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Comparative Analysis of Radiographic Marginal Bone Level Changes in Crestal vs Subcrestal Placement of Implants: A Retrospective Study

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Introduction

Implant placement **depth** has been widely recognized as an important factor influencing **marginal bone** preservation and long-term implant success. Despite favorable clinical outcomes with **both** crestal and subcrestal positioning, challenges remain in identifying the optimal vertical placement to **minimize** early bone remodeling. Previous studies[1-12] have reported **conflicting** results regarding the effect of implant depth on marginal bone level changes and peri-implant health.

Null Hypothesis

There is no statistically significant difference in radiographic marginal bone level changes (MBLC) between implants placed **crestally** and those placed **subcrestally** at follow-ups.

Materials and Methods

Records from a retrospective cohort of **Nobel Biocare** and **Straumann** implants placed in healed sites included **480** implants comprising of **201 crestal** and **279 subcrestal** placements. Only cases with radiographs available at implant placement (T0), prosthetic loading (T1), and a minimum one-year follow-up (T2) were included.

A prior **power** analysis was performed to determine the required sample size. An implant was considered to have survived if it remained clinically **functional** at T2.

Standardized radiographic measurements were used to assess marginal bone level change (MBLC) across time points. All measurements were conducted using **ImageJ 1.54**(NIH,Bethesda, MD, USA). The **apical** corner of the implant platform served as the **reference line** (RL). Marginal bone level (MBL) was defined as the distance from **RL** to the most **coronal** bone to implant **contact** on radiographs. Mesial and distal measurements were obtained and **averaged** to calculate MBLC. To compensate for periapical radiographic **distortion**, the correction formula **X= b*c/a** was applied where **a** = radiographic implant length, **b** = radiographic distance from RL to first bone contact, **c** = actual implant length, and **X** = corrected distance from RL to first bone contact.

Clinical **variables** collected included probing depth, bleeding on probing, plaque index, keratinized mucosa width, and mechanical complications. Data were anonymized and de-identified prior to analysis. Comparative analyses evaluated **MBLC** differences between **crestal** and **subcrestal** placement across **three** intervals: surgery-to-loading, loading-to-latest follow-up, and surgery-to-latest follow-up. Mean differences were reported with **95%** confidence intervals and **p-values**. Correlation analyses assessed relationships among remodeling intervals using Pearson and Spearman coefficients. Statistical significance was set at **α = 0.05**.

Figure 1. Workflow of retrospective data acquisition and radiographic analysis. *Cases were retrospectively selected and categorized by implant placement depth (crestal vs subcrestal). Standardized radiographs were obtained at implant placement (T0), prosthetic loading (T1), and latest follow-up (T2). Marginal bone level changes were measured using a calibrated reference line from the implant platform to the first bone-to-implant contact at mesial and distal aspects. Bone level outcomes were calculated across three intervals: surgery to loading, loading to latest follow-up, and cumulative change. Additional clinical parameters, including probing depth, bleeding on probing, and keratinized tissue thickness, were incorporated into comparative correlation analyses.*

Results

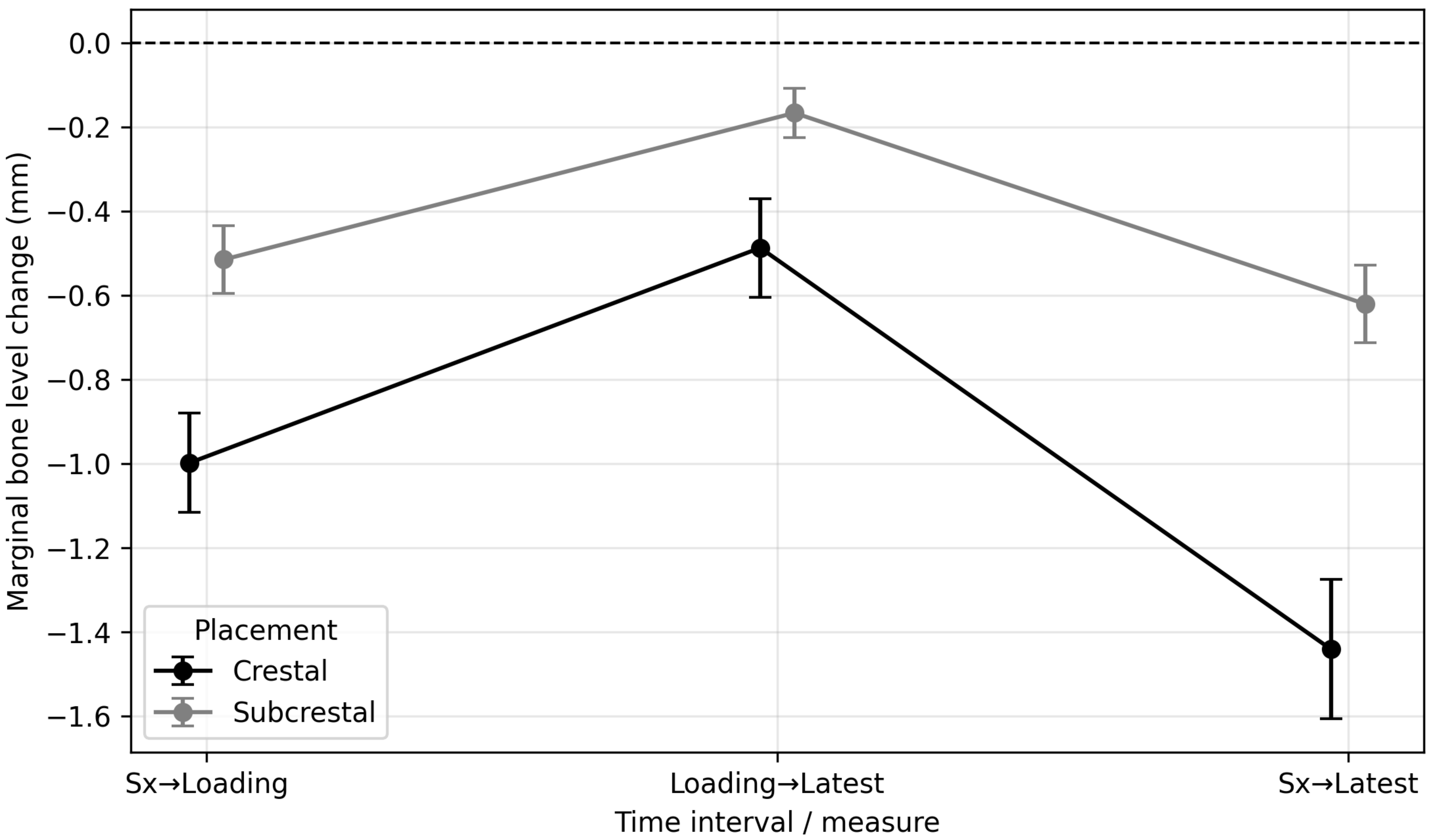

Figure 2. *Marginal bone level change (mm) over time demonstrating greater bone preservation in subcrestal compared with crestal implant placement across three intervals: surgery to loading, loading to latest follow-up, and cumulative change. The greatest divergence observed at cumulative follow-up.*

Subcrestal implants demonstrated significantly **greater** marginal bone level preservation compared with crestal implants across all time intervals. From time of surgery to loading, the **mean** difference in bone level change was **+0.483 mm** (95% CI: 0.349-0.618; p<0.001). From time of loading to latest follow-up, the difference was **+0.321 mm** (95% CI: 0.164-0.477; p<0.001). Cumulatively (surgery to latest), subcrestal placement showed **+0.821 mm** greater bone preservation (95% CI: 0.162-1.029; p<0.01).

Correlation analyses demonstrated a strong **positive** association between cumulative bone level change and its component intervals (r=0.614-0.684; p<0.001). A modest **inverse** correlation was observed between **early** and **late** remodeling in subcrestal implants (r=-0.223; p<0.001). Increased bleeding on probing was **independently** associated with **greater** bone loss (β= -0.170mm per +1 BOP; p=0.013), whereas keratinized tissue thickness, pocket depth, and plaque index were **not significantly** associated with cumulative bone change (p=0.21,0.25, 0.31). **No significant** interaction was observed between placement depth and bleeding on probing (p=0.21).

Placement	Nobel				Straumann				Location		Failure	Total
Crestal	110				91				Anterior	Posterior	31	201
	Active		Replace		BLT		BLX		45	156		
	39		71		86		5					
	Ti Ultra	Ti Unite	Ti Ultra	Ti Unite	SLA	SL Active	SLA	SL Active				
	19	20	38	33	41	45	0	5				
Placement	**Nobel**				**Straumann**				**Location**		**Failure**	**Total**
Subcrestal	166				113				Anterior	Posterior	25	279
	Active		Replace		BLT		BLX		103	176		
	73		93		108		5					
	Ti Ultra	Ti Unite	Ti Ultra	Ti Unite	SLA	SL Active	SLA	SL Active				
	36	37	38	55	63	45	0	5				

Table 1. *Distribution of crestal and subcrestal implants by implant system, implant design, surface characteristics, anatomical location, and failure outcomes*

Discussion

This **retrospective** analysis evaluated marginal bone level change (MBLC) between **crestal** and **subcrestal** implant placement across early, late, and cumulative healing intervals. Subcrestal implants demonstrated significantly **less** marginal bone loss at all time points, with **greatest** difference observed cumulatively, supporting the influence of placement depth on peri-implant bone stability.[1-4]

Greater divergence over time suggests **sustained** bone preservation beyond **initial** osseointegration. Subcrestal positioning may relocate the implant-abutment interface away from the crestal bone, reducing microgap-associated inflammation and crestal resorption, with platform switching and stress distribution patterns further contributing to this effect. [5,6,9,10] Multivariable analysis identified bleeding on probing as **independently** associated with **greater** cumulative bone loss, whereas keratinized tissue thickness was **not** significantly related to bone level change. Correlation findings suggest **early** remodeling patterns may influence **later** crestal stability, consistent with prior reports demonstrating enhanced marginal bone **preservation** with subcrestal placement. [7,8,11,12]

Conclusion

Within the **limitations** of the retrospective analysis, subcrestal implant placement was associated with significantly **reduced** marginal bone loss compared with crestal positioning across all evaluated intervals. **Increased** bleeding on probing was associated with **greater** bone loss, whereas keratinized tissue thickness was **not** significantly related to bone level changes. These findings suggest that subcrestal placement supports both favorable **initial** remodeling and **sustained** peri-implant bone over time, reinforcing its clinical value for optimizing **long-term** implant stability.

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