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REVIEW ARTICLE

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Impact of Adrenal Gland Dysfunction on Dental Implant Therapy and Osseointegration: A Narrative Review

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Abstract

Background: Dental implant therapy is widely used for oral rehabilitation, with success largely dependent on bone metabolism and effective osseointegration. Systemic conditions, particularly endocrine disorders such as adrenal gland dysfunction, may influence these biological processes. However, the impact of adrenal disorders on dental implant outcomes remains insufficiently explored in current clinical guidelines.

Methods: A narrative review was conducted. An electronic search was performed in PubMed/MEDLINE, Scopus, and Web of Science databases for studies published through December 2024. Relevant studies addressing adrenal gland dysfunction, corticosteroid therapy, bone metabolism, and dental implant therapy were included. A total of 24 publications were selected based on their clinical relevance and contribution to evidence-based recommendations.

Results: Current evidence suggests that adrenal gland dysfunction should not be considered an absolute contraindication for dental implant therapy. Patients with well-controlled adrenal insufficiency may achieve favorable outcomes with appropriate medical management and perioperative corticosteroid supplementation protocols. In contrast, uncontrolled hypercortisolism and prolonged corticosteroid therapy may negatively affect bone metabolism, impair wound healing, and increase the risk of peri-implant complications. Risk stratification protocols enable clinicians to optimize outcomes through individualized treatment planning.

Conclusion: Adrenal gland dysfunction represents a relative risk factor rather than a contraindication to dental implant therapy. Careful patient evaluation, interdisciplinary collaboration with endocrinologists, and individualized treatment planning incorporating stress-reduction protocols and appropriate corticosteroid supplementation are essential to optimize clinical outcomes and ensure long-term implant success. Future prospective studies with standardized protocols are needed to establish comprehensive evidence-based guidelines for perioperative management and long-term implant outcomes in patients with adrenal dysfunction.(International Journal of Biomedicine. 2026;16(3):320-326.)

Keywords: adrenal insufficiency • hypercortisolism • Cushing syndrome • corticosteroid therapy • dental implants • bone metabolism

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Introduction

Dental implants have become an established treatment option for the rehabilitation of edentulous and partially edentulous patients, demonstrating high survival rates and predictable long-term outcomes in healthy individuals. [1,2] The success of implant therapy depends largely on osseointegration, a complex biological process involving direct structural and functional contact between living bone and the implant surface.[3]

Increasing attention has been directed toward the influence of systemic conditions on implant success. Systemic diseases affecting bone metabolism, immune response, and tissue healing may influence both the osseointegration process and the long-term stability of peri-implant tissues. [4,5] Endocrine disorders are particularly relevant because hormonal regulation plays an essential role in bone remodeling and inflammatory responses.[6]

Among endocrine disorders, adrenal gland dysfunction is clinically relevant, yet remains an underrepresented area of research in implant dentistry. The adrenal glands regulate several physiological processes through the secretion of glucocorticoids, mineralocorticoids, and adrenal androgens. Cortisol, the principal glucocorticoid, plays a central role in

stress response, immune regulation, and bone metabolism.[7] Alterations in cortisol levels may therefore influence bone turnover and wound-healing processes essential for successful implant integration. Despite these implications, adrenal disorders are rarely addressed explicitly in implant guidelines.[8,9] This narrative review aims to synthesize current evidence regarding adrenal gland dysfunction and its clinical implications for dental implant therapy, with particular emphasis on osseointegration, perioperative management, corticosteroid supplementation protocols, and clinical outcomes.

Materials and Methods

This study was conducted as a narrative review. Due to the limited number of studies specifically addressing adrenal dysfunction and dental implants, a narrative review methodology was selected to allow integration of evidence from implant dentistry, endocrinology, oral surgery, and bone metabolism literature.

An electronic search was performed in PubMed/MEDLINE, Scopus, and Web of Science databases for studies published through December 2024.

The search strategy included combinations of the following keywords: adrenal insufficiency, Addison's disease, Cushing syndrome, hypercortisolism, corticosteroid therapy, glucocorticoids, dental implants, osseointegration, bone metabolism, perioperative management, and oral surgery. Boolean operators (AND, OR) were used to combine the search terms and refine the results.

Articles published in English that discussed adrenal dysfunction, corticosteroid therapy, bone metabolism, and implant therapy were considered eligible. Narrative reviews, systematic reviews, clinical studies, and clinical practice guidelines were included. Animal and in vitro studies lacking direct clinical relevance were excluded.

Titles and abstracts of the retrieved articles were screened to identify relevant studies. Due to the limited number of publications specifically addressing dental implants in patients with adrenal disorders, additional relevant literature from related fields, particularly oral surgery, endocrinology, and bone physiology, was also considered.

A total of 24 publications met the inclusion criteria and were included in the final analysis. These studies were selected for their direct relevance to dental implant therapy and adrenal gland dysfunction, as well as their contributions to understanding the physiological mechanisms that influence bone metabolism, immune response, and surgical outcomes. Priority was given to studies that provided clinically applicable data and comprehensive reviews that addressed both endocrine and implant-related aspects.

Physiology of Adrenal Glands and Bone Metabolism

Glucocorticoids play a fundamental role in bone remodeling and bone tissue homeostasis by regulating the activity of osteoblasts and osteoclasts. Physiological levels of cortisol are essential for maintaining the balance between bone formation and bone resorption. However, chronic exposure to elevated levels of glucocorticoids inhibits the differentiation and activity of osteoblasts, increases osteocyte apoptosis, and stimulates osteoclast-mediated bone resorption.[11,12] Consequently, these alterations may lead to a reduction in bone mineral density and impairment of bone microarchitecture. These changes are of particular clinical significance, as bone quality and remodeling capacity represent key determinants for the successful osseointegration of dental implants.

At the molecular level, glucocorticoids inhibit collagen synthesis and interfere with signaling pathways involved in the regulation of osteogenesis. In addition, they modify the balance between the receptor activator of nuclear factor-κB ligand (RANKL) and osteoprotegerin (OPG), promoting osteoclast differentiation and activity and consequently enhancing bone resorption.[12] These mechanisms are of considerable relevance in implant dentistry, as successful osseointegration depends on early bone formation and the establishment of stable contact between the implant surface and the surrounding bone tissue.

In contrast to hypercortisolism, adrenal insufficiency primarily affects the body's physiological response to stress and does not directly cause pronounced bone catabolism. Reduced cortisol production may compromise the body's ability to respond adequately to surgical stress and may affect hemodynamic stability during invasive procedures, including oral and implant surgery.[10] However, with appropriate perioperative management and corticosteroid supplementation, these risks can be effectively mitigated.

Table 1.

Effects of cortisol on bone metabolism and dental implants.

Parameter	Physiological cortisol	Low cortisol (Adrenal Insufficiency)	High cortisol (Hypercortisolism)
Bone formation (Osteoblasts)	Normal	Slightly reduced	Significantly inhibited
Bone resorption (Osteoclasts)	Equilibrium	Normal	Markedly increased
Collagen synthesis	Normal	Slightly reduced	Significantly inhibited
Wound healing	Normal	May be delayed	Compromised
Bone quality	Good	Acceptable	Compromised
Stress response	Normal	Compromised	Impaired
Risk for osseointegration	Minimal	Low (with management)	Moderate to high

Adrenal Insufficiency and Dental Implant Surgery

Adrenal insufficiency may be classified as primary (Addison's disease) or secondary, most commonly resulting from prolonged corticosteroid therapy. In patients undergoing dental implant surgery, the main concern is not impaired osseointegration but rather the possibility of an inadequate physiological response to surgical stress.[13] Cortisol plays an essential role in maintaining metabolic stability, vascular tone, and an adequate stress response during surgical procedures.

Current evidence suggests that adrenal insufficiency should not be considered an absolute contraindication to dental implant placement. Patients with well-controlled disease may achieve favorable clinical outcomes when appropriate perioperative management strategies are implemented.[14] Therefore, careful medical evaluation, including assessment of the patient's endocrine status and current corticosteroid therapy, is essential before performing implant surgery.

Nevertheless, the risk of adrenal crisis during oral surgical procedures, although relatively rare, represents a potentially life-threatening complication. Adrenal crisis may manifest with hypotension, fatigue, nausea, and electrolyte imbalance, requiring immediate medical intervention.[15] For this reason, careful preoperative assessment and close clinical monitoring are recommended in patients with known adrenal insufficiency.

Perioperative Corticosteroid Supplementation

Dental implant placement is generally considered to induce mild to moderate surgical stress. The need for perioperative corticosteroid supplementation should be individualized based on patient factors, including disease control, medication regimen, and surgical complexity. For well-controlled adrenal insufficiency undergoing minor procedures such as single implant placement, current guidelines from endocrine societies suggest that standard replacement therapy may be adequate without additional "stress-dose" supplementation.[20,21]

However, for more extensive surgical procedures or in patients with inadequate disease control, perioperative corticosteroid supplementation is recommended. The standard approach involves administering 25 mg hydrocortisone intravenously (IV) at the time of surgical incision, with consideration for continued supplementation based on surgical duration and complexity.[8,10,15] This dosing protocol is supported by clinical practice guidelines from endocrine organizations and has demonstrated safety and efficacy in preventing perioperative adrenal crisis.[22]

Coordination with the patient's treating endocrinologist is essential to optimize the perioperative management plan and ensure seamless transition to standard replacement therapy in the postoperative period. With appropriate medical management and careful surgical planning, dental implant therapy can be performed safely in most patients with adrenal insufficiency.

Hypercortisolism and Cushing Syndrome

Hypercortisolism, whether endogenous or iatrogenic, has well-documented negative effects on bone metabolism and immune function. Chronic exposure to elevated cortisol levels is a major cause of secondary osteoporosis, characterized by reduced bone formation and increased bone resorption.[16] The severity of bone loss correlates with the duration and magnitude of cortisol excess, and recovery of bone density may be prolonged even after successful treatment of the underlying hypercortisolism.[23]

In implant dentistry, compromised bone quality may negatively influence primary implant stability and delay the osseointegration process. In addition, impaired soft-tissue healing and increased susceptibility to infection may elevate the risk of peri-implant complications, including peri-implantitis and implant loss.[17,23] Furthermore, patients with Cushing syndrome often present with multiple comorbidities, including hypertension, impaired glucose tolerance, and immunosuppression, that further compromise surgical outcomes and healing capacity.

Although direct clinical studies linking Cushing syndrome to implant failure remain limited, available evidence suggests that uncontrolled hypercortisolism should be considered a significant relative risk factor when planning implant therapy. Ideally, implant therapy should be deferred until the hypercortisolism is adequately controlled through medical or surgical intervention, with restoration of cortisol levels to physiological ranges.

Chronic Corticosteroid Therapy

Long-term systemic corticosteroid therapy represents another important factor that may influence implant outcomes. Prolonged glucocorticoid exposure negatively affects bone density, immune function, and wound healing while also suppressing the hypothalamic–pituitary–adrenal (HPA) axis.[12,17] Cumulative dose and duration of therapy are important determinants of bone loss and other metabolic complications.[23]

Despite these potential concerns, several studies suggest that implant therapy may still be successful in patients receiving corticosteroid treatment when systemic disease is well controlled and appropriate surgical precautions are taken.[18,23] Therefore, chronic corticosteroid therapy should generally be regarded as a relative risk factor rather than an absolute contraindication. However, patients on doses exceeding 10 mg daily prednisone equivalent warrant particular attention and more conservative surgical approaches.

Clinical Implications and Risk Stratification

A comprehensive medical evaluation is essential before implant placement in patients with adrenal dysfunction. Clinicians should obtain a detailed history of adrenal disease, current medications, corticosteroid dosage and duration, previous adrenal crises, and associated comorbidities. Laboratory assessment of baseline cortisol levels and ACTH concentrations may be useful for documenting disease control.

Interdisciplinary collaboration with endocrinologists is recommended, particularly when the patient's endocrine status or perioperative management is uncertain. Written communication with the treating endocrinologist regarding surgical timing, anesthetic approach, and perioperative

corticosteroid management is essential to ensure safe clinical outcomes.

Practical Considerations for Optimizing Clinical Outcomes

Stress-reduction protocol: The use of profound local anesthesia, short and atraumatic surgical procedures, and, when indicated, oral sedation may help minimize surgical stress and reduce the physiological demand for endogenous cortisol production.

Corticosteroid supplementation: As outlined in Section 4, the need for perioperative corticosteroid supplementation should be assessed on an individual basis in consultation with the patient's endocrinologist. For well-controlled patients undergoing minor procedures, standard replacement therapy may be adequate; however, more extensive procedures typically require supplementation with 25 mg hydrocortisone IV at induction.[8,10,15]

Surgical approach: Minimally invasive techniques, careful tissue handling, and atraumatic surgical execution are recommended to reduce trauma, inflammation, and healing time. When feasible, flapless techniques or limited-flap approaches may be advantageous in patients with compromised healing capacity.

Healing protocols: Delayed loading and extended osseointegration periods (6-8 months) may be beneficial in patients with compromised bone metabolism or significant cortisol excess. Progressive loading protocols should be considered in high-risk patients to allow adequate bone remodeling before full functional loading.

Infection prevention: Patients with adrenal dysfunction, particularly those with hypercortisolism or long-term corticosteroid use, are at increased risk of infection. Enhanced oral hygiene protocols, antimicrobial rinses, and consideration of prophylactic antibiotics may be warranted.[23] Long-term antimicrobial mouth rinses containing chlorhexidine or povidone-iodine may reduce early peri-implant complications.

In addition, clinicians should consider that patients with adrenal dysfunction, particularly those with hypercortisolism or long-term corticosteroid use, may present with associated comorbidities such as hypertension, impaired glucose

Table 2.

Risk stratification and management protocols for dental implants in patients with adrenal dysfunction

Risk category	Type of Dysfunction	Disease control	Surgical guidelines	Corticosteroid supplementation	Additional considerations
Low risk	Adrenal insufficiency	Well-controlled	Standard local anesthesia; Short procedure; Single implant	25 mg hydrocortisone IV at induction (8,10,15)	Coordination with endocrinologist; Standard post-op care
Moderate risk	Mild hypercortisolism or chronic low-dose corticosteroid therapy	Controlled	Minimally invasive technique; Extended healing period; Consider flapless approach	Depending on the endocrinologist's decision, additional supplementation may be required.	Enhanced infection prevention; Delayed loading (6-8 months)
High risk	Uncontrolled hypercortisolism or high-dose corticosteroid therapy (>10 mg prednisone equivalent daily)	Poorly controlled	Postpone elective procedure; Endocrinologist consultation; Consider systemic disease treatment first	Postpone procedure until disease control is achieved.	Defer implant therapy; Optimize systemic control; Reassess in 3-6 months

Table 3.

Summary of the impact of adrenal disorders on dental implant requirements and outcomes.

Component	Adrenal insufficiency	Hypercortisolism	Chronic corticosteroid therapy
Bone quality	Good (with adequate cortisol replacement)	Compromised (secondary osteoporosis)	Compromised (dose-dependent)
Wound healing	May be delayed (requires optimization)	Significantly compromised	Compromised (dose-dependent)
Immune response	Slightly reduced	Markedly compromised	Reduced (dose-dependent)
Implant stability (primary)	Good	Moderate to high risk	Moderate risk
Implant stability (long-term)	Good	High risk without disease control	Moderate to high risk
Management compatibility	Good (with perioperative supplementation)	Requires careful planning and disease control	Requires close monitoring and coordination
Risk of peri-implantitis	Low	Moderate to high	Moderate
Recommended loading protocol	Standard (3-6 months)	Delayed (6-8 months)	Delayed (6-8 months)

tolerance, osteoporosis, and delayed soft-tissue healing. These factors may further influence postoperative recovery and should be taken into account during comprehensive treatment planning.

Table 2 and Table 3 provide a comprehensive summary of how each category of adrenal disorder impacts critical parameters of dental implant therapy, including bone quality, wound healing, immune response, and implant stability. This comparative analysis is particularly useful for differentiated treatment planning and prognostication in distinct patient populations with adrenal dysfunction.

Limitations of Current Evidence

Direct clinical studies evaluating dental implant outcomes specifically in patients with adrenal gland disorders are scarce. Much of the available evidence is drawn from the broader literature on systemic diseases, oral surgery, bone metabolism, and endocrinology, necessitating careful extrapolation to the context of implant dentistry.

Several specific limitations merit discussion:

Limited prospective data: Most available evidence on implant outcomes in patients with adrenal disorders comes from small case reports, case series, or observational studies. Large-scale prospective clinical trials specifically evaluating implant success rates in patients with documented adrenal dysfunction are lacking.

Heterogeneity of patient populations: Variability in disease severity, medication regimens, dosages, duration of disease, and presence of comorbidities significantly complicates the interpretation and generalization of available findings. Patients with adrenal insufficiency on replacement therapy may have substantially different outcomes compared to those with uncontrolled hypercortisolism or those on high-dose corticosteroid therapy for systemic disease.

Lack of standardized protocols: Perioperative corticosteroid supplementation protocols vary widely across institutions and clinicians. No universally accepted, standardized protocols for dental implant surgery exist, making it difficult to compare outcomes across studies and to establish evidence-based recommendations.

Confounding variables: Many patients with chronic corticosteroid therapy have underlying systemic conditions (such as autoimmune diseases or malignancies) that independently affect bone metabolism, immune function, and healing capacity, making it difficult to isolate the effects of corticosteroids alone on implant outcomes.

Limited long-term follow-up data: Most available studies report short-term implant survival (1-3 years). Long-term follow-up data (5-10 years) specifically examining peri-implant bone loss, soft-tissue health, and functional outcomes in patients with adrenal dysfunction are sparse.

Outcome measurement heterogeneity: Studies use varying definitions and assessment methods for implant success, making meta-analysis and direct comparison problematic. Standardized outcome measures, including implant survival, marginal bone loss, peri-implant soft-tissue health, and patient-reported outcomes, are needed.

These limitations underscore the need for well-designed prospective studies with standardized protocols and comprehensive outcome reporting to establish robust evidence-based guidelines for implant dentistry in patients with adrenal disorders.

Future Research Directions

Future research should prioritize the following:

Prospective clinical trials: Multicenter prospective studies evaluating implant survival, osseointegration kinetics, marginal bone loss, and peri-implant tissue health in patients with documented adrenal insufficiency, hypercortisolism, and chronic corticosteroid therapy should be conducted with adequate follow-up periods (minimum 5 years).

Standardized perioperative protocols: Research should establish and validate standardized corticosteroid supplementation protocols specific to dental implant surgery in patients with adrenal dysfunction, including dose recommendations based on surgical complexity and disease control status.

Biomarker studies: Investigation of bone metabolism biomarkers (P1NP, CTX, RANKL/OPG ratios) in patients with adrenal dysfunction may help predict osseointegration potential and guide individualized treatment strategies.

Surgical technique evaluation: Comparative studies examining outcomes with different surgical approaches (conventional flap versus flapless, immediate versus delayed loading) in patients with adrenal dysfunction would inform evidence-based surgical decision-making.

Comorbidity assessment: Prospective evaluation of how comorbidities frequently associated with adrenal disorders (hypertension, diabetes, osteoporosis) modify implant outcomes would improve patient risk stratification.

Long-term peri-implant health: Longitudinal studies specifically examining rates of peri-implantitis, marginal bone loss, and soft-tissue complications in patients with adrenal disorders would establish long-term prognosis and guide maintenance protocols.

Patient-centered outcomes: Research incorporating patient-reported outcomes, quality of life measures, and functional assessments would provide a comprehensive understanding of implant therapy success beyond traditional survival metrics.

Conclusions

Adrenal gland dysfunction should be considered a relative risk factor rather than an absolute contraindication to dental implant therapy. Well-controlled adrenal insufficiency does not appear to significantly compromise osseointegration when appropriate perioperative corticosteroid supplementation (25 mg hydrocortisone IV) and medical management are implemented. Conversely, uncontrolled hypercortisolism and high-dose chronic corticosteroid therapy may negatively affect bone quality, healing capacity, and immune function, thereby increasing the risk of implant failure and peri-implant complications.

Successful implant outcomes depend on:

- Comprehensive preoperative medical assessment and documentation of endocrine disease control
- Interdisciplinary collaboration with endocrinologists to optimize perioperative management
- Individualized surgical planning incorporating risk stratification
- Implementation of stress-reduction protocols and appropriate corticosteroid supplementation
- Modified surgical techniques and healing protocols tailored to the patient's physiological status
- Enhanced infection prevention strategies in immunocompromised patients
- Consideration of extended osseointegration periods and delayed loading in high-risk patients

Furthermore, systemic conditions frequently associated with hypercortisolism—such as hypertension, impaired glucose metabolism, and osteoporosis—may also compromise soft-tissue healing, increase susceptibility to infection, and adversely affect long-term peri-implant health. Comprehensive patient management addressing these comorbidities is essential for optimizing implant prognosis.

Future prospective studies with standardized protocols, standardized outcome measures, and adequate long-term follow-up are essential to establish comprehensive evidence-based guidelines for perioperative management and long-term implant outcomes in patients with adrenal dysfunction. Until higher-quality evidence becomes available, clinicians should apply individualized risk assessment and interdisciplinary management strategies to optimize implant success in patients with adrenal dysfunction.

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AI-assisted tools were used solely for language editing and manuscript formatting, based on scientific material provided by the authors.

Author Contributions

Bylbyl Reçica: Conceptualization, validation, formal analysis, investigation, data curation, writing—original draft, writing—review and editing, visualization, supervision, project administration.
Vjosa Hamiti Krasniqi: Investigation, data curation, writing—original draft, and writing—review and editing.
Jehona Ahmedi: Investigation, data curation.
Besir Salihu: Investigation, data curation.
All authors have approved the final article.

Competing interests

The authors declare no conflict of interest

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