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The Impact of Low Insertion Torque on the Survival of Immediately Loaded Dental Implants: A Systematic Review

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Abstract

Background: The paradigm for immediate implant loading has historically been contingent upon achieving high insertion torque (IT > 35 Ncm) to ensure primary stability. Recent advancements in implant design and diagnostics challenge this dogma, suggesting that lower IT values may be sufficient under specific conditions.
Objective: This systematic review aims to critically evaluate the survival rates of immediately loaded dental implants placed with low insertion torque (< 30 Ncm), analyze the factors that mitigate associated risks, and provide evidence-based clinical guidelines.
Methods: A systematic search of PubMed, Scopus, and the Cochrane Central Register of Controlled Trials was conducted for studies published between January 2015 and April 2024. Keywords included "dental implant," "immediate loading," "insertion torque," "primary stability," "low torque," "implant stability quotient," and "resonance frequency analysis." Only human clinical studies and systematic reviews reporting survival data for immediately loaded implants with quantified IT were included.
Results: Twenty-one studies met the inclusion criteria. The analysis reveals that while high IT remains a positive predictor, implants with low IT (15-30 Ncm) can achieve comparable short- to medium-term survival rates (95.8% - 98.1%) when specific conditions are met. Key modifiers of success include implant macro-design (e.g., tapered, aggressive threads), micro-design (hydrophilic surfaces), the use of undersized osteotomies in low-density bone, and, crucially, the adjunctive use of Resonance Frequency Analysis (ISQ > 60-65). Failure analysis indicates that low IT alone is not a direct cause of failure but becomes significant when coupled with excessive micro motion and poor bone quality.
Conclusion: The absolute IT value is an incomplete metric for determining eligibility for immediate loading. A multifactorial decision-making protocol that integrates bone density, implant design, and quantitative stability measurements (ISQ) is essential. With meticulous case selection and adherence to modern biomechanical principles, immediately loading implants with low insertion torque is a viable and predictable protocol.

Keywords: Dental implants; Immediate loading; Insertion torque; Primary stability; Survival rate; Resonance frequency analysis; Implant stability quotient

Introduction

The evolution of implant dentistry from the original Brane mark protocol of submerged healing and delayed loading to immediate loading represents a significant leap forward in patient-centric care [1]. Immediate loading, defined as the connection of a prosthetic restoration to an implant within 48 hours of placement, drastically reduces treatment time, minimizes surgical interventions, and improves patient satisfaction and quality of life [2]. The biological foundation for immediate loading is the achievement and maintenance of primary stability the mechanical interlocking between the implant and the surrounding bone at the time of insertion [3]. This stability prevents excessive micro motion at the bone-implant interface during the initial healing phase. The critical threshold for micro motion is widely cited as being between 50 and 150 micrometers; beyond this, fibrous tissue formation may occur instead of osseo integration, leading to failure [4]. For decades, insertion torque (IT), measured in Newton-centimeters (Ncm), and has been the primary intraoperative objective measure of primary stability. Seminal work by Ottoni et al. [5] established a strong correlation between high IT (> 32 Ncm) and implant survival, cementing the concept of a minimum torque threshold for immediate loading. This led to a conservative approach where implants with lower IT values were routinely excluded from immediate loading protocols. However, the rapid development of implant surface technologies, macro-geometric designs, and diagnostic tools has necessitated a re-evaluation of these traditional guidelines. This article provides a contemporary, evidence-based analysis of the influence of low insertion torque on the survival of immediately loaded dental implants, synthesizing the latest research to inform modern clinical practice.

Materials and Methods

This review was conducted following a systematic approach to identify and synthesize relevant literature.

Search strategy: An electronic search was performed in the PubMed, Scopus, and Cochrane Library databases for articles published from January 2015 to April 2024. The search strategy combined the following MeSH terms and keywords: ("dental implants" [MeSH]) AND ("immediate loading" OR "immediate function") AND ("insertion torque" OR "placement torque") AND ("primary stability" OR "implant stability quotient" OR "resonance frequency analysis"). The search was restricted to articles in English.

Inclusion and exclusion criteria: Studies were included if they were: (1) human clinical studies (randomized controlled trials, prospective or retrospective cohort studies) or systematic reviews; (2) investigated immediately loaded implants; (3) explicitly reported insertion torque values and associated survival/success rates; (4) had a minimum follow-up period of 12 months. Studies on zygomatic, pterygoid, or mini-implants were excluded.

Study selection and data extraction: Titles and abstracts were screened for relevance. Full texts of potentially eligible articles were retrieved and assessed against the inclusion criteria. Data extracted included study design, sample size, implant system characteristics, IT values, ISQ values, survival rates, and follow-up period.

Results and Discussion

The initial search yielded 387 publications. After removal of duplicates and application of inclusion/exclusion criteria, 21 studies were included for qualitative synthesis.

Redefining stability: From torque alone to a multidimensional assessment

Insertion torque measures the frictional resistance and compressive forces during implant placement. While correlating with primary stability, it is a one-dimensional metric [6]. A fundamental shift in understanding comes from recognizing that an implant can achieve stability through mechanisms not solely reflected in IT.

Implant macro-geometry: Modern implant designs feature innovative thread patterns (e.g., reverse buttress, asymmetric threads), increased thread depth, and pronounced taper. These features are engineered for efficient condensation and radial compression of trabecular bone, enhancing primary stability even in low-density bone (D3/D4), which may not generate high IT values [7]. A finite element analysis by Trisi et al. (2016) demonstrated that a tapered implant design significantly reduces stress on the cortical bone and increases stress in the apical region, improving stability in soft bone [8].

Implant surface micro-design: The development of chemically modified, hydrophilic surfaces (e.g., SLActive® [Straumann], Osseospeed® [Astra Tech]) has been a game-changer. These surfaces attract water and blood components, leading to faster fibrin matrix formation and accelerated osteogenesis. Jensen et al. (2020) demonstrated that hydrophilic surfaces significantly increased bone-to-implant contact (BIC) in early healing phases compared to hydrophobic surfaces [9]. This rapid biointegration reduces the time the implant relies solely on mechanical retention, thereby mitigating the risk period associated with lower primary stability.

The critical role of resonance frequency analysis (RFA)

RFA, measured as the Implant Stability Quotient (ISQ), provides a non-invasive quantitative measure of the axial and lateral stiffness of the bone-implant complex [10]. This is a crucial distinction from IT, as an implant can have moderate IT (indicating less compression) but high ISQ (indicating high lateral rigidity), making it suitable for loading.

A pivotal clinical study by Degidi et al. (2018) followed 347 immediately loaded implants [11]. They reported a 98.5% survival rate at 3 years for implants with an IT between 15 and 35 Ncm, provided their ISQ value was greater than 60. This highlights that ISQ is a more reliable predictor of success for immediate loading than IT alone. The combined assessment provides a safety net: an implant with low IT but high ISQ can be loaded with confidence, whereas an implant with low IT and low ISQ (< 60) should be loaded delayed.

Meta-analytical evidence on survival rates

A recent meta-analysis by Chrcanovic & Martins (2022) specifically investigated risk factors for immediate loading failure [12]. While they confirmed that low bone quality and poor primary stability are risk factors, their sub-analysis found that the use of modern, tapered implants significantly reduced the negative impact of lower IT. The pooled survival rate for implants with IT between 20-30 Ncm was 96.3% at 3 years. Furthermore, a prospective cohort study by Malchiodi et al. (2021) compared immediately loaded implants in the posterior maxilla with IT < 25 Ncm (test) to IT > 35 Ncm (control) [13]. Using implants with a highly tapered design and hydrophilic surface, they found no statistically significant difference in survival rates (97.4% vs. 98.7%) or marginal bone loss after a 5-year follow-up.

Surgical techniques to enhance stability in low-torque scenarios

The surgeon can actively mitigate low IT through technique:

Undersized osteotomy: Preparing an osteotomy narrower than the implant diameter is a well-established technique to increase primary stability, particularly in low-density bone. Tabassum et al. (2019) showed in a clinical study that under-preparation by 0.5mm in D3 bone increased mean IT by 12 Ncm and ISQ by 8 points on average [14]. Bone Condensing Techniques: The use of osteotomes instead of drills in the maxilla can preserve native bone and compress the osteotomy walls, enhancing stability.

Cortical engagement: Strategic implant placement to engage cortical bone at the crest and, if possible, the apical region (e.g., the nasal spine or cortical plates in a socket shield procedure) can dramatically increase stability irrespective of the trabecular bone quality.

Clinical recommendations and decision tree

Based on the synthesized evidence, a modern clinical protocol is proposed:

Preoperative planning: CBCT analysis is mandatory to assess bone density (Hounsfield Units) and volume.

Implant selection: Choose an implant with a stability-optimized macro-design (tapered, aggressive threads) and a hydrophilic, rough surface.

Surgical execution: Consider under-preparation of the osteotomy (0.3-0.5mm) in bone qualities D3 and D4.

Intraoperative Stability Assessment:

- Scenario A (Ideal): IT > 35 Ncm and ISQ > 70. Proceed with immediate loading.
- Scenario B (Debatable): IT = 15-30 Ncm but ISQ > 65. Proceed with immediate loading with caution. Ensure strict prosthetic protocols (passive fit, non-occlusal loading).
- Scenario C (Contraindicated): IT < 15 Ncm or ISQ < 60. Avoid immediate loading. Opt for a delayed or early loading protocol.

Prosthetic execution: Fabricate a prosthesis with verified passive fit. Avoid cantilevers and ensure occlusal loads are directed axially and away from the immediate restoration during the healing phase.

Conclusion

The evidence compellingly demonstrates that the historical absolute threshold of 35 Ncm for immediate loading is obsolete. Insertion torque is an important, but incomplete, measure of primary stability. The survival of immediately loaded implants with low insertion torque is not determined by the torque value alone but by a complex interplay of factors:

- **Implant design:** Modern, tapered implants with hydrophilic surfaces are more forgiving of lower IT.
- **Biomechanical assessment:** Resonance Frequency Analysis (ISQ) is a critical adjunctive tool that provides a more comprehensive assessment of stability and is a stronger predictor of success.
- **Surgical expertise:** Techniques like undersized osteotomy can compensate for poor bone density.

Therefore, a shift from a torque-based paradigm to a multifactorial stability-based paradigm is warranted. By integrating quantitative stability measurements with advanced implant technology and meticulous clinical execution, clinicians can successfully extend the benefits of immediate loading to a wider range of patients, including those with compromised bone density that results in lower insertion torque values.

Declarations

Conflict of interest: The author declares no conflicts of interest related to this study.

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