Subcrestal vs. Equicrestal Implant Placement in Augmented Posterior Mandibular Sites: A Biomechanical and Histomorphometric Comparative Evaluation of Crestal Bone Stability and Osseointegration Kinetics

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Abstract. Crestal bone preservation around dental implants placed in augmented posterior mandibular sites remains a clinically contested objective, with implant positioning depth representing a critical yet insufficiently standardized variable. This prospective comparative study evaluated subcrestal (1.5 mm) versus equicrestal implant placement protocols in 84 patients (168 implants) across a 24-month follow-up period. Primary outcomes included marginal bone level changes assessed by standardized periapical radiography and cone-beam computed tomography, while secondary outcomes encompassed implant stability quotient evolution, histomorphometric bone-to-implant contact ratios, and peri-implant soft tissue health indices. Subcrestal placement demonstrated statistically significant superiority in crestal bone maintenance (mean bone loss: 0.41 ± 0.12 mm vs. 0.89 ± 0.21 mm; $p < 0.001$) without compromising osseointegration kinetics or increasing peri-implant mucositis incidence. These findings advocate for protocol-specific implant depth selection contingent upon bone graft maturation staging and prosthetic emergence profile requirements.

Keywords: subcrestal implant placement, crestal bone resorption, osseointegration kinetics, bone-to-implant contact, guided bone regeneration, implant stability quotient, histomorphometric analysis, posterior mandible augmentation, peri-implant marginal bone loss

Introduction

Peri-implant marginal bone loss continues to represent one of the most diagnostically and therapeutically challenging sequelae encountered in contemporary implant dentistry, with its etiopathogenesis remaining multifactorial and incompletely elucidated despite decades

of rigorous investigation. As of 2025, global dental implant market penetration has expanded substantially, with an estimated 15 million implants placed annually worldwide, a figure projected to increase by 6.8% annually through 2030. Within this clinical landscape, the preservation of crestal bone architecture following implant installation is recognized not only as a biological imperative but also as a critical determinant of long-term prosthetic stability, emergence profile aesthetics, and peri-implant soft tissue architecture. The implant–abutment interface microgap, platform switching geometry, thread macro-design, and collar surface topography have each been independently implicated in driving early marginal bone resorption through biomechanical stress concentration, bacterial microleakage, and biological width re-establishment phenomena. Among these variables, the axial depth of implant installation relative to the alveolar crest—defined operationally as subcrestal, equicrestal, or supracrestal positioning—has attracted renewed investigative interest given accumulating evidence that positioning depth modulates both the local biomechanical stress distribution at the bone–implant interface and the spatial availability of connective tissue attachment for biologic width reconstitution. Particular complexity arises in posterior mandibular sites that have undergone prior guided bone regeneration (GBR) or particulate bone grafting procedures. In such augmented sites, graft maturation kinetics, residual graft particle incorporation, and cortical-to-trabecular bone density ratios differ substantially from native bone, potentially altering the osseointegration trajectory and the crestal bone response to varied implant positioning depths. Despite this clinical significance, no prospective randomized study has systematically compared subcrestal versus equicrestal placement protocols exclusively within GBR-augmented posterior mandibular sites with concurrent histomorphometric endpoint validation. Furthermore, existing systematic reviews and meta-analyses on this topic are constrained by marked heterogeneity in implant macro-design, surface treatment protocols, loading timelines, and bone quality classification schemes, rendering pooled conclusions of limited direct clinical applicability. The absence of a standardized histomorphometric companion dataset alongside conventional radiographic marginal bone level measurements represents a persistent methodological gap that this investigation specifically addresses. The present study was therefore designed to provide a rigorous, dual-methodology comparative evaluation—integrating cone-beam computed tomographic volumetric analysis with quantitative histomorphometry of trephine biopsy specimens—to delineate the differential effects of subcrestal versus equicrestal implant positioning on osseointegration quality, crestal bone stability, and peri-implant soft tissue health in augmented posterior mandibular sites over a 24-month follow-up horizon. The manuscript is structured as follows: Section 2 details the materials and methods including patient selection criteria, surgical protocols, and outcome measurement methodologies; Section 3 presents quantitative results stratified by placement depth group; Section 4 contextualizes findings within the current mechanobiological evidence base and discusses clinical translation implications; and Section 5 summarizes conclusions and delineates directions for future multicenter longitudinal investigation.

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