A Critical Review of Abutment and Prosthetic Screw Failure in Implant-Supported Restorations

Abstract: Abutment and prosthetic screw loosening and fracture remain important mechanical complications of implant-supported restorations and may compromise prosthetic stability, increase maintenance requirements, and contribute to component failure. This critical narrative review evaluates the mechanisms, clinical determinants, prevention, and management of screw-related complications, with emphasis on screw preload, the settling effect, implant–abutment connection design, prosthetic fit, implant angulation, occlusal and parafunctional loading, and tightening protocols. Evidence from clinical trials, observational studies, systematic reviews, meta-analyses, and biomechanical investigations published through 2026 indicates that screw stability is multifactorial and depends on the interaction of preload, connection geometry, component integrity, prosthetic fit, occlusal loading, and functional conditions. In implant-supported single crowns, reported cumulative 5-year incidences are approximately 12.7% for screw or abutment loosening and 0.35% for screw or abutment fracture, although considerable variability exists across implant systems and clinical indications. Morse-taper connections have demonstrated low reported rates of screw loosening, whereas bruxism has been associated with an approximately 3.4-fold increased risk. Experimental evidence suggests that controlled retightening can improve preload maintenance, while repeated tightening and loosening may progressively reduce joint stability and increase component wear. Overall, no single connection design, screw material, torque protocol, or restorative approach eliminates the risk of screw failure. Effective prevention and management require accurate prosthetic fit, compatible components, appropriate implant positioning, manufacturer-recommended torque application, favorable occlusal and prosthetic biomechanics, and systematic evaluation of underlying causes when screw loosening recurs.

Keywords: Dental implants; implant-supported restorations; abutment screw; prosthetic screw; screw loosening; screw fracture; preload; settling effect; implant–abutment connection; tightening torque; retightening; mechanical complications.

1. Introduction

Osseointegrated dental implants have transformed the rehabilitation of partially and completely edentulous patients by providing stable support for fixed and removable prostheses. Although implant-supported restorations demonstrate high survival rates, biological and technical complications remain clinically relevant during long-term function. Mechanical complications may involve the implant, abutment, abutment screw, prosthetic screw, framework, veneering material, or other restorative components. Among these complications, screw loosening represents one of the most frequently reported technical problems associated with implant-supported restorations.[1-3]

The clinical significance of screw loosening extends beyond the immediate loss of retention. A loose screw can permit micromovement between the implant and abutment, alter load distribution, increase stress concentration within the screw joint, and eventually contribute to screw or component fracture. Repeated mechanical instability may also compromise the implant–abutment interface and increase the likelihood of prosthetic and peri-implant complications.[2,4]

The development of reliable implant–abutment connections, improved screw materials, more precise manufacturing, and controlled torque application has substantially improved the mechanical performance of implant-supported restorations. Nevertheless, screw-related complications continue to occur, particularly when unfavorable biomechanical conditions, prosthetic misfit, inadequate preload, excessive functional loading, or parafunctional activity are present.[1,2,11-17]

2. Epidemiology of Screw Loosening and Fracture

The frequency of screw-related complications varies considerably among studies because reported outcomes are affected by implant system, connection geometry, restoration type, number of implants, follow-up period, location, prosthetic design, and definition of failure. A systematic review by Jung et al. evaluating implant-supported single crowns reported a 5-year cumulative incidence of screw or abutment loosening of approximately 12.7%, whereas screw or abutment fracture occurred in approximately 0.35% of restorations.[1] These findings demonstrate an important distinction between screw loosening and screw fracture: loosening is relatively common and often manageable, whereas fracture is less frequent but may require substantially more complex intervention.

Theoharidou et al. systematically evaluated abutment screw loosening in single-implant restorations and found that the estimated 3-year complication-free proportion was approximately 97% for both external- and internal-connection groups.[3] Their findings suggested that screw loosening was relatively uncommon when appropriate antirotational features and recommended torque values were employed. However, the authors also emphasized limitations in the quality and comparability of the available clinical evidence.[3]

Subsequent evidence continues to refine these estimates. Systematic reviews of zirconia-ceramic and metal-ceramic single crowns,[11] monolithic ceramic restorations,[13] and screw-retained zirconia prostheses followed for up to 12 years[15] consistently identify screw loosening among the most frequent prosthetic complications, while institutional data extending to 30 years confirm that screw-related events persist as a maintenance burden across restorative materials and designs.[12,14,16] A narrative review of medium- and long-term clinical evidence similarly concludes that screw loosening remains the predominant technical complication of implant prosthodontics.[17]

The literature therefore supports a multifactorial interpretation of screw failure rather than attributing complications solely to implant connection geometry. Modern implant systems may demonstrate low rates of mechanical complications when the implant, abutment, screw, prosthesis, and occlusion function as a mechanically compatible system.

3. Biomechanics of the Implant-Abutment Screw Joint

3.1 Preload and clamping force

The fundamental objective of tightening an abutment screw is to generate sufficient preload to maintain intimate contact between the implant and abutment. When torque is applied to the screw, part of the applied torque is converted into tensile force within the screw. This tensile force produces a corresponding clamping force between the components. The stability of the joint depends on maintaining sufficient preload so that functional forces do not separate the implant and abutment.[5,6]

Burguete et al. demonstrated the mechanical relationship between applied torque and screw preload and emphasized the importance of achieving appropriate tightening torque for reliable screw-joint performance.[5] Torque that is too low may produce insufficient preload and increase the risk of loosening, whereas excessive torque may exceed the elastic capacity of the screw or damage the screw or implant threads.

Consequently, the manufacturer's recommended torque should be followed rather than relying on subjective hand tightening. Mechanical torque-control devices provide greater consistency than manual drivers and are particularly important when multiple components are being connected. Surveys of European clinicians indicate that torque-limiting devices are widely used, although adherence to calibration routines and manufacturer protocols remains variable,[21] and comparative analyses have shown meaningful differences in the accuracy of the torque-limiting devices supplied by different implant manufacturers.[22]

3.2 Settling effect

Immediately after tightening, microscopic irregularities on contacting surfaces undergo deformation and flattening. This phenomenon, commonly referred to as the settling effect, produces a reduction in preload despite the screw remaining apparently tightened.[6,7]

The settling effect is clinically important because a reduction in preload decreases the resistance of the screw joint to functional forces. Winkler et al. identified screw loosening and fracture as important restorative complications and discussed the mechanical importance of preload, torque, and surface settling.[6]

Retightening after initial torque application has therefore been investigated as a strategy for improving preload maintenance. In vitro studies demonstrate that the method and timing of retightening influence screw-joint stability: Sun et al. showed that retightening protocols produced higher removal torque values than a single tightening procedure, with an immediate loosen-and-retorque technique improving long-term stability while reducing chair time,[7,19] and fatigue-simulation research confirms that tightening protocol directly affects the probability of survival of screw-retained crowns.[20] Protocols nevertheless vary among implant systems and studies, and manufacturer-specific instructions remain essential.[7]

3.3 Repeated tightening and removal

Repeated tightening and loosening of implant components requires careful consideration. Laboratory studies have demonstrated that repeated screw manipulation can alter the

mechanical characteristics of the screw joint. Nascimento et al. found that repeated tightening and loosening increased bacterial leakage across the implant-abutment interface under their experimental conditions.[8] Attiah et al. further showed that retightened screws subjected to dynamic cyclic loading loosened more readily than new screws, supporting replacement rather than reuse of a screw once it has been retrieved.[18]

A 2026 systematic review and meta-analysis of repeated tightening and loosening cycles found significant removal-torque loss after as few as five cycles, with visible thread wear after ten cycles,[24] underscoring that each additional screw manipulation measurably degrades the joint. The clinical implication is that a screw should not simply be repeatedly tightened without identifying the reason for recurrent loosening. If a screw continues to loosen, the clinician should evaluate the prosthetic fit, implant position, connection design, screw integrity, torque application, occlusion, and functional loading. Fig 1.

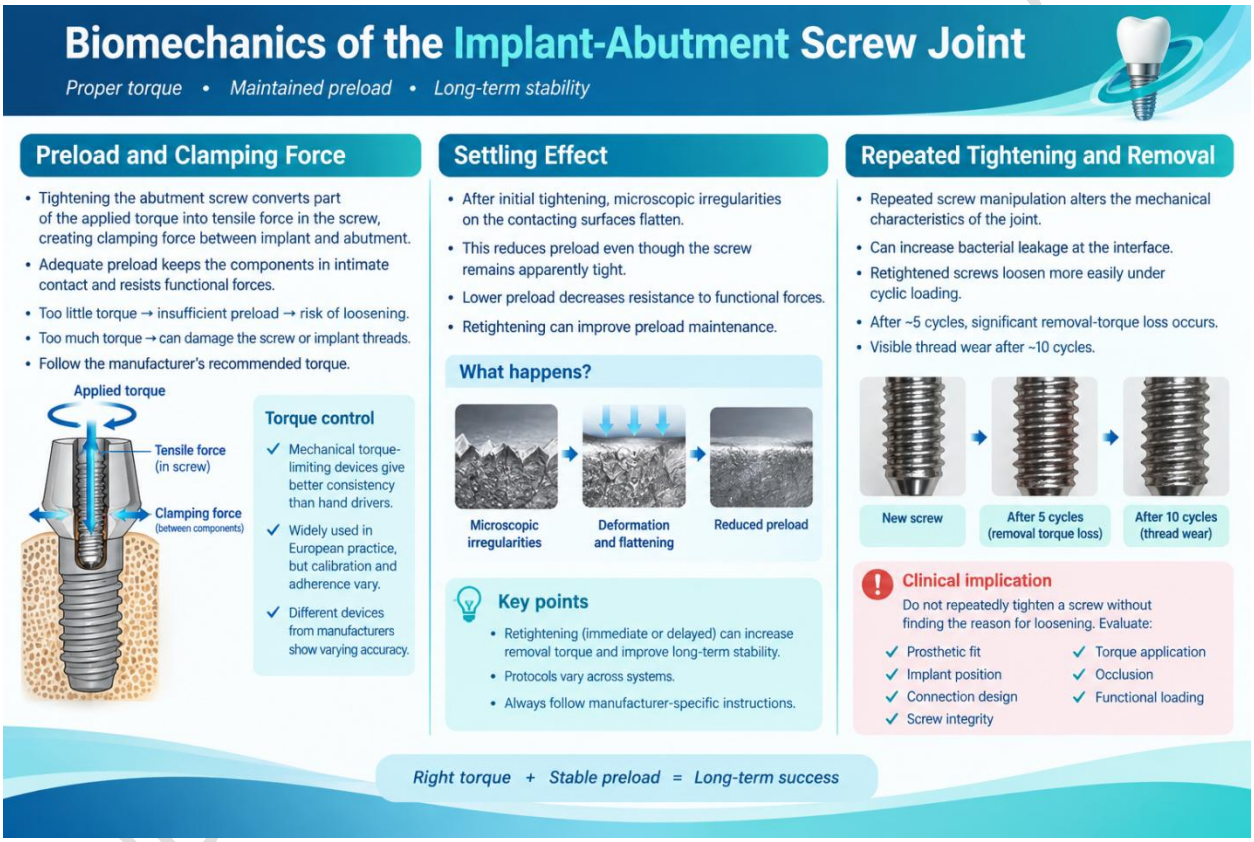

Fig 1. Biomechanics of the Implant-Abutment Screw Joint

4. Implant-Abutment Connection Design

Implant-abutment connections can broadly be categorized into external and internal connection systems. External-hex connections were fundamental to early implant systems, whereas contemporary systems increasingly employ internal hexagonal, internal trilobe, conical, and Morse-taper-type connections.

Connection geometry influences rotational stability, resistance to lateral forces, load distribution, and the mechanical behavior of the screw joint. Gracis et al., in a systematic review, reported that screw loosening was the most frequently occurring technical complication in both internal- and external-connection systems. The review suggested that more screw loosening was reported with external connections, although the available evidence was limited and heterogeneous.[2] A subsequent systematic review and meta-analysis by Lemos et al. found numerically higher overall complication rates with external connections, but the differences did not reach statistical significance,[25] reinforcing that connection geometry is only one determinant within a broader mechanical system.

Internal connections provide deeper engagement between the implant and abutment and may provide greater resistance to lateral displacement. Conical and Morse-taper-type connections can additionally provide frictional engagement between the mating surfaces. In a 1- to 9-year retrospective study of a Morse taper connection system, Yang et al. reported screw loosening in only 1.27% of restorations; prosthetic screw fracture and other abutment complications nevertheless still occurred, illustrating that even favorable connection geometries do not eliminate screw-related events.[26] Recent work also confirms that connection fit, together with proximal contact tightness, influences screw loosening.[27]

An in vitro study by Coppedê et al. comparing internal-hex and internal-conical connections found greater resistance to deformation under oblique compressive loading in the internal-conical group.[9] Although laboratory findings cannot be directly equated with clinical outcomes, these results illustrate how connection geometry can influence mechanical resistance. Connection design alone, however, does not eliminate screw complications: proper preload, accurate prosthetic fit, appropriate component selection, and controlled occlusal loading remain essential.

5. Prosthetic Factors Associated With Screw Failure

5.1 Prosthetic misfit

Passive or accurate prosthetic fit is an important consideration in implant-supported restorations. A framework or restoration that does not seat accurately may introduce unwanted stresses into the implant-abutment complex even before functional loading occurs. When occlusal forces are subsequently applied, these stresses may contribute to screw fatigue and loss of preload.

Therefore, recurrent screw loosening should prompt evaluation of the restoration rather than simply replacement of the screw. Clinical assessment may include verification of complete seating, radiographic evaluation when indicated, evaluation of proximal and occlusal contacts, and assessment of the framework or crown for distortion.

5.2 Screw-retained versus cement-retained restorations

Retention type also affects the management of screw-related complications. In screw-retained restorations, the prosthetic access channel permits direct access to the retaining screw, facilitating retrieval, tightening, and component replacement. The access channel must nevertheless be sealed with a material that protects the screw head and can be removed

without damaging the surrounding ceramic or composite; sealing efficacy and removal convenience of access-hole materials have been compared experimentally.[23]

In cement-retained restorations, access to the abutment screw may be limited or absent. Consequently, recurrent screw loosening may be more difficult to diagnose and manage because the restoration may need to be removed before the abutment screw can be accessed.

Comparative evidence remains inconsistent. A systematic review found no definitive difference in overall complication rates between retention types,[28] whereas randomized clinical trials over 24 months[29] and 7.5 years[30] reported conflicting outcomes for posterior single crowns. This heterogeneity underscores the need to base the choice between screw- and cement-retained restorations on esthetics, retrievability, implant angulation, occlusion, available restorative space, and anticipated maintenance requirements rather than on complication rates alone.

6. Implant Angulation and Off-Axis Loading

Implant angulation can alter the direction and magnitude of forces transmitted through the implant-abutment complex. Angulated abutments may be necessary when implant placement does not permit an ideal restorative emergence profile or screw-access position; however, they may also modify the mechanical environment of the restoration.

Omori et al. conducted a systematic review and meta-analysis evaluating biological and mechanical complications associated with angulated abutments. The authors identified evidence of increased biological and mechanical concerns in certain angulated-abutment situations, although the available studies were heterogeneous.[10] Consistent with these findings, a systematic review of in vitro studies reported increased screw loosening as the angle of correction increased in angulation-correcting single-implant restorations.[34]

Abutments with angulated screw channels (ASC) were developed to combine the retrievability of screw retention with corrected screw-access positioning. One-year prospective data are encouraging,[31,32] but a 5-year prospective case series reported screw loosening in 30% of full-zirconia single molar restorations with ASC abutments,[35] and a systematic review of clinical and laboratory outcomes concluded that long-term evidence remains limited.[33] The use of angled components should therefore be based on restorative and biomechanical considerations rather than simply correcting the position of the screw-access channel. Whenever possible, implant placement should be planned prosthetically to minimize unfavorable loading conditions.

7. Occlusal Loading and Parafunction

Occlusal loading is an important contributor to mechanical complications. Implant-supported restorations lack the periodontal ligament-mediated sensory feedback present around natural teeth, and the manner in which occlusal forces are transmitted therefore differs from that of natural dentition.

Excessive occlusal forces may contribute to repeated micromovement and fatigue within the screw joint. Risk may be increased in patients with heavy occlusal function or parafunctional activity such as bruxism; a systematic review with meta-analysis reported a substantially greater

incidence of screw loosening in patients with bruxism and an approximately 3.4-fold increase in the associated risk.[38]

Cantilevers may further increase bending moments because forces applied away from the supporting implant create a lever arm. The magnitude of this effect depends on implant number and distribution, cantilever length, prosthetic design, occlusal contacts, and functional loading. A meta-analysis of posterior implant-supported cantilever fixed partial dentures confirmed that prosthetic complications, including screw-related events, remain a relevant concern in these designs,[36] and a scoping review of implant-supported fixed partial dentures reached similar conclusions.[37]

For patients with suspected parafunction, treatment planning should include careful evaluation of occlusion and prosthetic design. When clinically appropriate, protective occlusal strategies and maintenance protocols may be considered.

8. Screw Material and Component Integrity

The screw represents a relatively small component within the implant-restoration system but is mechanically critical because it maintains the clamping force between the implant and abutment. Screw material, geometry, surface characteristics, manufacturing tolerances, and thread design can influence mechanical behavior.

Fatigue failure may occur when cyclic loading repeatedly stresses the screw. A screw that has already experienced deformation, thread damage, or fracture should not be considered equivalent to a new component.[18,24]

Component compatibility is also essential. Implant manufacturers specify compatible screws and prosthetic components for particular implant systems. Substitution with non-compatible components can alter the fit, preload, or mechanical behavior of the connection.

9. Clinical Presentation of Screw Loosening

Patients with screw loosening may report mobility, discomfort during function, altered occlusion, or a sensation that the restoration has become loose. In some cases, however, the patient may be asymptomatic and the complication may be identified during routine examination.

Clinical examination should determine whether movement originates from the restoration, abutment, implant, or surrounding structures. A loose prosthetic crown should not automatically be interpreted as a loose implant. Differential diagnosis is essential because implant mobility may indicate loss of osseointegration rather than prosthetic screw loosening.

Radiographic assessment may be indicated to evaluate the implant and surrounding bone and to identify other causes of discomfort or prosthetic instability.

10. Management of Screw Loosening

Management should begin with identification of the underlying cause. If the screw is intact and the implant-abutment connection is undamaged, the restoration may be removed, the

components inspected, and the screw replaced or retightened according to the manufacturer's protocol.

Before definitive retightening, the clinician should evaluate:

1. Screw integrity and deformation.
2. Condition of the implant and abutment threads.
3. Seating of the restoration.
4. Prosthetic fit.
5. Implant-abutment connection.
6. Occlusal contacts.
7. Implant angulation.
8. Presence of cantilever loading.
9. Evidence of parafunctional activity.
10. Correctness of the torque-control procedure.

If screw loosening recurs, repeated tightening without diagnosis is inappropriate. Recurrent loosening indicates that an underlying mechanical or biological factor may remain unresolved.[8,18,24]

11. Management of Screw Fracture

Screw fracture represents a more advanced mechanical complication. Management depends on the location of the fracture, accessibility of the fractured segment, condition of the internal threads, and integrity of the implant.

When possible, the fractured fragment should be retrieved using conservative techniques that minimize damage to the implant's internal connection or threads. If retrieval is unsuccessful or the implant itself has been damaged, more extensive intervention may be required.

Following retrieval, the cause of fracture should be investigated. A replacement screw alone may not solve the problem if excessive loading, prosthetic misfit, component incompatibility, or another mechanical factor remains.

12. Prevention

Prevention begins during treatment planning rather than after the first mechanical complication occurs. The following principles are particularly important:

- Prosthetically driven implant positioning.
- Selection of an appropriate implant-abutment connection.
- Accurate impression or digital acquisition and laboratory procedures.
- Verification of prosthetic fit.
- Use of manufacturer-compatible components.
- Application of manufacturer-recommended torque.
- Use of calibrated torque-control devices.[21,22]

- Appropriate management of occlusal contacts.
- Minimization of unfavorable cantilevers and excessive lever arms.[36,37]
- Recognition and management of parafunctional activity.[38]
- Regular maintenance and recall examinations.

Recent experimental evidence indicates that tightening technique can influence immediate and long-term screw-joint stability. Sun et al. demonstrated that retightening strategies produced higher removal torque values than a single tightening procedure in their in vitro model.[7,19,20] However, these findings should not be interpreted as justification for applying a universal retightening protocol to every implant system. Manufacturer-specific instructions and the clinical context remain essential.

13. Critical Appraisal of the Evidence

The literature demonstrates that screw loosening is a well-recognized technical complication, but considerable heterogeneity exists among published studies. Differences in implant systems, connection geometries, screw materials, torque values, prosthetic designs, loading protocols, follow-up periods, and definitions of failure make direct comparison difficult.

Systematic reviews provide stronger evidence than individual laboratory studies, but even systematic reviews have noted limitations in the quality and comparability of available clinical studies.[3,17] Laboratory investigations are valuable for understanding preload, fatigue, connection mechanics, and the effects of cyclic loading, but their results cannot automatically be extrapolated to clinical failure rates.[24,25,30]

Accordingly, the most appropriate interpretation is that screw failure is multifactorial. No single implant-abutment connection, screw material, torque protocol, or restorative design can independently eliminate the possibility of mechanical complications.

14. Conclusion

Abutment and prosthetic screw loosening and fracture remain important mechanical complications of implant-supported restorations. The evidence indicates that screw stability depends on adequate preload, accurate component fit, appropriate implant-abutment connection design, controlled torque application, favorable prosthetic biomechanics, and management of functional and parafunctional loading.

The clinical significance of screw loosening extends beyond a loose restoration because persistent micromovement may contribute to progressive mechanical complications. Therefore, recurrent screw loosening should be regarded as a diagnostic finding rather than simply a maintenance event.

Successful prevention and management require a systematic approach that evaluates the entire implant-restoration complex. Accurate treatment planning, compatible components, appropriate torque, precise prosthetic fabrication, favorable occlusion, and regular maintenance remain the most important strategies for reducing the risk of screw-related failure.

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