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CLINICAL ARTICLE

Peri-Implant Supracrestal Resiliency (PSR): A Geometric Determinant Guiding Emergence Profile Execution

Young K. Kim[1,2] | Alexander Komar[1,3] | Huan Su[4] | Alberto Monje[5] | Oscar Gonzalez-Martin[6,7,8]

[1]Department of Prosthodontics, New York University College of Dentistry, New York, New York, USA | [2]Private Practice Limited to Surgical and Reconstructive Prosthodontics, Manhattan, New York, USA | [3]Private Practice, Manhattan, New York, USA | [4]Department of Periodontics, University of Washington School of Dentistry, Seattle, Washington, USA | [5]Department of Periodontology, Universitat Internacional de Catalunya, Barcelona, Spain | [6]Department of Periodontology, Complutense University of Madrid, Madrid, Spain | [7]Department of Restorative Dentistry and Biomaterials Sciences, Harvard School of Dental Medicine, Boston, Massachusetts, USA | [8]Private Practice, Atelier Dental Madrid, Madrid, Spain

Correspondence: Young K. Kim (ykk2@nyu.edu) | Oscar Gonzalez-Martin (oscar@atelierdentalmadrid.com)

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ABSTRACT

Objective: To introduce peri-implant supracrestal resiliency (PSR) as a geometrically grounded determinant that informs strategic emergence profile engineering in implant-supported restorations.

Clinical Considerations: Emergence profile development plays a pivotal role in peri-implant stability and esthetic success; however, conventional tissue-conditioning protocols often require additional provisional stages, custom components, or extended treatment sequences that may not be practical in academic, referral-based, or multidisciplinary settings. PSR is proposed as a dynamic descriptor of the capacity of supracrestal tissues to tolerate prosthetic contour displacement in response to restorative demands. Rather than prescribing specific techniques, PSR provides interpretive guidance to determine whether prosthetic modification of the emergence profile can be performed within existing workflows or whether adjunctive tissue modulation is warranted.

Clinical Significance: Recognition of supracrestal tissue resiliency supports geometrically driven and clinically pragmatic restorative strategies that balance esthetic intent with tissue tolerance and real-world clinical constraints.

Conclusions: PSR reconceptualizes the emergence profile acquisitions from a uniformly assumed objective to a geometry-driven, context-dependent decision guided by tissue behavior.

1 | Introduction

Emergence profile design represents one of the most consequential interfaces between restorative form and peri-implant tissue stability. Successful implant restorations must not only meet prosthetic objectives of contour, esthetics, and cleansability, but also biologic constraints dictated by the supracrestal soft-tissue complex within a transdisciplinary clinical approach [1]. When this interface is improperly managed, excessive contour pressure or forced displacement may induce an initial biologic response characterized by ischemia, marginal instability, and inflammatory changes, while such responses may undergo partial or complete stabilization over time, indicating that peri-implant tissues exhibit a dynamic adaptive capacity rather than a purely detrimental response to contour modification [2, 3]. In this sense, it has been noted that the emergence profile may further jeopardize marginal bone stability and impair the integrity of the junctional epithelium, resulting in peri-implant connective tissue inflammation [4–8].

The biologic relationship between prosthetic contour and peri-implant soft tissues has been previously conceptualized

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through structured emergence profile management principles. In particular, contour management contexts have emphasized the importance of controlling restorative geometry in the transgingival zone in order to preserve peri-implant soft tissue architecture and gingival margin stability [9]. These principles highlight the role of the critical and subcritical contour in determining how prosthetic emergence influences the position of the gingival margin, zenith, and peri-implant mucosal profile. Consequently, emergence profile design should not be regarded solely as a restorative or esthetic exercise but rather as a geometric-biologically mediated interaction between prosthetic contour and supracrestal tissue behavior.

Numerous surgical and prosthetic strategies have been described to condition peri-implant tissues prior to definitive restoration, including staged provisionalization [10–12], custom healing abutments [13, 14], and soft-tissue grafting procedures [15, 16]. Although these approaches are highly effective, they often require extended sequencing, multiple appointments, or additional laboratory support.

In contemporary clinical practice—particularly in academic, referral-based, and multidisciplinary settings—restorative clinicians frequently encounter implants placed under variable conditions and at advanced stages of healing. In these scenarios, idealized emergence-profile sculpting protocols are not consistently practical in everyday clinical settings.

The concept of peri-implant supracrestal resiliency is not intended to justify bypassing established tissue-conditioning principles. Rather, it proposes that when supracrestal tissues demonstrate sufficient resiliency, progressive tissue modulation may not be required. Under such conditions, the definitive emergence profile may be executed directly without intermediate steps. Conversely, when tissue resiliency is limited, staged conditioning remains the biologically appropriate strategy, as in dynamic compression protocols depicted by previous scholars [17]. PSR, therefore, serves to identify whether emergence profile execution can be achieved in a single step or whether gradual tissue adaptation is necessary.

Despite established emergence profile principles, a fundamental clinical question remains unresolved: can the definitive emergence profile be delivered immediately, or must peri-implant tissues be progressively conditioned? This decision is often made without a consistent biologic reference. Peri-implant supracrestal resiliency (PSR) is introduced to guide this decision.

2 | Conceptualization of Peri-Implant Supracrestal Resiliency (PSR)

2.1 | Definition of PSR

Peri-implant supracrestal resiliency (PSR) is defined as the clinically observable capacity of supracrestal soft tissues to tolerate a proposed emergence profile without biologic compromise at the time of restoration (Figure 1).

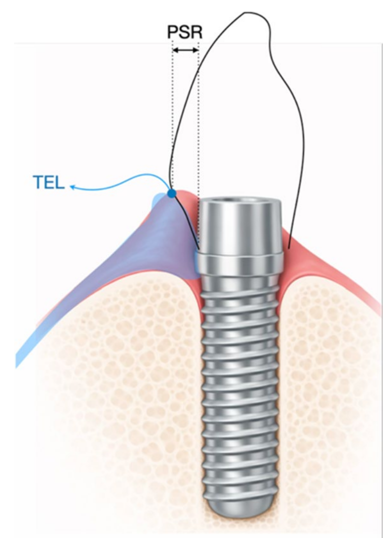

FIGURE 1 | Conceptual illustration of peri-implant supracrestal resiliency (PSR) in emergence profile design. Schematic cross-section of an implant restored with a conventional titanium healing abutment demonstrating the relationship between the proposed trajectory esthetic line (TEL) and peri-implant supracrestal resiliency (PSR). The TEL is derived from the gingival zenith trajectory of adjacent natural dentition and represents the intended prosthetic emergence contour. PSR is defined as the horizontal supracrestal soft-tissue zone capable of accommodating prosthetic contour displacement without biologic compromise. Although PSR is illustrated primarily as a horizontal displacement capacity, such tissue deformation may secondarily influence the vertical position of the gingival zenith due to coupled three-dimensional tissue adaptation. The blue shaded region illustrates the supracrestal tissue volume engaged during emergence profile engineering, emphasizing PSR as a dynamic, behavior-based determinant rather than a fixed anatomic dimension.

This definition intentionally frames PSR as a dynamic entity rather than a static morphologic descriptor or quantitative index. Supracrestal tissues are not simply characterized by thickness or dimension; rather, they exhibit time-dependent viscoelasticity influenced by connective tissue repair, epithelial maturation, vascularity, and local anatomy (Figure 2). PSR, therefore, represents the integrated response of this tissue complex to controlled restorative manipulation.

PSR represents the clinically observable capacity of supracrestal tissues to accommodate restorative contour changes without biologic compromise. Clinically, it may be assessed intraoperatively by observing tissue response to controlled probing or provisional contour simulation. Absence of blanching, collapse, or resistance suggests favorable PSR, whereas visible resistance or ischemic response indicates limited tolerance and the need for staged conditioning. Clinically, PSR resolves a direct question: can the final contour be delivered at this stage, or is staged tissue modification required?

2.2 | Determinants of PSR

PSR is not an inherent constant, but a context-dependent biologic characteristic shaped by multiple interacting biological and

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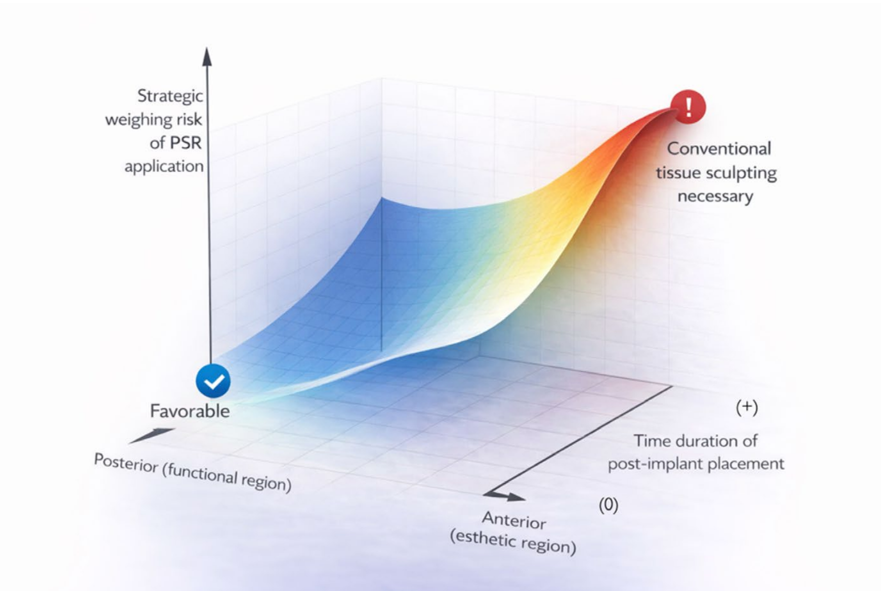

FIGURE 2 | Strategic weighting risk of peri-implant supracrestal resiliency (PSR) application. Three-dimensional conceptual graph illustrating how the strategic weighting risk of peri-implant supracrestal resiliency (PSR) application varies as a function of anatomic region and time elapsed following implant placement. The vertical axis represents the relative clinical risk associated with relying on PSR for definitive emergence profile execution, while the horizontal axes reflect the posterior–anterior (functional–esthetic) spectrum and increasing time duration post-implant placement. Favorable conditions for PSR-guided restorative execution cluster within posterior functional regions (less esthetic risk) and earlier restorative phases (less epithelial-fibril condensation, therefore more resiliency), whereas progression toward anterior esthetic regions and prolonged healing intervals results in a non-linear escalation of risk, culminating in scenarios where conventional soft-tissue sculpting or staged peri-implant tissue conditioning becomes necessary. The curved surface emphasizes PSR as a decision-weighted biologic property rather than a fixed or uniformly applicable parameter.

procedural variables. These factors determine whether the intended contour can be delivered immediately or requires staged adjustment.

2.2.1 | Soft Tissue Characteristics

The dimensional and morphological features of the peri-implant soft tissues define anatomical status and esthetics. The peri-implant mucosa is covered by stratified squamous epithelium and supported by connective tissue [18–21]. Three main components of the peri-implant soft tissue phenotype demand special attention: the keratinized mucosa width (KMW), the mucosal thickness (MT), and the supracrestal tissue height (STH) [18] due to their impact on the PSR. The connective tissue of the peri-implant mucosa contains a higher proportion of collagen fibers and exhibits lower cellularity and vascularity than the connective tissue within the periodontium [19–22]. Greater mucosal thickness and a well-developed connective tissue compartment may correlate with improved tolerance to controlled prosthetic displacement [23]. This is consistent with literature demonstrating the influence of peri-implant soft tissue phenotype on biologic stability and response to restorative manipulation. These tissues may demonstrate reduced ischemic response and enhanced marginal stability under modest contour pressure. Conversely, thin or fragile tissues may exhibit vulnerable adaptability, increasing the risk of inflammatory or esthetic complications even with minimal contour modification. Clinically, thicker and well-vascularized tissues more often permit immediate contour delivery, whereas thin tissues favor staged modification.

2.2.2 | Healing Stage and Restorative Timing

Supracrestal tissue behavior evolves throughout healing. Early-phase tissues may demonstrate increased compliance and adaptive mobility, whereas progressive maturation produces greater structural integrity but reduced displacement capacity. Accordingly, identical contour demands may be tolerated heterogeneously at different restorative stages. These temporal changes highlight the need for stage-specific interpretation of PSR rather than assuming a linear structural correlation over time. Accordingly, early healing stages may allow greater contour adaptation, whereas mature tissues may require staged adjustment.

2.2.3 | Graft Source and Augmentation Modality

When soft-tissue augmentation has been performed, the biological origin of the graft significantly influences supracrestal mechanical quality. Palatal connective tissue grafts typically exhibit balanced elasticity and adaptability, whereas tuberosity-derived grafts often demonstrate increased density, collagen content, and reduced compressibility, resulting in greater structural stability but diminished displacement tolerance [24] Histological studies have revealed that grafts from the tuberosity had a greater amount of lamina propria and less submucosa than those from the lateral palate [25]. In addition, the collagen content in the lamina propria appears similar at both donor sites, whereas the immunohistochemical profile shows differences in epithelial cell antibody expression, favoring tuberosity

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grafts [25]. Despite histological similarities between the sources, clinical findings did not show significant differences in peri-implant soft-tissue contour thickening [24]. Biomaterial-based substitutes may present variable integration patterns and viscoelastic responses depending on remodeling dynamics. However, based on the authors' expertise, the use of soft tissue substitutes may be a viable option only in scenarios with limited demand for buccal tissue contouring, given the pristine structures (i.e., thick buccal hard and soft tissue phenotypes).

These histologic and biomechanical differences translate into clinically observable variations in tissue resiliency. Consequently, graft source should be regarded as an independent determinant of PSR when evaluating the feasibility of prosthetic contour modification. Thus, graft origin influences whether immediate contour delivery is feasible or requires progressive modification.

2.2.4 | Anatomic Region

Regional anatomy further modulates PSR expression. Posterior functional areas often tolerate greater contour manipulation, whereas anterior esthetic zones may demonstrate reduced tolerance due to thinner phenotype, higher esthetic demands, and increased visibility of marginal discrepancies [2, 3]. In practice, anterior regions more frequently require staged approaches, whereas posterior sites may tolerate immediate contour delivery.

2.3 | PSR as a Strategic Determinant in Restorative Decision-Making

PSR translates biologic variability into a direct clinical decision for emergence profile execution. Under such circumstances, a universal expectation of emergence profile sculpting may not align with clinical realities. PSR provides a strategic rationale for determining whether prosthetic contour modification is biologically necessary during the restorative phase.

PSR-guided interpretation:

1. Favorable PSR → immediate definitive contour delivery.
2. Borderline PSR → cautious or partial contour modulation.
3. Limited PSR → staged conditioning or soft-tissue augmentation.

When PSR is favorable, supracrestal tissues accommodate controlled contour displacement without evidence of compromise, allowing emergence profile engineering with conventional restorative components. In practical terms, this condition allows the clinician to deliver the definitive emergence profile in a single restorative step. When PSR is exceeded by the projected contour demand, progressive tissue displacement through staged conditioning is necessary to achieve a biologically compatible emergence profile (Figure 3). While this threshold is currently interpreted through clinical judgment, ongoing investigative efforts—including biomechanical and clinical studies—are expected to define measurable parameters of supracrestal tissue response that may further refine this decision-making process.

This approach allows clinicians to reconcile biologic principles with practical workflow limitations. Rather than mandating additional visits, custom components, or prolonged provisionalization in every case, PSR supports measured decisions that balance tissue tolerance with real-world clinical feasibility. This approach reduces variability in judgment by linking tissue response directly to restorative timing.

2.4 | Relationship Between PSR and Quantitative Approaches

PSR is presented as a clinical decision concept rather than a quantitative measurement. Approaches such as direct (Figure 4) and staged (Figures 5, 6) pathways operationalize this reasoning by estimating the magnitude of tissue displacement required for a proposed contour and comparing it to local tolerance (Figure 3). These techniques do not define PSR; instead, they represent practical expressions of PSR-guided decision-making.

3 | Discussion

Peri-implant supracrestal resiliency (PSR) defines emergence profile execution as a geometry-driven decision constrained by the biologic limits of tissue accommodation. Emergence profile development has traditionally been framed as a technical

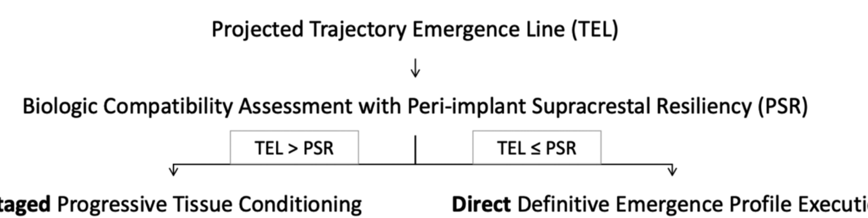

FIGURE 3 | PSR-guided biologic decision model for emergence profile execution. Schematic workflow illustrating how the projected trajectory emergence line (TEL) is interpreted relative to peri-implant supracrestal resiliency (PSR) to guide restorative pathway selection. When the projected contour demand remains within the biologic accommodation capacity of the supracrestal tissues (TEL ≤ PSR), the definitive emergence profile may be executed directly during the restorative phase without intermediate conditioning procedures. Conversely, when the projected contour exceeds the available supracrestal resiliency (TEL > PSR), progressive tissue displacement through staged conditioning becomes necessary to allow biologically compatible emergence profile development. This model conceptualizes PSR as a biologic decision variable determining whether emergence profile execution can occur in a single step or requires gradual tissue adaptation.

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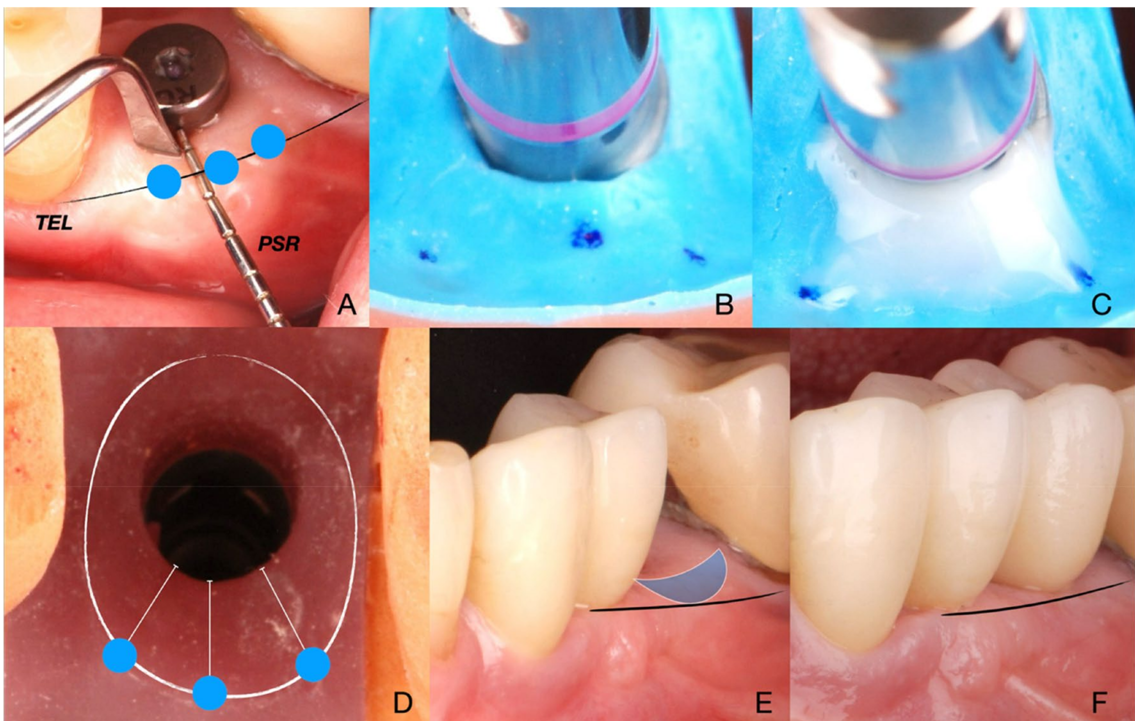

FIGURE 4 | Clinical translation of peri-implant supracrestal resiliency (PSR) using a direct approach pathway. (a) Intraoral dynamic tissue evaluation demonstrating the trajectory emergence line (TEL) relative to peri-implant supracrestal resiliency (PSR). In this clinical example, TEL approximates PSR, indicating sufficient supracrestal tissue resiliency to accommodate a direct approach. (b–d) Transfer of horizontal displacement reference landmarks ("tri-dot" markers) from the clinical evaluation to the definitive impression using wax indexing, enabling controlled extra-oral translation of the planned emergence trajectory. (e,f) Schematic and clinical representations of emergence profile extension and definitive restoration delivery directly, illustrating appropriate contour development consistent with the predetermined trajectory emergence line without any pre-tissue modulation.

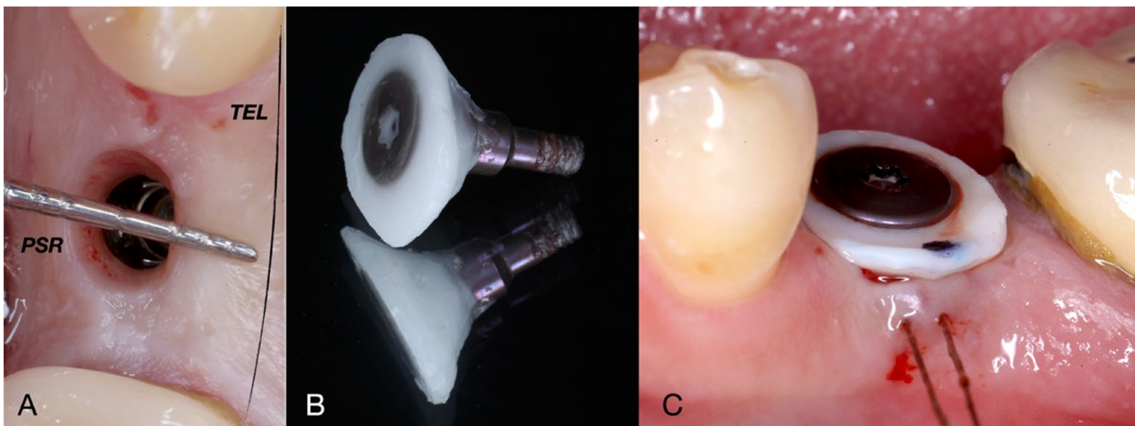

FIGURE 5 | Emergence profile development through a staged approach using a pre-existing Ti healing abutment. (a) Intraoral dynamic tissue evaluation demonstrating a trajectory emergence line (TEL) that exceeds the available peri-implant supracrestal resiliency (PSR), indicating limited soft-tissue accommodation and the need for intra-oral emergence profile conditioning. (b) Immediate chair-side fabrication of a composite resin ring around the pre-existing titanium healing abutment, illustrating adaptation of standard armamentarium without the use of additional components, custom healing abutments, or provisional restorations. (c) Intra-oral delivery of the semi-custom healing abutment following internal releasing incision and horizontal mattress suturing, with a buccal indexing mark facilitating orientation during placement. This approach highlights a pragmatic, resource-efficient strategy for emergence profile development when PSR is exceeded. Final emergence profile demonstrates stable peri-implant soft tissue adaptation following conditioning.

objective achieved through tissue sculpting or prosthetic conditioning. Within this paradigm, the workflow is directed toward reproducing an idealized contour, assuming that soft tissues will adapt favorably. However, identical prosthetic manipulations may yield markedly different biologic responses across patients and sites. This variability justifies the dynamic behavior of the supracrestal tissue complex rather than attributing it solely to technique-related inconsistencies.

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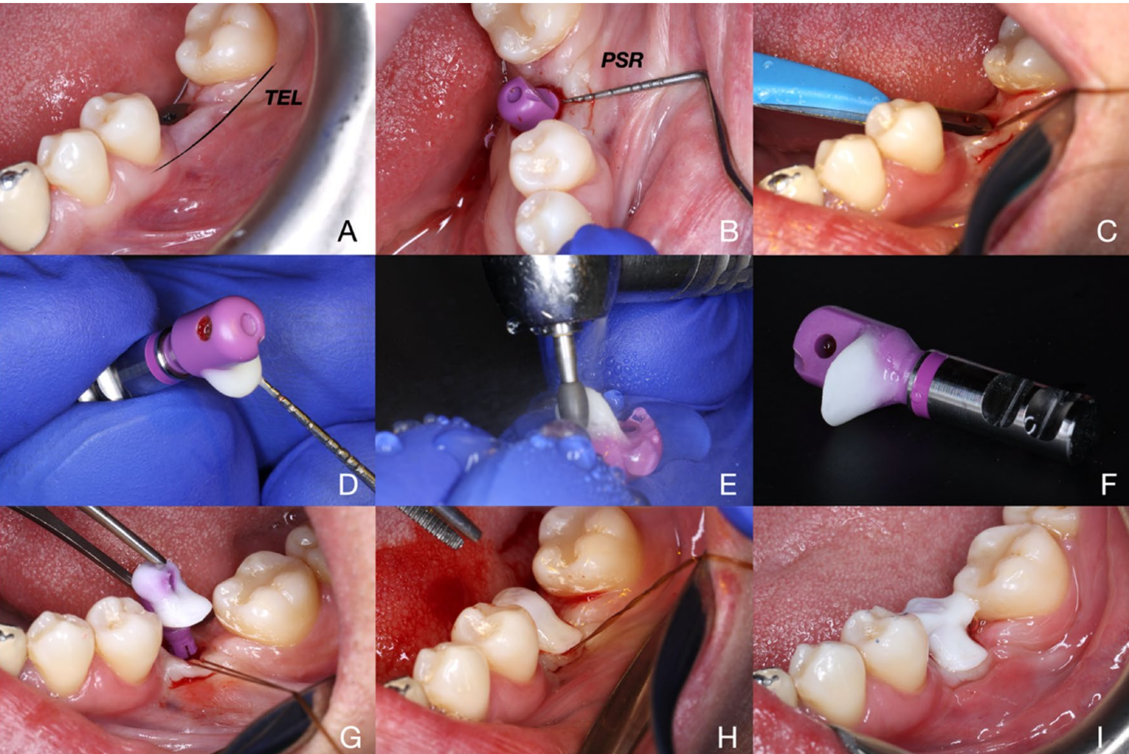

FIGURE 6 | Emergence profile conditioning using a modified bite registration aid. (a,b) Dynamic peri-implant soft-tissue evaluation demonstrating a trajectory emergence line (TEL) that exceeds peri-implant supracrestal resiliency (PSR), indicating insufficient supracrestal tissue accommodation and necessitating an intra-oral emergence profile conditioning approach. (c) Internal horizontal releasing incision performed to facilitate passive seating of the conditioning jig. (d–f) Fabrication of a semi-custom healing abutment using a standard bite registration aid modified with composite resin, illustrating repurposing of pre-existing restorative armamentarium without the need for custom healing abutments or provisional restorations. (g,h) Intra-oral delivery and stabilization of the semi-custom healing abutment during surgical placement. (i) Incorporation of stabilizing and cleansability-oriented design features to promote retention and peri-implant tissue health during the healing phase.

Paradoxically, this heterogeneity serves as an interpretable anatomical characteristic of PSR. Instead of asking how a desired contour should be imposed on peri-implant tissues, PSR first asks whether the local tissues possess the mechanical and biological capacity to accommodate such displacement at the time of restoration. This shift from technique-centered to tissue-centered reasoning represents a conceptual transition from prescriptive contouring to biologically moderated decision-making.

Several established concepts have advanced the understanding of implant emergence profile design, including critical and subcritical contour principles [26], biologic contour strategies [27], and staged provisionalization protocols [10, 11]. These approaches emphasize the geometric relationship between the restoration and the peri-implant soft tissues and provide valuable technical guidance for achieving esthetic integration. PSR complements, rather than replaces, these concepts. Whereas the critical and subcritical contour logic primarily describes the geometric design of prosthetic contours [9], PSR introduces a biologic decision dimension by evaluating whether the peri-implant supracrestal tissues possess sufficient adaptive capacity to tolerate the intended contour at the time of restoration. In this sense, PSR functions as an upstream determinant that contextualizes established contouring strategies. A given contour design may be technically correct yet biologically inadvisable if PSR is limited. Conversely, a favorable PSR may permit efficient prosthetic execution without extensive tissue conditioning (Figure 3).

By introducing this temporal and biological dimension, PSR expands emergence profile planning from a purely geometric exercise into a dynamic, behavior-based assessment. It should also be recognized that although PSR is conceptualized primarily as a horizontal accommodation capacity of the supracrestal tissues, tissue deformation during emergence profile modification occurs in three dimensions. Horizontal contour displacement may induce secondary vertical changes in the position of the gingival zenith through tissue compression and remodeling of the epithelial–connective tissue interface. Consequently, clinicians should interpret PSR not as a strictly planar parameter but as a three-dimensional biologic response in which horizontal prosthetic contour modification may have vertical esthetic implications.

As a result, PSR should not be interpreted as a spatially uniform property of the peri-implant supracrestal complex. Emerging observations indicate that tissue response to prosthetic contour displacement exhibits directional variability, differing between bucco–lingual and mesio–distal axes. From a clinical and mechanobiologic standpoint, this anisotropic behavior likely reflects variations in soft-tissue thickness, underlying bone morphology, vascular supply, and functional loading patterns across surfaces. Notably, both experimental

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and clinical observations have demonstrated relative preservation of lingual bone even under conditions of increased emergence angle, whereas buccal tissues appear more susceptible to contour-induced alterations [4, 5]. Although these findings have not been explicitly synthesized in prior interpretations, they support the premise that supracrestal tissue tolerance may be direction-dependent. Within this perspective, PSR is more appropriately defined as a vector-dependent biologic response, wherein the capacity for tissue accommodation varies according to the direction and magnitude of prosthetic contour displacement. This directional characteristic advances PSR beyond a scalar form into a spatially responsive paradigm with direct implications for contour design and restorative strategy.

From a mechanobiologic perspective, the supracrestal complex exhibits properties analogous to viscoelastic soft tissues elsewhere in the body. Controlled displacement induces elastic deformation, fluid redistribution, and vascular compression within the supracrestal complex. When tissue tolerance is exceeded, prolonged ischemia and inflammatory responses may compromise marginal stability or lead to recession [28]. In contrast, adequate tissue thickness, organized collagen structure, and sufficient vascularity allow controlled displacement with a reversible biologic response.

This interpretation clarifies why graft source, maturation stage, and anatomic region significantly influence restorative outcomes. Dense tuberosity-derived grafts, for example, often display reduced compressibility compared with palatal grafts [24], altering their displacement characteristics. Similarly, late-stage tissues with increased epithelial–connective tissue integration may exhibit greater structural stability but reduced adaptive mobility [12]. PSR synthesizes these variables into an intertwined clinical principle.

A central motivation for proposing PSR is its applicability within real-world clinical environments. Contemporary implant care frequently involves a distributed set of responsibilities among surgical, restorative, and laboratory providers. Restorative clinicians may encounter implants placed months or years later, without the opportunity to influence initial tissue conditioning. Under these circumstances, strict adherence to idealized emergence profile protocols may be impractical or biologically inappropriate.

PSR offers a pragmatic decision workflow (Figure 3). Clinically, this may be assessed chairside through dynamic evaluation of tissue response to contour simulation, allowing real-time determination of whether definitive contour delivery is feasible or staged conditioning is required. When supracrestal tissues may demonstrate favorable resiliency, the definitive emergence profile may be executed directly during the restorative phase without intermediate tissue-conditioning procedures (Figure 4). In such circumstances, the biologic tolerance of the tissue complex permits delivery of the final contour in a single step. Critically, clinicians must remain aware that horizontal contour displacement may produce secondary vertical tissue changes, particularly in esthetic regions where small alterations in zenith position may become clinically relevant. When the projected contour exceeds the available resiliency, however, progressive tissue displacement through staged conditioning or adjunctive soft-tissue management becomes necessary (Figures 5 and 6). This distinction represents the core clinical implication of the PSR concept: determining whether emergence profile development can be achieved immediately or must be guided through gradual tissue adaptation.

Beyond its clinical utility, PSR offers value as a shared conceptual language across disciplines and training levels. In educational settings, trainees often focus on reproducing ideal contours without fully appreciating the biological constraints that govern tissue behavior. Framing emergence profile decisions through the lens of resiliency encourages the integration of surgical, prosthetic, and biologic reasoning through a transdisciplinary rationale [1]. This approach promotes judgment-based decision-making rather than protocol dependence. Instead of applying uniform contour strategies, clinicians are guided to interpret tissue response and adapt interventions accordingly. Such adaptability is particularly important in interdisciplinary environments, where continuity of care may be fragmented and individualized solutions are required. Clinically, PSR does not introduce a new technique; it directs whether existing restorative steps can be performed immediately or should be staged according to tissue tolerance. The present description of PSR is intentionally conceptual, serving as a proof of concept. It does not yet establish quantitative thresholds or standardized indices. While structured methodologies may approximate supracrestal tolerance through geometric or mechanical assessment, PSR itself remains an interpretive construct intended to guide reasoning rather than dictate measurements.

This limitation also represents an opportunity for future investigation. Prospective studies correlating supracrestal behavior with clinical outcomes, digital simulation of tissue displacement, and biomechanical modeling of grafted versus native tissues may enable the development of reproducible parameters that refine PSR assessment. Integration of such data into digital planning workflows may further enhance predictive accuracy. Until such validation is achieved, PSR should be regarded as a biologically informed decision-support concept that complements, rather than replaces, established clinical judgment.

Collectively, these considerations establish PSR as an integrative proof-of-concept that portrays geometric principles with biologic constraints in restorative strategy. PSR may also serve as a conceptual and educational tool to support biologically guided restorative reasoning across training levels and interdisciplinary settings. By privileging tissue behavior over prescriptive technique, PSR advances a paradigm of individualized, context-responsive care that harmonizes esthetic objectives with biologic tolerance. In doing so, it reinforces the pursuit of long-term peri-implant stability while preserving pragmatic applicability within contemporary clinical practice. At present, PSR should be interpreted as a conceptual theorem supported by emerging empirical evidence, with broader applicability anticipated as digital and quantitative assessment methods evolve.

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4 | Conclusion

PSR guides the timing of emergence profile execution based on tissue tolerance at the time of restoration.

1. Peri-implant supracrestal resiliency represents a dynamic geometric-biologic determinant of tissue tolerance to prosthetic contour displacement.
2. PSR is influenced by tissue thickness, healing stage, anatomic region, and graft source.
3. Incorporation of PSR into restorative planning supports context-sensitive, geometrically guided design of the emergence profile aligned with tissue tolerance.

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Disclosure

The authors have nothing to report.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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