

# Glycaemic Control and Peri-implant Care: Translating Diabetes Biology into Clinical Decisions

How current metabolic stability, local disease control and careful interpretation of HbA1c shape implant planning and maintenance



**Core message:** diabetes is not an automatic contraindication to implant therapy. Risk is better understood through current glycaemic control, diabetes-related complications, local inflammatory burden, procedural demands and the patient's capacity for long-term maintenance.

Educational material for dental students, postgraduate trainees and academic teachers

# Diabetes is a heterogeneous clinical context

Diabetes mellitus comprises disorders characterized by chronic hyperglycaemia, but the underlying biology, treatment and pattern of complications differ. Type 1 diabetes is primarily caused by autoimmune destruction of pancreatic beta cells and requires insulin replacement. Type 2 diabetes is dominated by insulin resistance with progressive beta-cell dysfunction, although its phenotype is highly variable. Glycaemic control can be stable or unstable in either type.

| Clinical dimension | Type 1 diabetes                                                     | Type 2 diabetes                                                                         | Relevance to implant care                                                        |
|--------------------|---------------------------------------------------------------------|-----------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| Dominant mechanism | Autoimmune beta-cell destruction and absolute insulin deficiency.   | Insulin resistance with progressive loss of beta-cell function.                         | The diagnostic label does not describe current stability or complication burden. |
| Typical treatment  | Insulin is essential; delivery and monitoring systems vary.         | Lifestyle measures and one or more glucose-lowering medicines; insulin may be required. | The dental team records treatment but does not alter it.                         |
| Acute concerns     | Hypoglycaemia and diabetic ketoacidosis are particularly important. | Hypoglycaemia may occur with selected therapies; hyperosmolar crisis is possible.       | Appointment planning should reflect individual history and medical advice.       |
| Chronic concerns   | Microvascular, neural, renal, cardiovascular and immune effects.    | Similar complications, often alongside obesity, dyslipidaemia or hypertension.          | Complications may matter more to surgical risk than diabetes type alone.         |

## A diagnosis is not a prognosis

Two people with the same diabetes type can have very different HbA1c values, glucose variability, vascular health, renal function, medication burden and self-care capacity. Implant decisions should therefore avoid deterministic language and should be based on an individualized, current assessment.

**Use person-specific language: “diabetes with current control and complications” is more informative than treating “diabetic patient” as a single risk category.**

# How hyperglycaemia may influence peri-implant tissues

Persistent hyperglycaemia can affect vascular, immune and skeletal pathways that participate in wound healing and host defence. These mechanisms are biologically plausible and supported to different degrees by experimental and clinical evidence; they do not allow one-to-one prediction of an individual implant outcome.

| Pathway                         | Potential biological effect                                                                                                 | Clinical interpretation                                                                                                 |
|---------------------------------|-----------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------|
| Advanced glycation end products | Protein glycation and RAGE signalling may amplify oxidative and inflammatory pathways and alter matrix quality.             | Long-term exposure may modify tissue resilience, but no single AGE measurement is used routinely for implant selection. |
| Innate immune response          | Neutrophil and macrophage functions may become less coordinated, with impaired microbial control or prolonged inflammation. | Plaque-associated challenge remains essential; systemic risk does not create peri-implantitis in isolation.             |
| Microvascular function          | Endothelial dysfunction and impaired perfusion may reduce oxygen and nutrient delivery.                                     | The practical significance varies with control, disease duration and vascular complications.                            |
| Redox balance                   | Excess reactive oxygen species may impair mitochondrial function and tissue repair.                                         | Oxidative stress is a framework, not a chairside diagnostic test.                                                       |
| Bone remodelling                | Osteoblast differentiation and coupled remodelling may be impaired while inflammatory osteoclast signalling increases.      | Healing may be slower or less predictable when control is poor, but integration is still possible.                      |

## Local and systemic biology interact

Hyperglycaemia may modify the host response to a biofilm or surgical wound. It does not replace the need to identify plaque retention, periodontitis, implant malposition, prosthetic inaccessibility, residual cement, excess load or other local determinants.

**Risk-modifier model: glycaemic dysregulation may change the magnitude or resolution of a local response; it should not be presented as an independent substitute for local causation.**

# From uncertain evidence to a more graded interpretation

Earlier reviews often found insufficient or inconsistent evidence because studies used small samples, cross-sectional designs, different definitions of peri-implant disease and poorly standardized categories of glycaemic control. More recent systematic reviews and dose-response analyses generally suggest that peri-implant bleeding, probing depth, marginal bone change and healing indicators worsen as glycaemic exposure increases. The certainty and magnitude of these relationships remain limited by heterogeneity and confounding.

| Question                                  | Evidence-informed answer                                                                                                                 | Boundary of the claim                                                          |
|-------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|
| Is diabetes an absolute contraindication? | No. Implant therapy can be successful in people with diabetes, particularly when systemic and local conditions are stable.               | Success rates from selected studies do not guarantee safety for every patient. |
| Does poorer control matter?               | Higher HbA1c and poorly controlled diabetes are associated in several reviews with worse peri-implant parameters and more complications. | Categories and follow-up periods vary; association is not a universal cutoff.  |
| Does good control remove risk?            | Well-controlled diabetes may show outcomes closer to those without diabetes.                                                             | Other local, vascular, behavioural and mechanical risks still apply.           |
| Can HbA1c predict one implant?            | It contributes useful context but cannot independently predict osseointegration or peri-implantitis.                                     | A single value omits variability, complications and local conditions.          |

## Why recommendation strength and evidence certainty can differ

The 2023 EFP guideline recommends promotion of glycaemic control for peri-implant health. This is clinically coherent and consistent with general diabetes care, even though direct implant-specific evidence for the exact size of benefit is limited. A strong recommendation does not mean that one HbA1c threshold has been validated for all implant procedures.

**Evidence-calibrated conclusion: better metabolic stability is desirable, but there is no universally validated HbA1c number that alone determines implant eligibility.**

# Interpreting HbA1c without creating a false threshold

HbA1c reflects the proportion of glycated haemoglobin and approximates average glycaemic exposure over the preceding two to three months, with greater influence from more recent weeks. It is useful for longitudinal context, but it is neither a direct measure of wound glucose nor a stand-alone test of surgical fitness.

| Record                              | Why it matters                                                                                                                  | What not to infer                                                                    |
|-------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| Exact HbA1c value and test date     | Avoids vague labels such as “controlled” and shows how current the information is.                                              | Do not translate one value into guaranteed success or failure.                       |
| Trend when available                | A stable or improving pattern may be more informative than an isolated result.                                                  | A favourable trend does not exclude glucose variability or complications.            |
| Individual medical target           | Targets differ with age, comorbidity, hypoglycaemia risk and treatment goals.                                                   | Dental teams should not create or change the medical target.                         |
| Conditions affecting interpretation | Anaemia, altered red-cell turnover, haemoglobin variants, transfusion, pregnancy and advanced kidney disease can distort HbA1c. | An apparently reassuring or high value may not accurately represent average glucose. |

## Why study categories cannot become a universal rule

Research commonly divides participants into categories such as lower, intermediate or higher HbA1c, but the boundaries differ among studies. Some reviews report poorer biological or peri-implant measures above approximately 8%, yet those findings do not validate 8% as a universal cancellation threshold. Procedure extent, infection, urgency, comorbidity, healing history and medical stability remain relevant.

## When additional glucose information may help

If HbA1c is unreliable or the patient reports substantial variability or recurrent hypoglycaemia, the treating clinician may use self-monitoring or continuous glucose data. Interpretation and treatment adjustment remain within diabetes care. The dental team can request clarification when it affects timing or safety.

**Document, do not label: record the number, date, source and relevant medical context instead of writing only “good” or “poor” control.**

# Pre-operative assessment and medical coordination

| Assessment domain           | Questions and actions                                                                                         | Possible response                                                           |
|-----------------------------|---------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|
| Current metabolic stability | Recent HbA1c when relevant; major recent changes; severe hypoglycaemia; hyperglycaemic crisis; acute illness. | Seek medical clarification and adapt timing if control is unstable.         |
| Diabetes complications      | Cardiovascular, renal, neurological, visual, vascular and healing complications.                              | Modify surgical, medication and follow-up planning; coordinate when needed. |
| Medication and nutrition    | Insulin or other agents, meal timing, fasting requirements and previous appointment-related hypoglycaemia.    | Avoid unplanned fasting; follow the patient-specific medical plan.          |
| Oral inflammatory burden    | Periodontitis, plaque control, mucosal health, active infection and cleansability.                            | Control active local disease before elective implant therapy.               |
| Procedure and site          | Grafting, surgical extent, primary stability, tissue phenotype and prosthetic access.                         | Stage or simplify treatment when the combined risk justifies it.            |
| Maintenance capacity        | Attendance, dexterity, home care, smoking and support systems.                                                | Plan a realistic recall and supportive-care pathway.                        |

## What coordination should achieve

Communication with the diabetes-care clinician should answer a specific question: Is the condition stable? Is the available HbA1c interpretable and current? Are there complications or medication considerations relevant to the planned procedure? The request should describe the procedure and expected fasting, bleeding and healing demands.

## What the dental team should not do

Dental clinicians should not independently change insulin, glucose-lowering medication or individualized glycaemic targets. They should also avoid promising that a particular laboratory value makes surgery risk-free.

**Coordinate when information changes a decision. Routine “medical clearance” without a focused clinical question can create delay without improving risk assessment.**

# Local disease control remains the foundation

Periodontal and peri-implant diseases are biofilm-associated inflammatory conditions. Metabolic dysregulation may increase susceptibility or impair resolution, but it does not diminish the importance of plaque control and an accessible prosthetic design.

| Local priority        | Clinical action                                                                                            | Interaction with diabetes                                                             |
|-----------------------|------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| Periodontal stability | Complete periodontal assessment and active therapy before elective implant placement.                      | A history of periodontitis and poorer control may combine to raise maintenance needs. |
| Plaque control        | Demonstrate site-specific home care and confirm that planned contours are cleanable.                       | Hyperglycaemia cannot be "compensated for" by antibiotics or mouthrinse.              |
| Implant position      | Plan three-dimensional placement for tissue support, restoration and hygiene access.                       | Systemic optimization cannot correct malposition.                                     |
| Prosthetic design     | Provide retrievability and access for probing, debridement and home care.                                  | Complexity may need reconsideration when dexterity or vision is impaired.             |
| Baseline records      | Record probing, bleeding/suppuration, mucosal condition and a baseline radiograph at the appropriate time. | Longitudinal change is more informative than isolated findings.                       |

## Treat active disease without unnecessary delay

Basic infection control, periodontal therapy and urgent care should not be deferred simply because an HbA1c target has not yet been reached. Elective invasive therapy can be sequenced according to systemic stability, while ongoing local inflammation is addressed in parallel.

## Antibiotics are not a metabolic intervention

Diabetes or an elevated HbA1c alone does not establish an indication for antibiotics. Prophylactic and therapeutic decisions should follow procedure-specific recommendations, infection findings, individual medical factors and antimicrobial-stewardship principles.

**Parallel risk reduction: improve plaque control and periodontal stability while medical colleagues optimize systemic health. Neither pathway substitutes for the other.**

# Surgery, healing and early review

The procedural plan should reflect the combined burden of metabolic, vascular, local and mechanical risk. The objective is not to create a special implant protocol for every person with diabetes, but to reduce avoidable tissue trauma and ensure that changes are detected early.

| Phase                  | Practical considerations                                                                                                                                               | Escalation trigger                                                                                                            |
|------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|
| Appointment planning   | Confirm meals and medicines follow the patient-specific plan; avoid unnecessary fasting; have rapid glucose available for conscious patients at risk of hypoglycaemia. | Symptoms of hypoglycaemia, acute illness or marked instability require immediate assessment and appropriate emergency action. |
| Surgical planning      | Use atraumatic technique, secure primary stability, preserve vascularized tissue and consider staging extensive grafting or complex procedures.                        | Unexpected tissue quality, bleeding, infection or inadequate stability may require revision of the plan.                      |
| Early healing          | Review wound closure, pain trajectory, swelling, infection signs and patient-reported glucose disruption.                                                              | Worsening pain, spreading swelling, purulence, fever or systemic deterioration requires prompt evaluation.                    |
| Restorative transition | Assess clinical stability and tissue health; use loading appropriate to site and implant stability.                                                                    | Do not infer biological readiness from calendar time alone.                                                                   |

## Hypoglycaemia is the immediate chairside emergency to anticipate

Clinical manifestations may include sweating, tremor, hunger, behavioural change, confusion or reduced consciousness. Dental practices should maintain a current emergency protocol and staff training. Treatment depends on consciousness and swallowing safety; local emergency guidance takes priority.

## Post-operative hyperglycaemia is nonspecific

Pain, infection, physiological stress and disrupted meals can raise glucose. Persistent or severe disturbance warrants medical advice, but an isolated reading should not be used to diagnose a surgical complication without examination.

**Do not let an HbA1c number replace clinical monitoring. Wound appearance, symptom trajectory, implant stability and systemic signs remain essential.**

# Supportive care and communication over time

Maintenance intervals should be based on combined risk rather than the diabetes diagnosis alone. Relevant factors include current glycaemic stability, history of periodontitis, plaque levels, smoking, prosthetic cleansability, bleeding or suppuration, previous peri-implant disease and attendance.

| At supportive visits        | Document                                                                                          | Respond                                                                              |
|-----------------------------|---------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| Update health status        | Changes in medication, HbA1c when clinically relevant, complications, acute events and care team. | Coordinate if medical instability could affect treatment or healing.                 |
| Assess peri-implant tissues | Plaque, bleeding, suppuration, probing depth, mucosal recession and tenderness.                   | Investigate repeated or progressive inflammatory findings.                           |
| Compare with baseline       | Site-specific probing and radiographic changes when indicated.                                    | Diagnose from longitudinal clinical and radiographic evidence, not biomarkers alone. |
| Review function and access  | Occlusion, prosthesis integrity and the patient's ability to clean all surfaces.                  | Modify the prosthesis or hygiene strategy when access is inadequate.                 |
| Reinforce shared care       | Home-care technique, smoking status, diabetes follow-up and recall adherence.                     | Use neutral language that supports action rather than blame.                         |

## Language that preserves accuracy

| Avoid                                                   | Prefer                                                                                            |
|---------------------------------------------------------|---------------------------------------------------------------------------------------------------|
| "Diabetes caused the implant problem."                  | "Glycaemic dysregulation may have modified healing or inflammatory risk alongside local factors." |
| "Your HbA1c is safe for implants."                      | "This value contributes to the assessment; it is not a guarantee or a universal cutoff."          |
| "You must lower HbA1c before any dental treatment."     | "Urgent and infection-control care can proceed; elective surgery is timed to overall stability."  |
| "The dental team will adjust your diabetes medication." | "Medication changes remain with your diabetes-care clinician."                                    |

**Maintenance is active treatment. Long-term implant care depends on repeated risk assessment, accessible design, professional biofilm disruption and sustained self-care.**

# Clinical synthesis and selected references

## Clinical synthesis

- Identify diabetes type, current stability, medication, complications and relevant healing history.
- Record the exact HbA1c value and date when it will inform care; interpret limitations and trends.
- Do not apply a universal HbA1c threshold for implant placement.
- Control active periodontal and peri-implant inflammation and ensure prosthetic cleansability.
- Sequence elective invasive therapy according to systemic stability and procedure complexity.
- Do not defer urgent or basic infection-control care solely because glycaemic optimization is incomplete.
- Coordinate with the diabetes-care clinician using a focused question; do not change medication independently.
- Base supportive-care intervals on combined metabolic, periodontal, behavioural and prosthetic risk.

## Selected references

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## Educational use and limitations

This material supports clinical reasoning and interdisciplinary communication. It does not replace individualized medical assessment, emergency protocols, laboratory interpretation or procedure-specific clinical guidance.

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