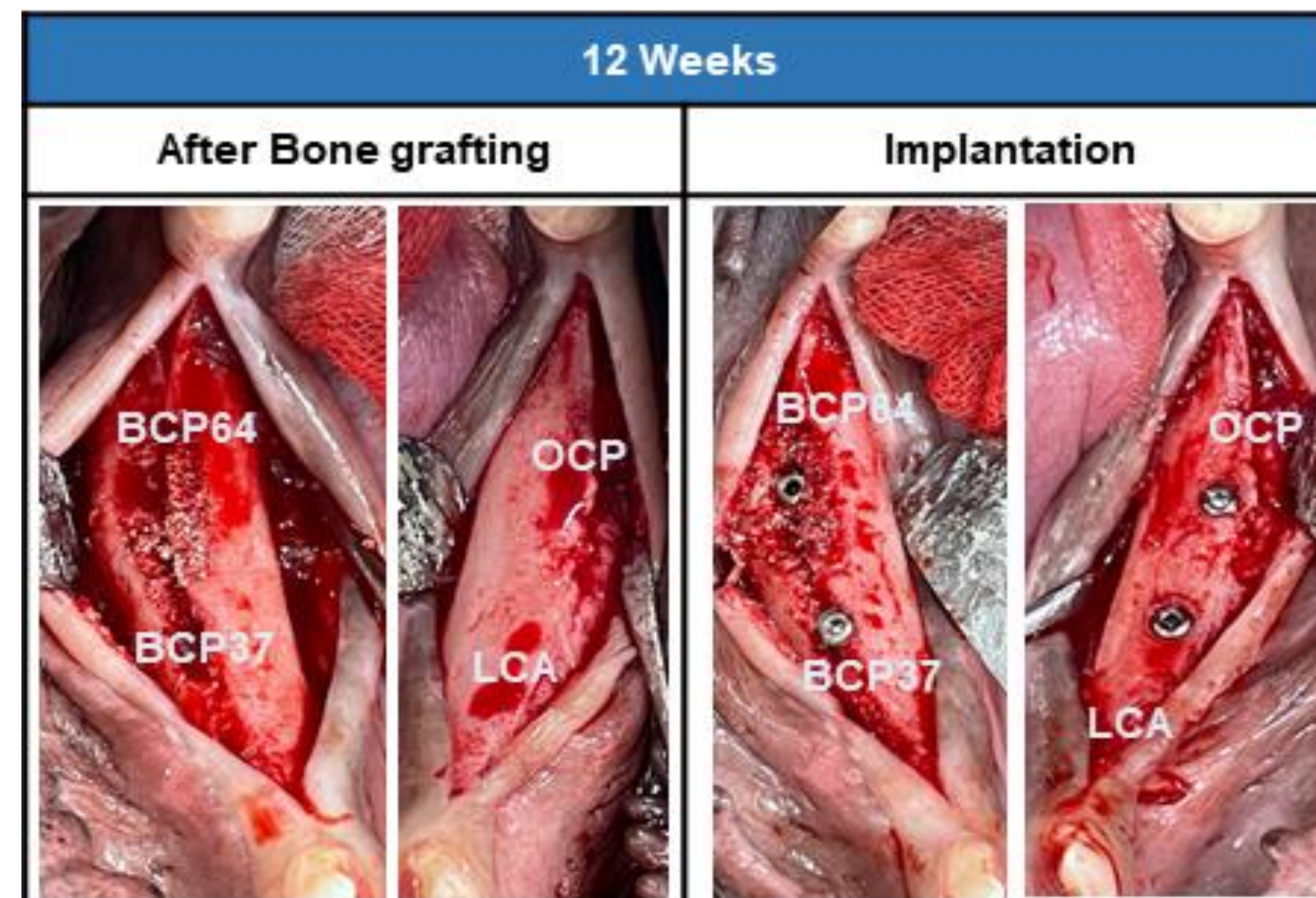


Fig.6 The mandibular alveolar ridge at 12 weeks post-socket preservation. Sites grafted with LCA and OCP exhibit favorable ossification, whereas sites grafted with BCP37 and BCP64 display residual, non-ossified bone graft material.

- At 12 weeks post-socket preservation, the LCA group demonstrated significantly higher insertion and drilling torque values compared to the BCP37 and BCP64 groups, and comparable or slightly higher values than the OCP group.
- At 6 weeks post-implantation, removal torque and ISQ results indicated that the LCA group had significantly higher stability compared to the BCP37 and BCP64 groups, while showing similar or marginally superior stability to the OCP group.

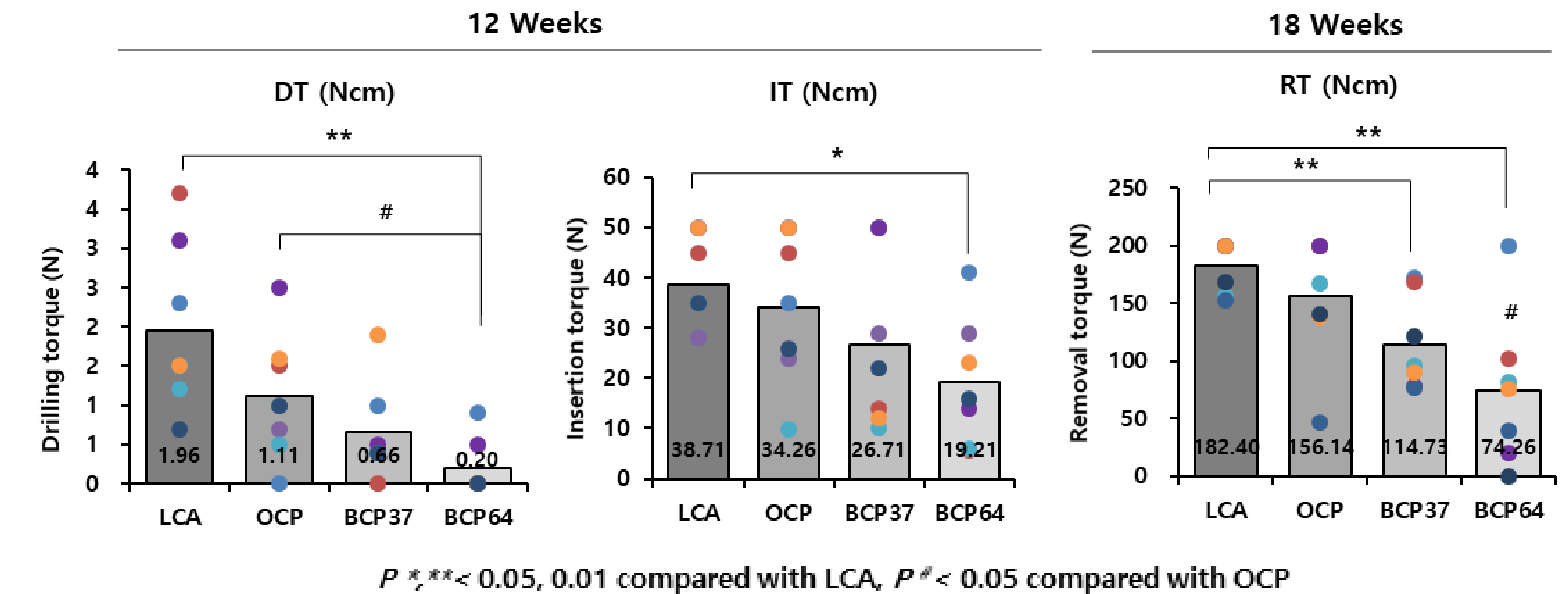


Fig.7 At 12 weeks, the LCA group exhibited significantly higher drilling torque (DT) and insertion torque (IT) values compared to the BCP64 group. At 18 weeks, removal torque (RT) measurements revealed that the LCA group had statistically higher values than both the BCP37 and BCP64 groups.

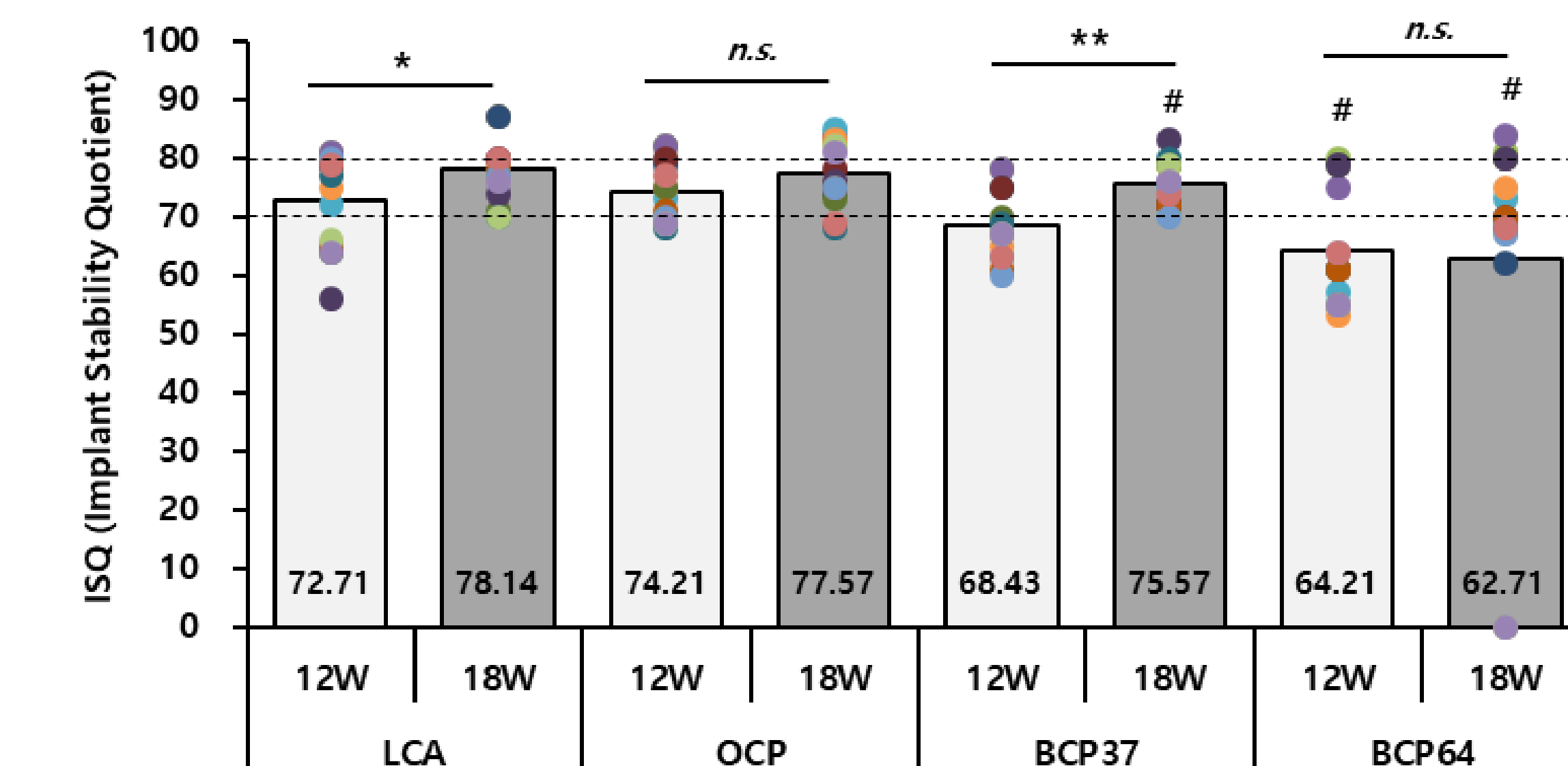


Fig.8 When comparing the Implant Stability Quotient (ISQ) values measured at the time of implant placement at 12 weeks and prior to implant removal at 18 weeks. Both the LCA and BCP37 groups showed a statistically significant increase in ISQ values after 6 weeks.

Results

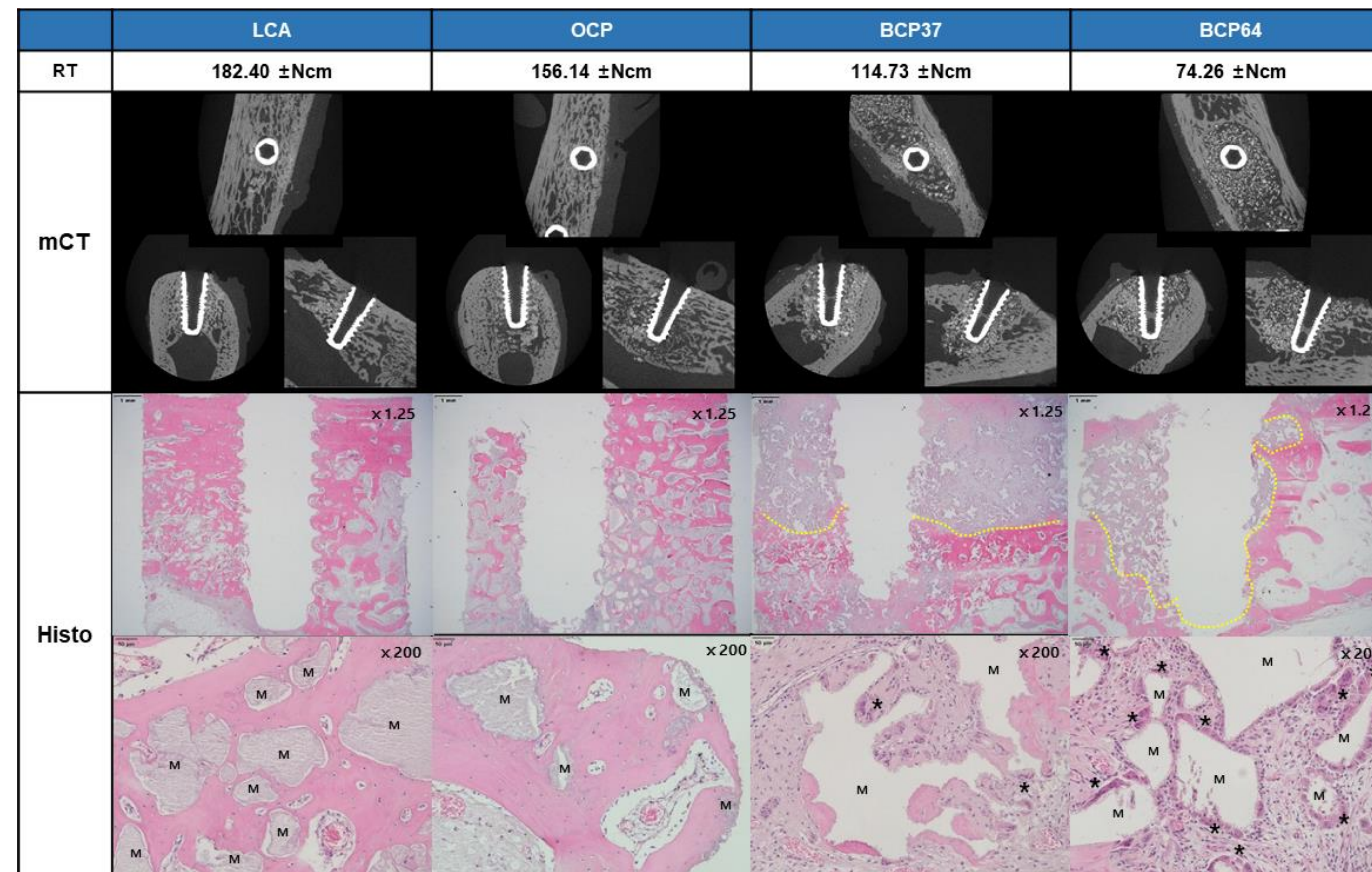


Fig.9 The micro-CT & Histologic Images of each Groups. * On the Histologic images demonstrates the Multi nucleated giant cells.

- The mCT analysis revealed that bone remodeling was most prominent in the LCA group, followed by the OCP group, while the BCP37 and BCP64 groups showed no distinct signs of bone remodeling, with residual non-ossified bone graft material still visible.

- Histologically, the LCA group exhibited significantly greater new bone formation compared to the other groups, further supporting its osteo-inductive properties. In contrast, histologic images of the BCP37 and BCP64 groups showed soft tissue involvement and the presence of multinucleated cells, suggesting incomplete osseointegration.

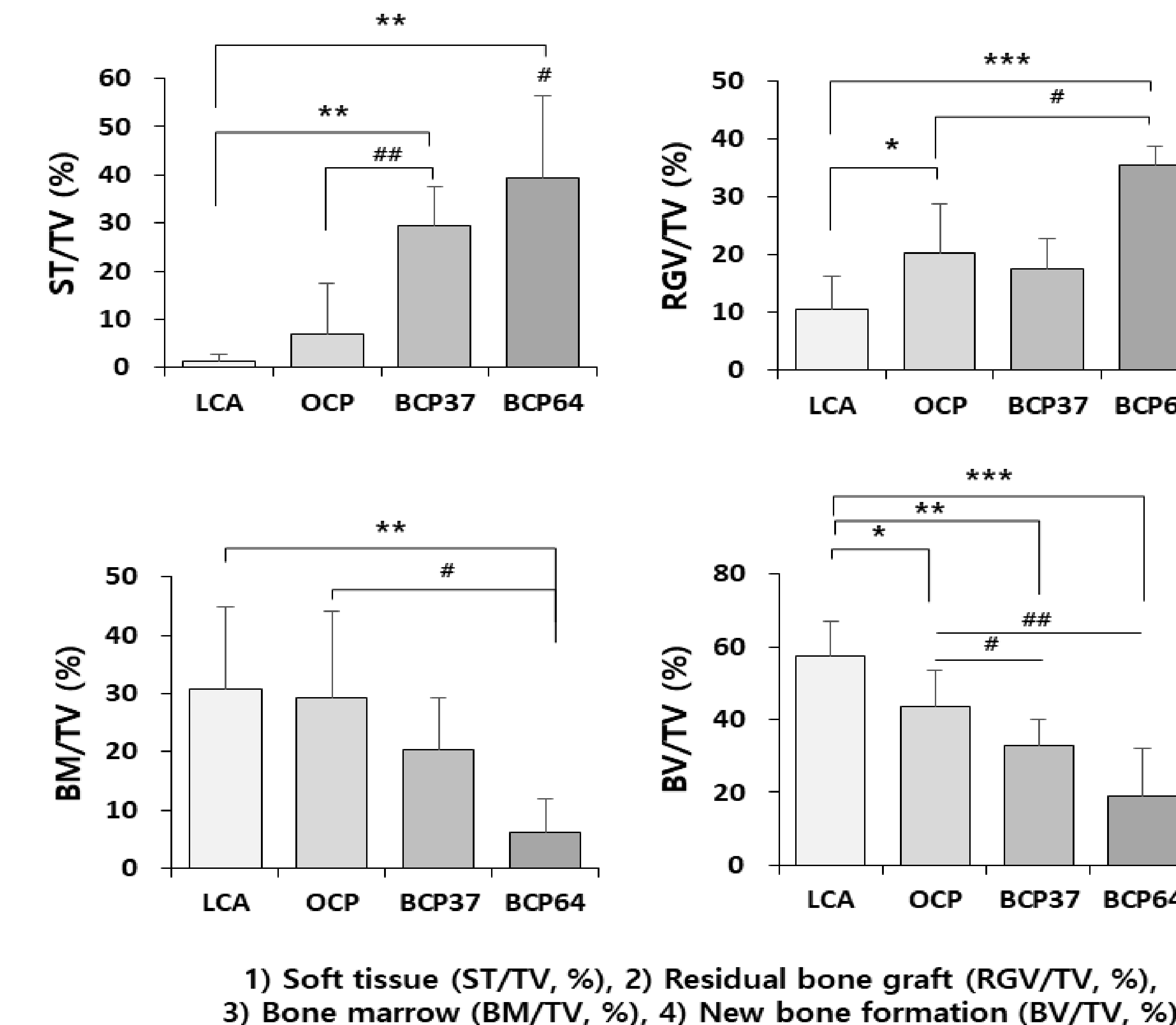


Fig.10 Table showing the histological composition ratios of each group, measured with reference to the methodology described in the study by Sergio et al.

- When comparing the histological composition ratios, the BCP64 and BCP37 groups showed a relatively higher proportion of soft tissue compared to the OCP and LCA groups, indicating greater soft tissue involvement.
- Additionally, the BCP64 group exhibited the highest amount of residual bone graft material, suggesting that the ossification process was slowest in this group.
- In contrast, the LCA and OCP groups demonstrated higher proportions of bone marrow and new bone formation compared to the other two groups, further indicating that ossification was most effective in the LCA group.



Evaluation of Low crystalline apatite (LCA) bonegrafts in the mandibular socket preservation : An experimental study in the mongrel dog

YongJun CHO DMD / Deok-Kyu Kang DDS / Hye-Sun KIM DDS, MS / Jae-Young KIM DDS, MS, PhD / Jong-Ki HUH DDS, MS, PhD

Department of Oral and Maxillofacial Surgery, Gangnam Severance Hospital, Yonsei University College of Dentistry, Seoul, Korea



Discussion & Conclusion

- This study demonstrates that Low Crystalline Apatite (LCA) offers superior bone regeneration and implant stability compared to conventional synthetic bone grafts.
- At 12 weeks post-socket preservation, the LCA group showed significantly higher drilling and insertion torque values, and at 18 weeks, it exhibited greater removal torque and ISQ values, indicating enhanced implant stability. Micro-CT and histological analyses confirmed that LCA promoted the most effective bone remodeling and new bone formation, while other groups showed delayed ossification and higher soft tissue involvement.
- A key factor in LCA's performance is its nano-scale microporous structure, which not only enhances osteoconductivity but also seems to reduce bacterial adhesion and biofilm formation. This suggests that LCA may lower the infection risks typically associated with synthetic bone grafts.
- Notably, despite being a synthetic bone graft, LCA showed progressive resorption after at least 4 months post-grafting, with corresponding new bone formation observed at the graft sites. This indicates that the bone-forming activity of LCA is comparable to that of autogenous bone grafts.
- In conclusion, LCA demonstrated significantly better bone regeneration, stability, and reduced infection susceptibility, making it a promising material for clinical applications in dental and maxillofacial surgery.

References

- 1. Stübinger S, Dard M. The rabbit as experimental model for research in implant dentistry and related tissue regeneration. J Invest Surg. 2013 Oct;26(5):266-82.
- 2. Beltrán V, Engelke W, Prieto R, Valdivia-Gandur I, Navarro P, Manzanares MC, Borie E, Fuentes R. Augmentation of intramembranous bone in rabbit calvaria using an occlusive barrier in combination with demineralized bone matrix (DBM): a pilot study. Int J Surg. 2014;12(5):378-83.
- 3. Gehrke SA, Aramburú Júnior J, Treichel TLE, Rodriguez F, N de Aza P, Dedavid BA. Comparative evaluation of two collagen-based biomaterials with different compositions used for bone graft: An experimental animal study. J Appl Biomater Funct Mater. 2022 Jan-Dec ;20:22.
- 4. Santhakumar S, Oyane A, Nakamura M, Yoshino Y, Alruwaili MK, Miyaji H. Bone Tissue Regeneration by Collagen Scaffolds with Different Calcium Phosphate Coatings: Amorphous Calcium Phosphate and Low-Crystalline Apatite. Materials (Basel). 2021 Oct 7;14(19):5860.
- 5. Kim J, Kim S, Song I. Octacalcium phosphate, a promising bone substitute material: a narrative review. J Yeungnam Med Sci. 2024 Jan;41(1):4-12.

