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CLINICAL PRACTICE ARTICLE

REVISED Early Stability Dynamics of UV-Functionalized Dental Implants Under Early Loading: Evaluating ISQ Changes in the Posterior Mandible: Case Reports

[version 2; peer review: 2 approved]
Previously titled: " Early Stability Dynamics of UV-Functionalized Dental Implants Under Early Loading: Evaluating ISQ Changes in the Posterior Mandible"

Awab Midani, Issam Alkhouri

Department of Oral and Maxillofacial Surgery, Damascus University Faculty of Dentistry, Damascus, Damascus Governorate, Syria

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Abstract

Background

UV photofunctionalization has been proposed as a method to enhance implant surface bioactivity and potentially improve early osseointegration.

Objective

This study aimed to evaluate early implant stability under early loading conditions by analyzing changes in Implant Stability Quotient (ISQ) values over time.

Methods

This case series included three implants placed in the posterior mandible and treated with UV photofunctionalization for 24 hours prior to placement. Implant stability was assessed using Resonance Frequency Analysis (RFA) at baseline (implant placement), at 3 weeks, and at 4 weeks prior to functional loading. Insertion torque values were recorded at the time of implant placement.

Results

A progressive increase in ISQ values was observed across all cases,

Open Peer Review

Approval Status ✓ ✓

	1	2
version 2 (revision) 18 Nov 2026		✓ view
version 1 17 Oct 2026	✓ view	? view

1. **MHD BAHAA ALDIN Alhaffar**, Karolinska institute, Stockholm, Sweden
2. **Dinesh Rokaya**, College of Dentistry, Ajman University, Ajman, United Arab Emirates

Any reports and responses or comments on the article can be found at the end of the article.

ranging from 77 to 85, with no evidence of a stability dip during the study period.

Conclusions

Within the limitations of this case series, the observed ISQ progression indicates a favorable stability pattern under early loading conditions. However, due to the small sample size and absence of a control group, no definitive conclusions can be drawn regarding the specific effect of UV photofunctionalization.

Keywords
UV photofunctionalization; dental implants; primary stability; ISQ; resonance frequency analysis; early loading; posterior mandible; case series

Corresponding author: Awab Midani (awab.midani@gmail.com)

Author roles: Midani A: Conceptualization, Data Curation, Formal Analysis, Investigation, Validation, Visualization, Writing – Original Draft Preparation; **Alkhouri I**: Conceptualization, Investigation, Methodology, Project Administration, Supervision, Validation, Visualization, Writing – Review & Editing

Competing interests: No competing interests were disclosed.

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REVISED **Amendments from Version 1**

In response to the reviewers' constructive comments, the following major revisions have been made in Version 2:

1. Added "Case Reports" to the manuscript title to clearly reflect the study design.

2. Expanded the Discussion section to explain the high, nearly constant ISQ values observed in Case 1 (83, 84, and 85) and Case 3 (85), relating them to optimal initial mechanical interlocking in dense D2 bone.

3. Clarified in the Discussion section that the stability improvement associated with UV photofunctionalization is not due to physical alterations in implant surface roughness or micro-topography, but rather to physicochemical surface modifications.

4. Expanded the Limitations and Conclusions sections to emphasize that these findings represent preliminary clinical observations from three case reports, acknowledged the role of natural physiological osseointegration and favorable patient/bone characteristics, and highlighted the need for larger sample sizes and longer follow-up periods.

5. Added two relevant references recommended during peer review (References 13 and 14).

Any further responses from the reviewers can be found at the end of the article

Introduction

Dental implant therapy has become a well-established and highly predictable treatment modality for the rehabilitation of partially and completely edentulous patients, demonstrating high long-term survival and success rates across various clinical scenarios.[1,2] Continuous advancements in implant macro- and micro-design, as well as surface modifications, have contributed significantly to improving osseointegration and overall treatment outcomes. Despite these advancements, reducing treatment duration while maintaining optimal biological and mechanical stability remains a key objective in contemporary implant dentistry.

Traditionally, conventional loading protocols recommend a healing period of 3 to 6 months to ensure adequate osseointegration before prosthetic loading.[1] However, increasing patient expectations, along with the desire to shorten treatment time, have led to the development of alternative loading protocols, including early and immediate loading approaches. Early loading, defined as functional loading occurring between 1 week and 2 months after implant placement, has shown favorable clinical outcomes when adequate primary stability and controlled occlusal conditions are achieved.[2,3] Previous systematic reviews and clinical studies have further supported the clinical feasibility of early loading protocols when appropriate primary stability is achieved and case selection is carefully considered.[4,5] Nevertheless, the predictability of early loading protocols is still influenced by several factors, including bone quality, implant design, surgical technique, and biomechanical loading conditions, particularly in posterior mandibular regions where occlusal forces are significantly higher.

Implant stability is a critical determinant for the success of early loading protocols. It comprises primary stability, which is mechanically achieved at the time of implant placement, and secondary stability, which results from biological bone remodeling and osseointegration.[3,6] The transition between these two phases is crucial, as a temporary reduction in stability—commonly referred to as the "stability dip"—may be associated with an increased risk of implant failure if loading is applied prematurely.[6] Resonance frequency analysis (RFA), expressed as the implant stability quotient (ISQ), has become a widely accepted, non-invasive tool for assessing implant stability and guiding clinical decisions regarding loading protocols.[3]

To enhance early osseointegration and improve implant stability, various surface modification techniques have been introduced. Among these, ultraviolet (UV) functionalization has gained increasing attention. Titanium implant surfaces undergo a process known as biological aging, characterized by the accumulation of hydrocarbon contaminants, which reduces surface energy and negatively affects protein adsorption and cellular response.[7,8] UV irradiation has been reported to reverse this phenomenon by restoring surface hydrophilicity, increasing surface energy, and enhancing protein adsorption, thereby potentially promoting osteoblastic attachment, proliferation, and differentiation.[8,9]

Experimental and clinical studies have demonstrated that UV-functionalized implants are associated with improved bone-to-implant contact and accelerated early osseointegration compared to untreated surfaces.[9,10] This enhanced biological activity may contribute to a reduction in healing time and potentially enable earlier loading without compromising implant success. Furthermore, photofunctionalization has been suggested to improve implant performance even in compromised clinical situations, including poor bone quality or high functional demand.[10,11]

The posterior mandible is considered a challenging clinical environment in implant dentistry due to increased occlusal forces and functional loading, which may influence peri-implant tissue stability and long-term outcomes.[11,12] Therefore, evaluating strategies that enhance early implant stability in this region is of particular clinical importance. Although previous studies have investigated early loading protocols, limited clinical evidence is available regarding the combined effect of UV functionalization and early loading in posterior mandibular single-tooth cases.

Accordingly, the aim of this case series is to describe implant stability dynamics under early loading conditions at 4 weeks in implants subjected to 24-hour ultraviolet functionalization and placed in posterior mandibular single-tooth edentulous sites. Implant stability progression, assessed using ISQ measurements at multiple time points, along with one-year radiographic outcomes, were used to describe clinical outcomes.

Methods

This case series included three systemically healthy patients (two females and one male) aged between 20 and 23 years, presenting with a single missing posterior mandibular tooth (first molar or premolar). None of the patients had a history of systemic disease or smoking. All patients received a dental implant (Point, South Korea) with a sandblasted, large-grit, acid-etched (SLA) surface. Implants of uniform dimensions (4.0 mm diameter × 10 mm length) were placed using a flap surgical approach under standard clinical protocols.

Prior to placement, all implants were subjected to ultraviolet (UV) irradiation for 24 hours using a UV activator device (UV-A200), aiming to enhance surface bioactivity.

Implant stability was assessed using resonance frequency analysis (RFA) with a Mega ISQ II device, expressed as the implant stability quotient (ISQ). ISQ measurements were recorded at implant placement (T0), at 3 weeks (T1), and at 4 weeks (T2). Insertion torque values were recorded at the time of implant placement.

Visual documentation was available for selected time points, including baseline and 4-week assessments.

Early prosthetic loading was performed at 4 weeks using porcelain-fused-to-metal (PFM) restorations.

Radiographic evaluation was carried out using periapical radiographs obtained at baseline (immediately after implant placement) and at 12 months follow-up to assess marginal bone stability.

All procedures were performed in accordance with standard clinical protocols and the principles of the Declaration of Helsinki.

Case presentation

Case 1

A 20-year-old female patient presented with a single missing mandibular first molar in the left posterior region (tooth 36). The site was a healed edentulous area with adequate bone volume in both height and width, and bone quality was classified as D2. Implant placement was performed under standard clinical protocols. The insertion torque recorded at the time of placement was 37 Ncm. Implant stability, assessed using ISQ, showed values of 83 at baseline (T0), 84 at 3 weeks (T1), and 85 at 4 weeks (T2). Early prosthetic loading was performed at 4 weeks using a porcelain-fused-to-metal (PFM) restoration. At the 12-month follow-up, radiographic evaluation demonstrated stable marginal bone levels.

Case 2

A 23-year-old male patient presented with a missing mandibular first molar in the left posterior region (tooth 36). Clinical and radiographic evaluation revealed a well-healed edentulous ridge with sufficient bone height and width, and bone quality was classified as D2. Implant placement was carried out following standard surgical protocols, achieving an insertion torque of 36 Ncm. Implant stability measurements demonstrated a gradual increase in ISQ values from 77 at baseline (T0) to 80 at 3 weeks (T1) and 83 at 4 weeks (T2). Early functional loading was performed at 4 weeks using a porcelain-fused-to-metal (PFM) restoration. Radiographic assessment at the 12-month follow-up confirmed stable peri-implant bone levels with no signs of bone loss.

Case 3

A 22-year-old female patient presented with a missing mandibular second premolar in the left posterior region (tooth 35). The implant site exhibited a completely healed ridge with adequate bone dimensions, and bone quality was categorized as D2. Implant placement was successfully performed under standard clinical conditions, achieving an insertion torque of 37 Ncm. ISQ values remained stable at a high level (85) across all recorded time points (T0, T1, and T2), indicating consistent implant stability without any detectable decrease. Early loading was completed at 4 weeks using a porcelain-fused-to-metal (PFM) restoration. Follow-up radiographs at 12 months demonstrated maintained marginal bone stability and satisfactory clinical outcomes.

Results

A total of three implants were placed in the posterior mandible of systemically healthy patients and followed for a period of 12 months. All implants achieved successful osseointegration, with no biological or mechanical complications observed throughout the follow-up period. ISQ values ranged from 77 to 85 at baseline (T0), with a progressive increase observed at 3 weeks (T1) and 4 weeks (T2) in two cases, while one case exhibited consistently high ISQ values across all time points. The trend of ISQ changes over time is illustrated in Figure 4. No evidence of a stability dip was detected

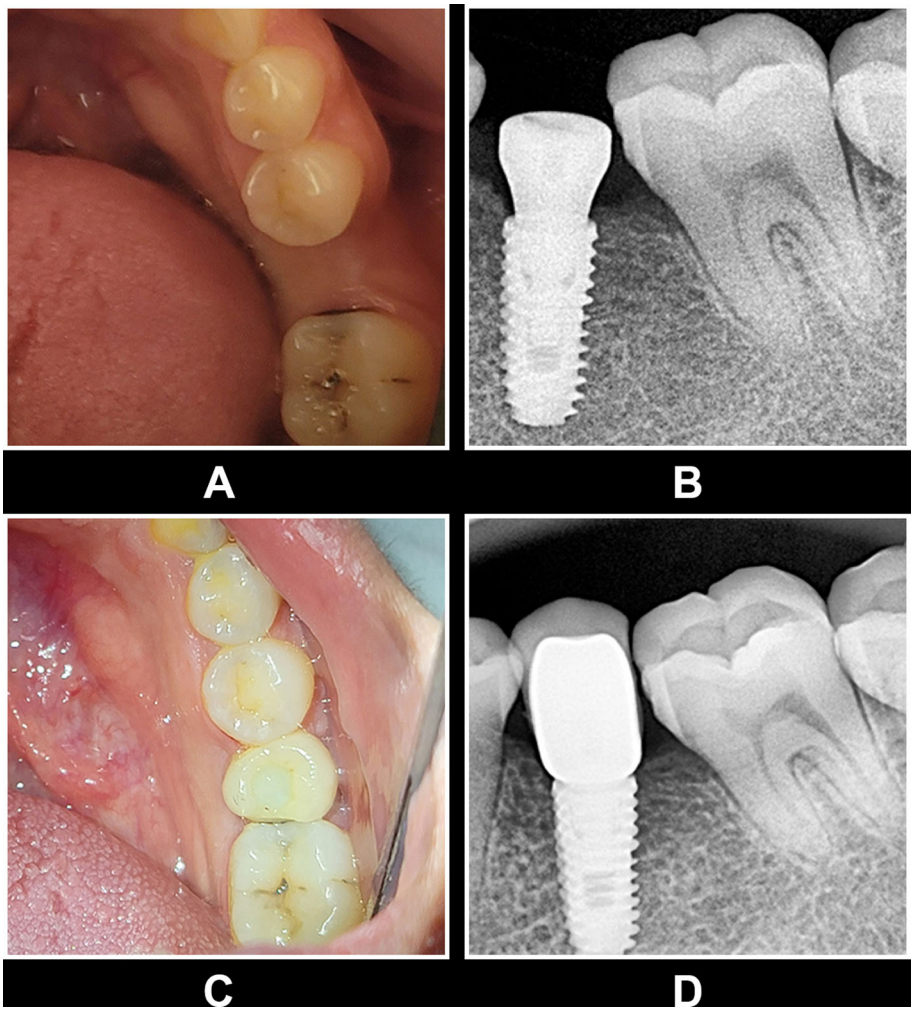


Figure 1. Clinical and radiographic sequence of Case 1 (mandibular first molar region). (A) Pre-operative clinical view. (B) Baseline periapical radiograph immediately after implant placement. (C) Final prosthetic restoration at 4 weeks. (D) Periapical radiograph at 12 months showing stable marginal bone levels.

during the early healing phase. At 4 weeks, all implants demonstrated ISQ values considered sufficient for early functional loading. Insertion torque values ranged from 36 to 37 Ncm, confirming adequate primary stability. Early prosthetic loading was successfully performed at 4 weeks using porcelain-fused-to-metal (PFM) restorations. Clinical evaluation revealed satisfactory functional outcomes, with no signs of implant mobility, peri-implant inflammation, or prosthetic complications. Radiographic assessment demonstrated stable marginal bone levels at the 12-month follow-up in all cases, with no detectable peri-implant bone loss. For each case, comprehensive documentation was obtained, including pre-operative clinical images, baseline radiographs obtained immediately after implant placement, clinical images of the final prosthetic restoration, and 12-month follow-up radiographs (Figures 1–3), illustrating both clinical and radiographic stability. A summary of the clinical characteristics and implant stability outcomes is presented in Table 1.

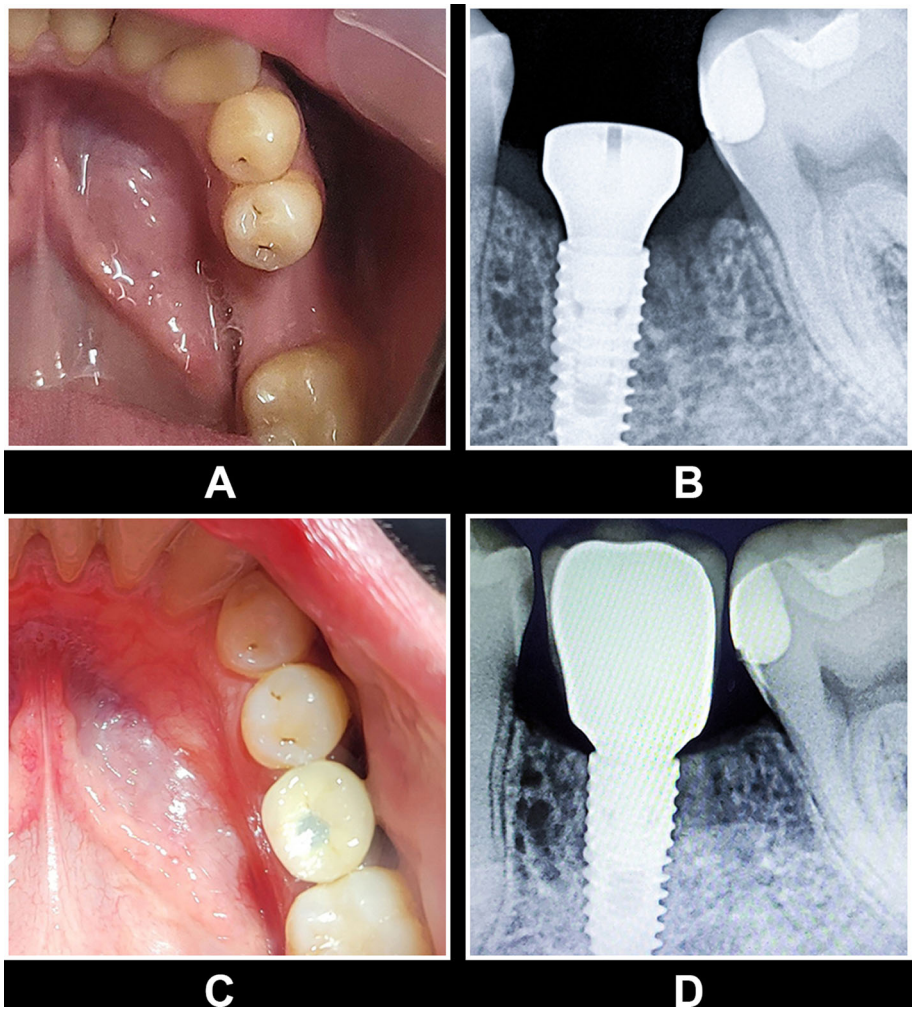


Figure 2. Clinical and radiographic sequence of Case 2 (mandibular first molar region). (A) Pre-operative clinical view. (B) Baseline periapical radiograph following implant placement. (C) Final prosthetic restoration at 4 weeks. (D) Periapical radiograph at 12 months demonstrating maintained peri-implant bone stability.

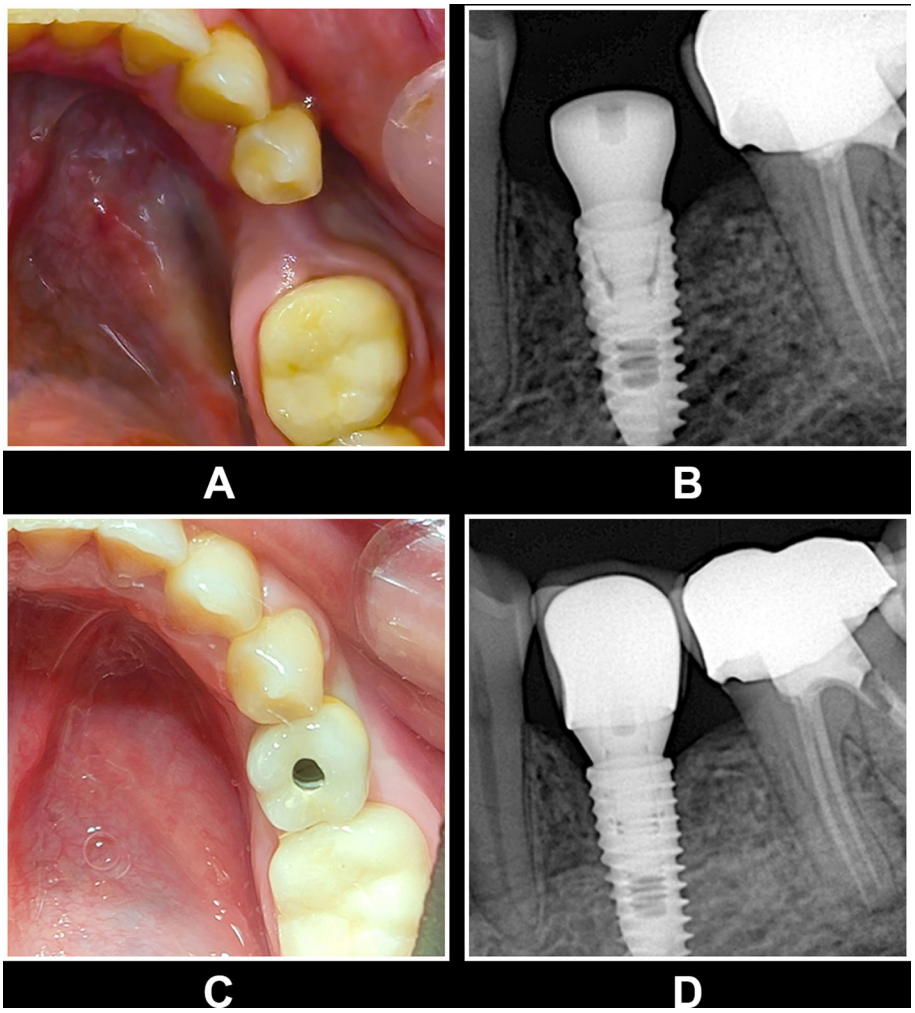


Figure 3. Clinical and radiographic sequence of Case 3 (mandibular second premolar region). (A) Pre-operative clinical view. (B) Baseline periapical radiograph immediately after implant placement. (C) Final prosthetic restoration at 4 weeks. (D) Periapical radiograph at 12 months demonstrating stable peri-implant bone levels.

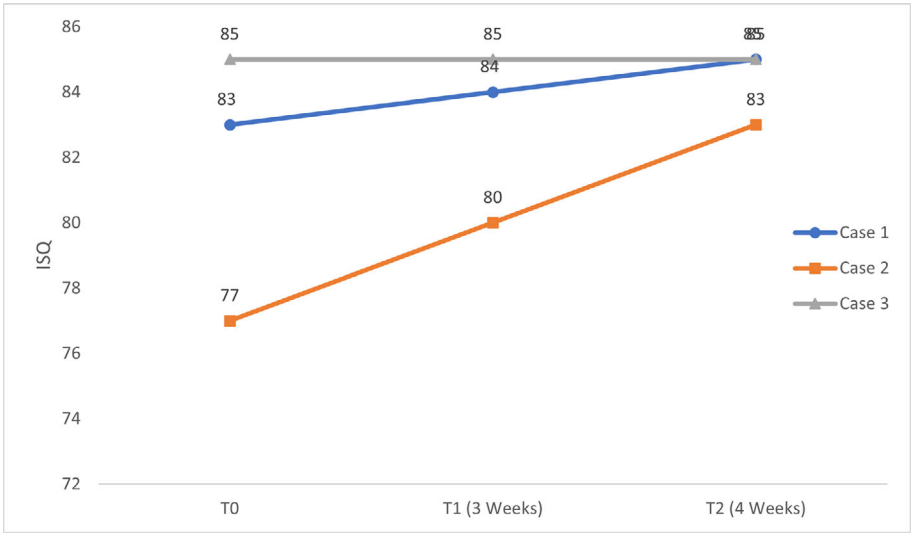


Figure 4. Changes in implant stability quotient (ISQ) values over time for the three cases. Measurements were recorded at baseline (T0), at 3 weeks (T1), and at 4 weeks (T2), demonstrating a progressive increase in ISQ values without evidence of a stability dip.

Table 1. Clinical characteristics and implant stability outcomes.

Case	Age	Gender	Tooth position	Bone type	Insertion torque (Ncm)	ISQ (To)	ISQ (T1–3 Weeks)	ISQ (T2–4 Weeks)	Loading time	Prosthesis	Out-come
1	20	Female	36	D2	37	83	84	85	4 Weeks	PFM	Stable bone at 12 months
2	23	Male	36	D2	36	77	80	83	4 Weeks	PFM	Stable bone at 12 months
3	22	Female	35	D2	37	85	85	85	4 Weeks	PFM	Stable bone at 12 months

Discussion

The present case series evaluated the clinical feasibility of early loading at 4 weeks in UV-functionalized dental implants placed in posterior mandibular single-tooth sites. The findings demonstrated a consistent increase in implant stability, as reflected by ISQ values, along with favorable clinical and radiographic outcomes over a one-year follow-up period.

Implant stability is a critical determinant for the success of early loading protocols. In the present study, all implants exhibited high primary stability at placement, followed by a progressive increase in ISQ values over time. This trend is consistent with previous evidence describing the transition from primary mechanical stability to secondary biological stability during early healing.[3,6] The absence of a pronounced stability dip in all cases further supports favorable osseointegration dynamics, which are essential for the predictability of early loading protocols.[6]

The consistently high or progressively increasing ISQ values observed across all cases may indicate a stable and predictable healing pattern under the present clinical conditions. Notably, Case 1 exhibited very high and nearly constant ISQ values across all time points (83 at T0, 84 at T1, and 85 at T2), while Case 3 maintained a steady value of 85 throughout the observation period. This minimal variation without any detectable decrease in stability likely reflects optimal initial mechanical interlocking achieved in dense D2 bone, where primary stability is already near the upper physiological limit of the RFA scale, leaving limited room for substantial numerical increases as secondary biological stability develops. Such observations support the concept that, when adequate primary stability is achieved, early loading can be performed without compromising implant stability.

The observed improvement in implant stability is likely multifactorial. In addition to implant design, surgical technique, primary stability, and the natural physiological process of osseointegration,[13] ultraviolet (UV) photofunctionalization may have contributed to the observed outcomes. Titanium implant surfaces are known to undergo biological aging due to hydrocarbon contamination, resulting in reduced surface energy and impaired cellular response.[7,8] It is important to note that the enhancement in stability associated with UV treatment is not attributed to alterations in implant surface roughness or micro-topography, as UV irradiation does not physically abrade or modify surface roughness parameters.[14] Instead, UV treatment reverses biological aging at the physicochemical level by removing hydrocarbon contaminants, restoring surface hydrophilicity, and increasing surface energy, thereby promoting protein adsorption and osteoblast attachment.[8,9] These biological mechanisms may explain the favorable ISQ progression observed during the early healing phase in the present study.

The present findings are in agreement with previous experimental and clinical studies reporting enhanced bone-to-implant contact and improved early osseointegration in UV-treated implants.[9,10] Furthermore, clinical evidence suggests that photofunctionalization may improve implant performance even in challenging clinical conditions, including sites subjected to higher functional demands.[10]

The posterior mandible represents a demanding clinical environment due to increased occlusal forces and functional loading. Despite these challenges, all implants in the present study achieved ISQ values considered sufficient for early loading at 4 weeks, with no biological or mechanical complications observed. These findings are consistent with previous evidence indicating that early loading can be successfully achieved when sufficient primary stability and appropriate case selection are ensured.[2,4]

Radiographic outcomes further supported the clinical findings, as all cases demonstrated stable marginal bone levels at the one-year follow-up. This observation aligns with previous studies indicating that early loading does not adversely affect peri-implant bone stability when biomechanical and biological conditions are adequately controlled.[4,11,12]

One of the strengths of this study is the use of serial ISQ measurements at multiple time points, providing insight into the dynamic changes in implant stability during the early healing phase. The continuous increase in ISQ values between 3 and 4 weeks suggests ongoing biological maturation, supporting the clinical decision to proceed with early loading at 4 weeks.

However, the findings of these case reports should be interpreted with caution as preliminary clinical observations rather than conclusive evidence that UV-functionalized dental implants definitively improved implant stability. The very small sample size (three implants) limits the generalizability of the results to broader patient populations and varied clinical conditions, and the absence of a control group prevents direct comparison with non-UV-treated implants. In addition, the observed stability and clinical success cannot be attributed solely to UV photofunctionalization, as they may also result from conventional osseointegration processes,[13] high primary stability, and favorable patient characteristics such as young age, good bone quality (D2), and the absence of systemic risk factors. Furthermore, the 12-month follow-up period provides only short-to-medium-term data; a longer follow-up duration would provide more comprehensive data regarding long-term marginal bone stability, prosthetic survival, and late biological or mechanical complications. Therefore, further well-designed randomized controlled clinical trials with larger sample sizes and extended follow-up periods are required to validate these findings and to establish standardized protocols for the use of UV photofunctionalization in early loading protocols.

Conclusions

Early loading at 4 weeks may represent a clinically feasible approach for UV-functionalized dental implants placed in posterior mandibular sites when adequate primary stability is achieved. The observed ISQ progression and stable 12-month radiographic outcomes suggest a favorable early stability pattern. However, these findings represent preliminary clinical observations from three case reports and, due to the limited sample size, relatively short follow-up, and absence of a control group, should be interpreted with caution rather than as definitive proof of UV photofunctionalization efficacy. Further well-designed randomized controlled clinical studies with larger cohorts and long-term follow-up are required to confirm these results and to clarify the specific effect of UV photofunctionalization on early implant stability.

Ethics approval and consent

This study was approved by the Ethical Committee of Damascus University with the number (DN-200825-494). All patients participating in this study signed written informed consent forms to participate in the study.

Consent

Written informed consent for publication of their clinical details and/or clinical images was obtained from the patient.

Data availability

All data underlying the results are available as part of the article and no additional source data are required.

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Publisher Full Text

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Current Peer Review Status: ✔ ✔

Version 2

Reviewer Report 19 November 2026

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✔ **Dinesh Rokaya**
College of Dentistry, Ajman University, Ajman, United Arab Emirates

The authors have addressed the comments and improved the article. It can be accepted.

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Prosthodontics, Dental materials

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Version 1

Reviewer Report 11 November 2026

https://doi.org/10.5256/f1000research.201333.r531664

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? **Dinesh Rokaya**
College of Dentistry, Ajman University, Ajman, United Arab Emirates

This article is interesting and uses UV-functionalized dental implants placed in posterior mandibular single-tooth sites in 3 cases. Some comments:

Please add "Case reports" in the title.

These case reports can not give conclusive results that UV-functionalized dental implants definitely improved stability. It can also be from osseointegration. DOI: refer (1)
Long-term follow-up is needed with more samples.
Please add all these to the limitations.

More discussion is needed;
Is the increase in stability related to implant roughness from the UV? Please explain and discuss more. DOI:Refer (2)

In patient 1, the stability is almost the same at T0, T1, and T3; please explain more.

If the researcher had followed up for a longer time, they can add more data and discussed more.

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1. Pandey C, Rokaya D, Bhattarai B: Contemporary Concepts in Osseointegration of Dental Implants: A Review. *BioMed Research International*. 2022; **2022** (1). Publisher Full Text
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Is the background of the cases' history and progression described in sufficient detail?
Partly

Are enough details provided of any physical examination and diagnostic tests, treatment given and outcomes?
Partly

Is sufficient discussion included of the importance of the findings and their relevance to future understanding of disease processes, diagnosis or treatment?
Partly

Is the conclusion balanced and justified on the basis of the findings?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Prosthodontics, Dental materials

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 12 Nov 2026

Awab Midani

Dear Reviewer,

We would like to thank you sincerely for your constructive review, valuable insights, and helpful suggestions, which have significantly strengthened the clarity and scientific rigor of our manuscript. We have carefully addressed all of your comments point by point in Version 2 as detailed below:

1. Addition of "Case reports" to the title:
We agree with your suggestion and have updated the manuscript title to explicitly include "Case Reports" to accurately reflect the study design.

2. Conclusive results, role of natural osseointegration, sample size, and follow-up duration in the Limitations:
Thank you for highlighting these critical points. We have expanded the Limitations paragraph in the Discussion section (as well as the Conclusions) to clearly state that these case reports provide preliminary observations rather than conclusive evidence that UV photofunctionalization alone improved implant stability. We also acknowledged that the favorable outcomes may result from conventional osseointegration processes (citing Pandey et al., 2022; Reference 13) and favorable patient/bone characteristics, and we emphasized the need for larger sample sizes and longer follow-up periods.

3. Discussion on whether stability increase is related to implant surface roughness from UV:
We have added a dedicated explanation in the Discussion section clarifying that the enhanced early stability observed with UV photofunctionalization is not caused by physical changes in implant surface roughness or micro-topography (citing Pujarern et al., 2026; Reference 14), as UV irradiation does not physically abrade or alter surface roughness parameters. Instead, it acts at the physicochemical level by removing hydrocarbon contaminants, restoring hydrophilicity, and increasing surface energy to promote early cellular attachment.

4. Explanation of the nearly constant ISQ values in Patient 1 (T0, T1, and T2):
We have expanded the Discussion section to explain the stability pattern in Patient 1 (83 at T0, 84 at T1, and 85 at T2), as well as Patient 3 (85 across all time points). This minimal variation is likely due to the high initial mechanical interlocking achieved in dense D2 bone, which places primary stability near the upper physiological limit of the ISQ scale, leaving limited room for substantial numerical increases as secondary biological stability develops.

5. Importance of longer follow-up and further discussion:
We fully agree that a longer follow-up period would provide richer longitudinal data on marginal bone stability and long-term prosthetic survival. We have incorporated this point into the Discussion and Conclusions sections to underscore the value of extended observation periods in future studies.

We hope that these revisions satisfactorily address all of your reservations, and we look forward to your favorable reconsideration.

Best regards,

The Authors

Competing Interests: No competing interests were disclosed

Reviewer Report 02 November 2026

https://doi.org/10.5256/f1000research.201333.r531662

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MHD BAHAA ALDIN Alhaffar
Karolinska institute, Stockholm, Sweden

The manuscript addresses an interesting and clinically relevant topic in implant dentistry, exploring the potential role of UV photofunctionalization in enhancing early implant stability and facilitating early loading. The study provides useful clinical observations through serial ISQ measurements, supported by clinical documentation and 12-month radiographic follow-up. The presentation is generally clear, and the discussion provides a reasonable overview of the biological rationale behind UV photofunctionalization.
One important limitation is the very small sample size, comprising only three implants. Consequently, the findings should be interpreted cautiously, and their generalisability to broader patient populations and different clinical conditions is limited.
The absence of a control group also makes it difficult to distinguish the potential contribution of UV photofunctionalization from other factors influencing implant stability, particularly primary stability and favourable patient characteristics.

I would suggest that the authors further emphasise these limitations and clarify that the findings represent preliminary clinical observations rather than evidence of the effectiveness of UV photofunctionalization. Nevertheless, the study offers an interesting clinical perspective and may provide a useful basis for further research, particularly larger controlled clinical studies.

Overall recommendation: Accept for indexing. The manuscript presents relevant preliminary clinical findings, and its limitations are appropriately acknowledged. With the findings interpreted within the context of the small case series, I believe the article makes a useful contribution to the literature.

Is the background of the cases' history and progression described in sufficient detail?
Yes

Are enough details provided of any physical examination and diagnostic tests, treatment given and outcomes?
Yes

Is sufficient discussion included of the importance of the findings and their relevance to future understanding of disease processes, diagnosis or treatment?
Yes

Is the conclusion balanced and justified on the basis of the findings?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: specialized in periodontology, legalized dentist in sweden, consultant.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Author Response 12 Nov 2026

Awab Midani

Dear Reviewer,

We sincerely thank you for your positive evaluation of our manuscript, your encouraging feedback, and your recommendation to accept the article for indexing.

We fully agree with your insightful comments regarding the limitations of our study. As you rightly pointed out, the very small sample size (three implants) and the absence of a control group make it difficult to isolate the specific contribution of UV photofunctionalization from other favorable clinical variables, such as high primary stability and optimal patient characteristics.

In accordance with your helpful suggestion, we have revised both the Discussion and Conclusions sections in Version 2 to further emphasize these limitations and explicitly clarify that our findings represent preliminary clinical observations rather than definitive evidence of the clinical effectiveness of UV photofunctionalization.

Thank you once again for your time and constructive review, which has helped improve the clarity and balance of our manuscript.

Best regards,
The Authors

Competing Interests: No competing interests were disclosed.

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