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LITERATURE REVIEW:

Supracrestal Tissue Attachment (Biologic Width) in Clinical Practice: A Narrative Review

Inserción tisular supracrestal (espacio biológico) en la práctica clínica: una revisión narrativa

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ABSTRACT: The supracrestal tissue attachment, historically referred to as the biologic width, represents a dentogingival unit fundamental for periodontal health and restorative predictability. This narrative review evaluates both conventional and technology-assisted strategies for its preservation. Searches were conducted in PubMed/MEDLINE, Scopus, and Web of Science. Eligible studies encompassed systematic and narrative reviews, consensus statements, clinical trials, comparative studies, and case series. The evidence was critically appraised using the Oxford Centre for Evidence-Based Medicine (OCEBM) framework and synthesized thematically into comparative and recommendation tables. Conventional techniques (gingivectomy, access flaps, osteotomy, and osteoplasty) remain reliable when guided by biologic and prosthetic principles. Laser-assisted procedures enhance soft tissue management through improved precision, effective hemostasis, and reduced morbidity. Digitally guided workflows that integrate CBCT, intraoral scanning, and CAD/CAM technology enable precise mapping and reproducibility, particularly in esthetically demanding cases. Optimal management requires individualized planning that integrates conventional, laser-assisted, and digital approaches within an evidence-based framework, ensuring periodontal stability, restorative longevity, and harmonious esthetic outcomes in clinical practice.

KEYWORDS: Periodontium; Gingiva; Gingival diseases; Periodontal surgery; Dental technology.

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RESUMEN: La inserción tisular supracrestal, conocida históricamente como ancho biológico, constituye una unidad dentogingival fundamental para la salud periodontal y la predictibilidad restauradora. Esta revisión narrativa evalúa las estrategias convencionales y asistidas por tecnología para su preservación. Se realizaron búsquedas en PubMed/MEDLINE, Scopus y Web of Science. Los estudios elegibles incluyeron revisiones sistemáticas y narrativas, documentos de consenso, ensayos clínicos, estudios comparativos y series de casos. La evidencia fue evaluada críticamente utilizando el marco del Oxford Centre for Evidence-Based Medicine (OCEBM) y se sintetizó temáticamente en tablas comparativas y de recomendaciones. Las técnicas convencionales (gingivectomía, colgajos de acceso, osteotomía y osteoplastia) siguen siendo confiables cuando se aplican bajo principios biológicos y protésicos. Los procedimientos asistidos con láser optimizan el manejo de los tejidos blandos al mejorar la precisión, lograr una hemostasia efectiva y reducir la morbilidad. Los flujos de trabajo digitalmente guiados que integran CBCT, escaneo intraoral y tecnología CAD/CAM permiten un mapeo preciso y reproducible, especialmente en casos con altas exigencias estéticas. El manejo óptimo requiere una planificación individualizada que combine enfoques convencionales, asistidos por láser y digitales dentro de un marco basado en la evidencia, garantizando así estabilidad periodontal, longevidad restauradora y resultados estéticos armónicos en la práctica clínica.

PALABRAS CLAVE: Periodonto; Encía; Enfermedades gingivales; Cirugía periodontal; Tecnología dental.

INTRODUCTION

The supracrestal tissue attachment, historically referred to as the biologic width, is a well-defined anatomical unit composed of the junctional epithelium and supracrestal connective tissue, extending from the base of the gingival sulcus to the crest of the alveolar bone (1-3). This complex serves as a biological barrier against microbial invasion and plays a pivotal role in maintaining periodontal homeostasis, soft tissue integrity, and the long-term preservation of both natural teeth and dental implants. Its average vertical dimension ranges from 2.73 to 3.0 mm; however, recent studies highlight substantial interindividual variability influenced by anatomical and clinical determinants (3,4). Despite this foundational knowledge, clinical uncertainty persists regarding how such variability and restorative demands affect the preservation or reestablishment of this attachment in daily practice.

The clinical management of the supracrestal tissue attachment is dictated by biologic, prosthetic, functional, and esthetic considerations, and is relevant to both periodontally healthy teeth and those with structural compromise (2,5). A comprehensive understanding of the architecture and biological limits of the dentogingival complex is essential for procedures such as clinical crown lengthening. This intervention must be carefully planned according to the width of keratinized tissue and the level of alveolar support (6), recognizing that such procedures may induce dimensional changes in hard and soft tissues during healing, potentially influencing the predictability of restorative outcomes (7,8). Consequently, clinicians face the challenge of selecting surgical or technology-assisted strategies that most effectively reestablish supracrestal dimensions while minimizing complications and ensuring long-term success.

This anatomical zone is particularly critical in clinical scenarios involving subgingival restorative margins, mucogingival alterations secondary to prostheses, or significant loss of coronal structure. Violation of the supracrestal tissue attachment whether due to disease, improper margin design, or restorative overextension may trigger chronic inflammation, soft tissue recession, or loss of periodontal support (5,9). In such cases, surgical strategies aim to reestablish physiological tissue architecture, promote soft tissue adaptation, and support the long-term success of restorative procedures (5,10,11). However, the available evidence remains fragmented across conventional, laser-assisted, and digitally guided approaches, underscoring the need for an updated synthesis.

A biologically respectful and clinically effective approach requires comprehensive diagnostic evaluation and meticulous surgical planning (12). Critical factors include the presence of inflammation or attachment loss, the quantity and quality of remaining tooth structure, esthetic demands, particularly in the anterior region, the measured distance from the gingival margin to the alveolar crest, and the width of keratinized tissue, which is a key determinant of surgical predictability and periodontal stability (13-15).

Given the pronounced anatomical variability of the periodontium and the increasing complexity of interdisciplinary treatment demands (14,16), the purpose of this review is to provide evidence-based clinical guidelines for the diagnosis, surgical management, and maintenance of the supracrestal tissue attachment. Specifically, it addresses the following research question: Which conventional, laser-assisted, or digitally guided approaches most effectively preserve or restore the supracrestal tissue attachment to ensure long-term periodontal stability and restorative predictability? These recommendations integrate contemporary biologic principles, esthetic considerations, and digital innovations including virtual planning and minimally invasive surgical techniques to support clinical decision-making, enhance predictability, and optimize long-term functional and esthetic outcomes (17-19).

MATERIALS AND METHODS

This structured narrative review was conducted using a transparent literature search strategy. Searches were performed in PubMed/MEDLINE, Scopus, and Web of Science (last search: July 2025). Controlled vocabulary (MeSH/DeCS) and free-text terms related to “supracrestal tissue attachment”, “biologic width”, “crown lengthening”, “periodontal surgery”, “laser”, “CBCT”, “intraoral scanning”, “digital workflow”, and “surgical guide” were combined using Boolean operators.

Inclusion criteria comprised systematic reviews, narrative reviews, consensus reports, clinical trials, comparative studies, and case series addressing diagnostic assessment, surgical management (conventional, laser-assisted, or digitally guided), prosthodontic implications, outcomes, or complications related to supracrestal tissue attachment. Exclusion criteria included studies unrelated to periodontal or restorative management of supracrestal tissue attachment, opinion articles without methodological basis, and publications lacking sufficient methodological detail for appraisal.

Titles and abstracts were screened followed by full-text assessment. The level of evidence was appraised according to the Oxford Centre for Evidence-Based Medicine (OCEBM) framework, and findings were synthesized thematically and summarized in Table 1 and Table 2.

A narrative design was selected because the primary objective was to provide an updated, clinically oriented protocol and to integrate alternative management strategies across conventional, laser-assisted, and digitally guided approaches. Given the diversity of intervention modalities, study designs, and clinical endpoints, a structured narrative format was considered.

Table 1. Comparative analysis of conventional, digitally guided, and laser assisted approaches in supracrestal tissue attachment management.

Aspect	Conventional Techniques (6,7,20,26,33)	Digital Technologies (Surgical Guides)(19)	Laser Surgery (25,29)
Surgical precision	Moderate; dependent on anatomy and flap design	High; 3D virtual planning improves accuracy	High for soft tissues; limited validation for bone
Control of design	Clinically determined; influenced by anatomical variability	Standardized via CAD/CAM and surgical guides	Visual control in soft tissues; limited bone precision
Operator variability	High; dependent on clinician expertise	Low; digital standardization reduces variability	Moderate; technique-sensitive
Impact on soft tissues	Greater trauma possible; influenced by flap elevation and osseous recontouring	Minimal when properly planned	Minimal; reduced inflammation and bleeding
Surgical time	Variable; increases with complexity	Reduced; efficient digital workflow	Short in minor cases; variable in complex procedures
Postoperative outcomes	Stable but risk of gingival rebound	Predictable healing and stable architecture.	Reduced edema, pain, and bleeding
Training requirement	Surgical and anatomical expertise	Advanced digital planning skills required	Certified laser training required
Accessibility / Cost	Widely available; low cost	High cost; digital infrastructure required	Equipment costly; variable cost-effectiveness
Ideal indications	Subgingival caries, fractures, altered passive eruption, short crowns	Esthetic crown lengthening; interdisciplinary precision cases	Gingival contouring and minimally invasive soft tissue management
Main limitations	Technique-sensitive; influenced by phenotype	Infrastructure-dependent; limited availability	Limited bone cutting efficacy; learning curve

Table 2. Evidence-based summary of diagnostic and surgical strategies for supracrestal tissue attachment management.

Intervention	Level of Evidence Grade of Recommendation	Clinical Comments
Diagnostic Procedures		
Periodontal clinical and radiographic evaluation (4,12)	Level 1 Grade A	Essential for diagnosis and treatment planning; CBCT improves precision
Evaluation of biologic width invasion (5)	Level 2 Grade B	Detects violation; prevents chronic inflammation and attachment loss
2017 Classification of periodontal and peri-implant diseases (1)	Level 1 Grade A	Standardized diagnostic framework
Soft tissue retraction in CBCT (24)	Level 3 Grade C	Improves soft tissue visualization; limited clinical validation
Conventional surgery		
(Gingivectomy, flap, osteotomy) (6,7,20,27)	Level 2 Grade B	Effective; outcome dependent on phenotype and surgical design
Systematic review on esthetic surgery (28)	Level 1 Grade B	Favorable outcomes; heterogeneity limits strength
Technology-Assisted Procedures		
Digitally guided surgery (4,17-19)	Level 2 Grade B	Enhances precision; infrastructure-dependent
Laser-assisted procedures (22,25,29,30)	Level 3 Grade C	Minimally invasive; limited evidence for osseous surgery
Deep margin elevation (8,10,11,23)	Level 2 Grade B	Facilitates provisional stability; long-term data limited
Preventive Considerations		
Pre-surgical periodontal stabilization (15)	Level 1 Grade A	Mandatory for predictable healing
Other Clinical or Conceptual Considerations		
Clinical case of STA violation (9)	Level 3 Grade C	Illustrative for complex management; limited external validity
Historical concept of STA and periodontal surgery (26)	Level 3 Grade C	Foundational reference; limited contemporary applicability
Guided surgery case in esthetics (18)	Level 3 Grade C	Technical report; single-case evidence
Prosthetic and anatomical impact on periodontium (2)	Level 1 Grade B	Highlights role of prosthetic planning and maintenance

SURGICAL MANAGEMENT OF THE SUPRACRESTAL TISSUE ATTACHMENT

SURGICAL RATIONALE

The primary objective of surgery is to reestablish and maintain the physiological vertical dimension of the supracrestal tissue attachment (2.73-3.0 mm) (3). This is essential for preserving periodontal health, reducing inflammation, and preventing gingival recession that could compromise the longevity of restorations (4). Beyond its biological function, correction of this zone harmonizes gingival architecture with tooth contours, which is fundamental for both esthetic integration and biomechanical stability (6,20). Maintaining an adequate distance between the gingival margin and the alveolar crest also enhances restorative compatibility, supports soft tissue adaptation, and ensures long-term periodontal stability (2,14).

ANATOMICAL REFERENCES

Pre-surgical mapping requires careful consideration of several anatomical landmarks: the mucogingival junction (MGJ), width of attached gingiva, keratinized tissue, gingival grooves (free and marginal), gingival margin, and alveolar mucosa. The width of keratinized tissue is measured from the gingival margin to the MGJ. The MGJ, as the apical limit of keratinized tissue, guides the decision between gingivectomy and an apically positioned flap. Adequate attached gingiva ensures flap stability, while the gingival margin determines the scallop line and the target for osseous reduction. When present, gingival grooves help delineate the sulcus-to-attached transition and assist in contour design. Flap margins are positioned coronal to the alveolar mucosa to improve stability (21).

CLINICAL INDICATIONS AND CONTRAINDICATIONS

Surgical management of the STA is indicated when periodontal or prosthetic integrity is at risk (2). Common indications include gingival overgrowth that interferes with restorative margins (16,22) and teeth with insufficient coronal structure due to fracture or caries, where surgical exposure of sound tissue improves retention and prognosis of fixed restorations (23). A key indication is the creation of a biologic ferrule, which enhances restoration resistance and longevity (11,23). From a prosthodontic perspective, reestablishing the supracrestal zone ensures a stable interface between restorative margins and periodontal tissues (10,11). Esthetically, correction of gingival asymmetries or excessive gingival display contributes to smile harmony (6), additionally, surgical crown lengthening is indicated to enable predictable rubber dam isolation in cases with insufficient coronal tooth structure, thereby facilitating adhesive procedures and reducing contamination risk.

Prior to surgery, a thorough clinical and radiographic evaluation is essential, ideally incorporating CBCT and digital impressions to confirm feasibility and guide planning (4,24). Contraindications include active periodontal disease, which compromises healing; advanced tooth mobility reflecting severe attachment loss and instability; and an unfavorable crown-to-root ratio, where additional osseous reduction could jeopardize tooth viability and long-term predictability (6).

PREOPERATIVE CARE PROTOCOL

CLINICAL EVALUATION AND EXAMINATION

A comprehensive patient interview is essential to design a safe and predictable treatment plan. It should include a complete medical and dental history (systemic conditions, medications, allergies, prior periodontal or restorative therapy) and proper documentation of informed consent. Understanding functional requirements and esthetic expectations is critical for individualized planning (12). Complementary extraoral and intraoral examinations should assess facial proportions, lip mobility, and gingival display at rest and during smiling (16). Additional parameters such as gingival zenith, width of keratinized tissue, periodontal phenotype, and papillary architecture must also be evaluated, as they define case complexity and esthetic risk. Digital impressions provide accurate three-dimensional visualization of dental and gingival structures; if unavailable, study models may be used. Photographs and video documentation are recommended for esthetic analysis, clinical monitoring, and long-term follow-up (16).

IMAGING AND LABORATORY TESTING

Radiographs are indispensable for diagnosis and treatment planning. Periapical and panoramic images provide baseline information, whereas CBCT enables precise three-dimensional assessment of bone thickness, alveolar crest level, and anatomical relationships (4). CBCT also assists in detecting hidden lesions or contraindications (19,24). Laboratory testing supports safe surgical procedures: complete blood count (CBC) to detect infections or hematologic disorders, coagulation profiles (PT, aPTT, platelet count) to assess bleeding risk, and metabolic panels (e.g., fasting glucose, HbA1c in diabetic patients) to control perioperative risks.

PERIODONTAL STABILIZATION

Stabilization of the periodontal condition is mandatory before surgery to ensure predictable healing (15). A complete periodontal chart should document probing depths, attachment levels, and gingival–bone relationships (12). An OHI-S or plaque index below 20% is the minimum acceptable threshold. Effective plaque control reduces infection risk, promotes healing, and ensures long-term stability.

SURGICAL AREA PREPARATION

BIOSAFETY PROTOCOL

Strict aseptic measures are essential to prevent cross-contamination and maintain a sterile environment during periodontal surgery. The sterility of all instruments and materials must be verified and maintained throughout the procedure. The surgical team should wear full sterile attire, including gown, cap, mask, protective eyewear, and gloves. Fenestrated sterile drapes are recommended to isolate the operative field, while exposed components such as the surgical motor, suction tubing, and operatory light should be covered with transparent sterile barriers to minimize contamination (21).

SURGICAL MATERIALS AND INSTRUMENTS

A well-organized surgical setup is fundamental to ensure efficiency, asepsis, and intraoperative control. Continuous irrigation with sterile saline, delivered via 30 mL disposable syringes, facilitates debridement and improves visibility, supported by sterile gauze and high-volume suction cannulas. For wound closure, resorbable 5-0 polyglycolic acid sutures are preferred due to their predictable absorption, biocompatibility, and reliable healing profile.

Instrument selection should prioritize precision, ergonomics, and preservation of soft tissues. Local anesthesia is administered with aspirating syringes and appropriately sized needles. Gingival incisions are performed using a No. 3 scalpel with a 15C blade, ideal for sulcular and interdental access. Flap elevation is carried out with Molt and P24G curettes or Prichard elevators to minimize trauma. Root debridement is performed with Gracey curettes (Nos. 5/6, 7/8, 11/12, 13/14) and Jacquette scalers (30/33, 31/32) to ensure thorough calculus removal (12).

Alveolar bone reshaping can be performed with Fedi chisels (buccal/palatal), Sugarman files (interproximal), or 2-3 mm round diamond burs for controlled osteoplasty. Piezoelectric systems represent a minimally invasive alternative, providing precision and reduced morbidity. For flap management and closure, atraumatic forceps (Adson, Dietrich), Castroviejo needle holders, and micro scissors are recommended. As adjuncts or alternatives to sutures, biocompatible tissue adhesives may be employed to optimize sealing and accelerate epithelialization (25).

CONVENTIONAL INTRAOPERATIVE PROTOCOL

ASEPSIS, ANTISEPSIS, AND ANESTHESIA

Strict aseptic protocols are fundamental to ensure surgical safety. Extraoral skin and intraoral mucosa should be disinfected with chlorhexidine or povidone-iodine, followed by sterile draping and placement of protective barriers. After topical anesthesia, local infiltration is administered at buccal, palatal/lingual, and interproximal sites. Profound anesthesia is essential to ensure patient comfort and enable atraumatic tissue manipulation.

INCISION DESIGN AND GINGIVECTOMY/ GINGIVOPLASTY

The incision design depends on the width of keratinized tissue. When keratinized tissue is ≥2 mm, a gingival collar excision can be performed without compromising stability. When keratinized tissue is <2 mm, an apically positioned flap is preferred to preserve the keratinized band (6,14). Indications include subgingival fractures, caries, or violation of the supracrestal tissue attachment (5,9). Esthetic or restorative crown lengthening may also be indicated in intact teeth to allow for proper margin repositioning.

For gingival overgrowth without flap elevation, an external bevel incision permits healing by secondary intention. More complex cases require an internal bevel incision at approximately 45° to the tooth axis, starting 1-2 mm coronal to the alveolar crest, combined with intrasulcular and horizontal releasing incisions to mobilize the flap and harmonize papillary contours (26).

SUPRACRESTAL DIMENSION ASSESSMENT

A periodontal probe is used to measure the distance between the gingival margin and the alveolar crest. If the measurement is ≥3 mm, osseous resection is unnecessary. If the distance is <3 mm, a full-thickness osteotomy is required to reestablish the supracrestal dimension (7,26,27).

ACCESS FLAP, OSTEOTOMY AND SUTURING

A full-thickness flap is elevated with Molt or P24G elevators to expose the alveolar crest. Inflamed tissue is carefully removed with curettes and scalers (27,28). Bone remodeling can be performed with Fedi or Ochsenbein chisels (buccal/ lingual), Sugarman files (interproximal), or 2-3 mm round burs. Piezoelectric systems represent a minimally invasive alternative, offering improved precision and reduced morbidity (6,27). Copious irrigation with sterile saline helps eliminate debris, reduce contamination risk, and promote healing (7). Closure is achieved with an internal vertical mattress suture at the papilla, using Castroviejo needle holders and atraumatic forceps to ensure flap stability and promote primary healing (27).

APICALLY POSITIONED FLAP

When keratinized tissue is limited, a partial-thickness dissection with apical repositioning preserves the keratinized tissue while exposing additional crown structure. Osteotomy, irrigation, and suturing follow the same principles described above (6,13,14).

POSTOPERATIVE CARE

To stabilize gingival contours, provisional restorations or coronal elevation with composite are recommended (10,11), maintaining spatial relationships during the healing phase (8,23). Clinical follow-up is necessary to monitor tissue response and perform suture removal. Pharmacologic management should be tailored to individual needs; standard regimens include analgesics, anti-inflammatory agents, and antibiotics when indicated (20). Patients are advised to follow a soft diet for 72 hours and to rinse with 0.12% chlorhexidine twice daily for 7 days to reduce microbial load and promote healing (21,27).

DIGITAL TECHNOLOGIES AND LASERS IN PERIODONTAL MANAGEMENT

The integration of digital and laser technologies has significantly transformed periodontal practice, enhancing diagnostic accuracy, surgical planning, and treatment predictability (17-19). Intraoral scanners, cone-beam computed tomography (CBCT), and computer-aided design (CAD) systems enable precise three-dimensional evaluation of the dentogingival complex, facilitating the fabrication of surgical guides and the delineation of safe intervention zones. In parallel, diode and erbium:YAG lasers provide minimally invasive soft tissue management, offering precise contouring, effective hemostasis, reduced trauma, and accelerated recovery (22,25,29,30). Together, these innovations improve reproducibility, optimize outcomes, and support evidence-based clinical decision-making.

LASER-ASSISTED SURGERY

Laser techniques allow minimally invasive management of the supracrestal tissue attachment, combining precise incisions with coagulative and antimicrobial effects (22,30). Clinical advantages include enhanced visibility, asepsis, reduced postoperative discomfort, and accelerated healing. For extensive bone remodeling, however, lasers serve primarily as adjunctive tools, with piezoelectric or rotary systems offering superior control.

Indications for laser use include esthetic crown lengthening, management of gingival overgrowth (29), and pocket decontamination in systemically compromised but stable patients (22,25). Contraindications include uncontrolled systemic conditions, sites with minimal keratinized tissue where thermal damage may occur, and cases requiring extensive osteoplasty, where conventional instruments are preferred. While lasers provide high precision, effective hemostasis, reduced morbidity, minimal need for suturing, bactericidal effects, and faster recovery (25), their limitations include high cost, a steep learning curve, and potential risk of thermal injury if misused. Safe clinical application requires appropriate training in laser physics and adherence to standardized protocols.

GUIDED SURGERY IN PERIODONTICS

Guided periodontal surgery integrates CBCT, intraoral, and facial scans into digital platforms to achieve comprehensive three-dimensional assessments (17,18). CAD/CAM workflows allow the fabrication of surgical guides that transfer virtual planning to the operative field, enhancing the accuracy of incisions, gingival recontouring, and osseous surgery while reducing operator variability (17-19).

This approach is particularly indicated for prosthetically driven crown lengthening in esthetic zones, multitooth cases, and interdisciplinary treatments requiring precise margin symmetry (19). Contraindications include active periodontal disease, severe tooth mobility, poor guide fit due to anatomical limitations, or lack of access to digital infrastructure. Accurate imaging and patient compliance are essential for predictable outcomes.

Guided surgery enhances precision, efficiency, reproducibility, and interdisciplinary communication. When incorporated into digital workflows, it strengthens both esthetic and prosthetic results (31,32). Limitations include high equipment and software costs, dependence on the quality of digital records, and potential interoperability issues across different systems, necessitating rigorous validation before clinical implementation.

DISCUSSION

Preservation of the supracrestal tissue attachment (STA) is a fundamental objective in contemporary periodontal surgery due to its pivotal role in periodontal health, tissue stability, and esthetic harmony. This unit, composed of the sulcular epithelium, junctional epithelium, and supracrestal connective tissue, serves as a biologic interface between the tooth and the oral environment. Its disruption, whether iatrogenic or pathologic, may lead to chronic inflammation, gingival overgrowth, or recession (1,5,9,14).

Previous studies consistently confirm that violation of this zone compromises periodontal integrity and long-term restorative success, reinforcing its clinical relevance (2,5,9). Our synthesis expands on these findings by contrasting conventional periodontal surgery with emerging innovations such as digital workflows and laser-assisted procedures, underscoring how these modalities are reshaping interdisciplinary treatment strategies.

Selection of the surgical approach must follow a comprehensive clinical and systemic evaluation, considering attachment level, keratinized tissue width, and the gingival margin–alveolar crest relationship. Baseline parameters such as probing depth, bleeding, and mobility help define periodontal status, while crown-to-root ratio and bone support determine restorative feasibility. For instance, a deficient keratinized band increases the risk of dehiscence and compromises prosthetic longevity (2,23).

Conventional surgery remains the cornerstone of management (6,20). Gingivectomy eliminates excessive tissue and corrects subgingival margins, improving plaque control and restorative precision. Access flaps facilitate debridement and root conditioning under direct vision (26). Osteoplasty, particularly when performed with periosteum preservation, allows controlled reshaping while maintaining vascular integrity (8,27). These findings corroborate earlier reports of stable outcomes when anatomy is respected, although variability persists in esthetic areas compared with digitally guided procedures.

Digital technologies have markedly enhanced both planning and execution. Guided procedures using CBCT, intraoral scanning, and CAD-based design enable precise three-dimensional mapping and surgical guide fabrication, reducing operator variability and improving accuracy, particularly in esthetic zones (4,15,17-19). In parallel, laser-assisted techniques provide minimally invasive soft tissue management with precise incisions, hemostasis, and antimicrobial effects, leading to reduced edema and faster recovery. Nonetheless, safe outcomes depend on a thorough understanding of laser-tissue interactions, as misuse may result in thermal injury (22,25,30). Current evidence supports laser application for gingivectomy (22,30), but remains weaker for osseous surgery, underscoring the need for well-designed clinical trials. Importantly, in many countries and clinical contexts, access to advanced technologies remains limited, and conventional surgery continues to represent the prevailing standard of care. This highlights the need for infrastructure investment, professional training, and updated clinical guidelines to ensure safe integration of emerging technologies.

While digital and laser modalities improve precision, efficiency, and patient experience, their adoption is largely influenced by infrastructure, training, and cost (28). Conventional approaches remain more widely accessible and adaptable across diverse clinical scenarios. Therefore, an integrative strategy that combines conventional, laser-assisted, and digital methods according to case complexity and available resources appears most realistic for contemporary practice.

Beyond structural considerations, the STA is critical for margin stability and esthetic harmony in complex rehabilitations (18). However, high interindividual variability and methodological heterogeneity limit long-term predictability. Early histologic studies reported an average STA of 2.73-3.0 mm (3,4), whereas recent digital analyses demonstrate broader ranges (0.02-5.85 mm; mean $\approx 2.05 \pm 0.99$ mm), varying by arch and tooth (4). Correlations with gingival thickness, buccal bone plate, and keratinized tissue width emphasize periodontal phenotype as a key determinant of surgical outcomes (6,7). This variability underscores the need for phenotype-based protocols to improve predictability.

Digitally guided approaches demonstrate favorable short-term accuracy and patient satisfaction (17). A recent meta-analysis found no significant short-term differences in supracrestal height, bone levels, or probing depth after crown lengthening; however, heterogeneity among studies and limited follow-up reduce the generalizability of these findings (33). Additional research indicates that gingival rebound is influenced by periodontal phenotype and flap positioning, highlighting the importance of individualized treatment planning (13,20,34,35).

To support clinical decision-making, this review provides a comparative synthesis (Table 1) of conventional, digital, and laser-based approaches, accompanied by stratified recommendations categorized by evidence level and strength according to the OCEBM framework. In addition, Table 2 summarizes diagnostic and therapeutic strategies with their clinical implications, offering a structured, evidence-informed guide for the preservation of the supracrestal tissue attachment.

FUTURE PERSPECTIVES

Future advancements in periodontal surgery will require multicenter clinical trials with long-term follow-up that directly compare conventional, laser-assisted, and digitally guided protocols, while incorporating both clinical and patient-centered outcomes. The development of standardized, phenotype-based protocols that account for gingival thickness, keratinized tissue width, and bone biotypes is essential to improve healing predictability and long-term stability. In addition, the integration of artificial intelligence with CBCT and digital scanning holds great promise for advancing personalized planning, enhancing clinical predictability, and further optimizing functional and esthetic outcomes in daily practice (36).

CONCLUSIONS

The supracrestal tissue attachment is a critical determinant of long-term periodontal stability and restorative success. Its preservation and reestablishment rely on accurate diagnosis, precise soft tissue mapping, and biologically guided surgical planning. Conventional techniques remain reliable and widely applicable, whereas laser-assisted and digitally guided workflows enhance precision, esthetic outcomes, and patient comfort when supported by appropriate training and resources.

This review contributes to clinical practice by reinforcing biological awareness, providing clear decision-making criteria, and offering a comparative analysis of conventional, digital, and laser-based approaches. It also encourages scientific updating, promotes the safe adoption of emerging technologies, and delivers practical guidance for everyday clinical application. With its integrative perspective, the manuscript underscores the pivotal role of supracrestal tissue management in achieving esthetic excellence, restorative longevity, and long-term periodontal stability, ultimately enhancing both clinical predictability and patient-centered outcomes.

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