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Systematic Review

Long-term clinical outcomes of immediate loading versus nonimmediate loading in single-implant restorations: An umbrella review

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ABSTRACT

Background: Immediate loading (IL) offers patients the advantage of reduced treatment time by immediate prosthesis placement or 48 h after implantation. Non-IL (NIL), on the other hand, involves a recovery period to allow osseointegration. Both methods are widely used, but their long-term effectiveness remains controversial. This study provides an umbrella review of long-term clinical outcomes of immediate and NIL protocols in single-implant restorations. This review combines and analyzes the findings of several systematic reviews and meta-analyses to evaluate implant survival rate, bone stability, peri-implant soft-tissue health, and complications associated with each approach.

Materials and Methods: Systematic reviews and meta-analyses published in the past two decades were evaluated, and studies comparing immediate and NIL protocols with follow-up periods of at least 6 months were included in this comprehensive review. Using key terms such as "immediate loading" OR "nonimmediate loading" OR "delay loading" AND "single-implant restoration" * " OR "tooth implant*" OR "Dental Implant*," valid national and international databases such as PubMed, Scopus, and Cochrane Library were searched to achieve the objectives of the study. After screening the retrieved studies, information about the implant survival rate, marginal bone loss, peri-implant soft tissue health, and prosthetic complications were extracted.

Results: Immediate and NIL protocols showed a high long-term implant survival rate, varying between 92% and 98%. IL showed a slightly higher rate of marginal bone loss than NIL, especially in the 1st year after implant placement. However, peri-implant soft tissue health and overall patient satisfaction were similar in both protocols. Moreover, IL can be equally successful in cases where high initial implant stability is achieved. Yet, NIL remains the preferred choice in patients with compromised bone quality or high-risk conditions.

Conclusion: Our research demonstrates that both immediate and NIL protocols offer high long-term implant survival rates (92% to 98%). While IL shows a slightly higher rate of marginal bone loss, particularly in the 1st year, it remains a viable option in cases with high initial implant stability. Peri-implant soft-tissue health and patient satisfaction were similar for both protocols. NIL continues to be the preferred approach for patients with compromised bone quality or high-risk

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conditions. These findings emphasize the importance of individualizing treatment plans based on implant stability and patient-specific factors to optimize outcomes in single-implant restorations.

Key Words: Dental implants, immediate loading, nonimmediate loading, single-implant restorations

INTRODUCTION

Dental implants have revolutionized restorative dentistry and are the most effective method to replace missing teeth and provide a long-term solution to restoring dental function and aesthetics. Dental implants have changed the treatment plan for people suffering from tooth loss. However, like other medical procedures, they are not immune to complications.[1] Dental implants have been widely accepted as a treatment for many edentulous patients, with a survival rate of 89.4% after 10 years and a success rate of 90%.[2,3] Among the different procedures for dental implant placement, two main techniques have emerged: immediate loading (IL) and non-IL (NIL). While both are effective, they differ significantly in application, timing, and patient outcomes.[4] The loading time in single-implant restorations has become a major focus of dental implantology, and long-term clinical outcomes are at the center of this debate.

IL, where the implant is restored shortly after placement, offers distinct advantages, including shorter treatment time and immediate esthetic improvements, which increase patient satisfaction.[5] One of the main prerequisites for implant success is acceptable initial stability both during implant placement and after implant loading. The need for adequate bone volume and density, longer or wider implants, and the suggested 3–6-month delay before implant loading support this fundamental principle.[6] The debate between immediate and NIL protocols for single-implant restorations is a research and clinical focal point. Understanding the nuances of each technique is critical for dental professionals to optimize patient care and implant success. However, there are still concerns about achieving initial stability and ensuring proper osseous integrity under IL conditions.[7]

This approach aims to reduce the time the patient has to remain edentulous, and it has gained popularity due to its convenience and potential to increase patient satisfaction.[8] This technique invests in the initial stability of the implant and is usually used in cases where the bone has desirable quality and quantity, and the implant has sufficient initial stability.[9] The successful outcome of IL largely depends on achieving adequate initial stability during implant placement, often being determined by the bone quality and quantity and implant insertion torque.[10] For this reason, IL is used more in patients with good bone density, such as the anterior mandible, where the bone has better quality.[11]

However, the long-term success of immediately loaded implants is often questioned due to the potential risks associated with premature loading, which may compromise the osseointegration process and increase the likelihood of implant failure.[12] To reduce this risk, clinicians should carefully assess the biomechanical environment and use techniques such as multiple implant splinting or implants with surface modifications that enhance osseous integrity. Studies have shown that when appropriate patient selection criteria are met, IL can achieve a success rate comparable to the delayed loading protocol.[13]

In contrast, nonimmediate or delayed loading involves a recovery period ranging from 3 to 6 months before the prosthetic restoration placement. This conventional method assumes that a stress-free treatment environment allows for optimal osseointegration and thus improves the stability and long-term success of the implant.[14] This period allows for osseointegration, a process in which the implant integrates with the jawbone, providing a stable and secure base for the prosthesis. Despite the predictability and success of NIL, it increases the duration of treatment and requires multiple visits, which can be unpleasant for patients.[15] This approach is considered the gold standard, especially when patients present with poor bone density, insufficient bone volume, or systemic conditions that may interfere with the treatment.

Delayed loading provides a more predictable environment for implant success, as the long treatment phase allows the bone-implant interface to fully mature before any functional stress is applied.[16] Research has shown that this method significantly reduces the risk of premature implant failure,

especially in cases where the initial stability of the implant may not be ideal at the time of implantation.[17] In addition, delayed loading is often preferred in cases where bone grafting or reconstructive procedures are performed, as these procedures require a longer treatment period to achieve sufficient bone volume and density for successful implant integration. Research shows that the delayed protocol allows the surrounding bone to adapt and regenerate around the implant and causes stronger and more stable long-term results.[18] Although the longer treatment time may be considered a disadvantage, the delayed loading protocol has consistently demonstrated high survival rates and long-term success among different groups of patients.[19]

The choice between immediate and NIL is influenced by several factors, including the patient's oral health, bone density, and implant site.[9] IL may be preferred in cases where esthetics is the main concern, and the patient needs a quicker solution.[20] However, implant failure is a concern, especially if the implant has not achieved sufficient initial stability during implantation. Since immediate and NIL methods have advantages and challenges, dental professionals should consider them carefully to ensure optimal results.[21] With the progress of research, the decision-making process for choosing the appropriate implant loading protocol is increasingly guided by evidence-based practices and individual patient care.[22]

It is necessary to research immediate and delayed loading of dental implants to advance clinical practices and improve patient outcomes in implant dentistry. Furthermore, it is essential to assess the immediate and delayed loading of dental implants to modify treatment protocols and address the limitations of each approach. While both techniques have shown high success rates, their long-term effects vary depending on individual patient characteristics, such as bone quality, systemic health, and the presence of risk factors such as smoking or bruxism. Further investigations could help determine which loading protocol is most appropriate for different clinical scenarios and ensure optimized implant survival and success rates in a larger patient population.[23] In addition, IL is becoming increasingly popular as patients seek faster and more convenient treatment options. However, comprehensive research should confirm its long-term effectiveness compared to delayed loading, especially in complex cases involving compromised bone conditions or multiple missing teeth.[24]

Despite the success of both loading protocols, there is considerable variability in how they are applied to different patient populations and clinical scenarios. Understanding the biomechanical and biological factors that influence the success of each approach is essential to optimize treatment protocols and minimize the risk of implant failure. Research can help clarify specific conditions under which IL is appropriate, particularly in patients with compromised bone quality or those undergoing complex procedures such as bone grafting.[18] IL requires high initial stability; however, the exact threshold and conditions for this stability are still debated. Studies that examine factors such as implant design, surface modifications, and surgical techniques provide essential data to improve the predictability of IL outcomes.[25] Similarly, examining how different qualities of bones, such as maxilla or mandible, respond to immediate or delayed loading will inform clinicians on how to customize treatment plans for individual patients.[26] In addition, with the development of implantology, there is a need for evidence-based guidelines that inform clinicians when to choose immediate versus delayed loading based on patient-specific factors and implant characteristics.[27]

In addition, the demand for faster and more beautiful results increases as more patients seek implant treatment to replace missing teeth. IL offers the potential to reduce treatment time, increase patient satisfaction, and improve functional outcomes, but its widespread acceptance must be supported by rigorous, long-term research. Comparative studies investigating the success rates, complications, and long-term stability of implants under both protocols can provide valuable data to help clinicians normalize the benefits of immediate restoration with the risk of failure in different clinical contexts.[28] Research is also needed to examine the economic implications of both protocols because IL, if successful, may reduce the number of visits and overall treatment costs, benefiting patients and healthcare systems.[29] In summary, further research on loading protocols will improve clinical decision-making and the predictability of results and ultimately enhance patient care in implant dentistry.

LITERATURE REVIEW

In a systematic review of clinical trials, Cochran *et al*. concluded that delayed loading is particularly effective in complex cases or suboptimal bone

conditions, highlighting its reliability in extending the implant life.[21] Chaushu *et al*. compared immediate and delayed loading in a clinical study on single-tooth implants. Their findings showed that IL did not negatively affect implant survival or success rate compared to delayed loading, supporting IL under appropriate clinical conditions.[30]

In a systematic review and meta-analysis, Pigozzo *et al*. evaluated and compared the clinical outcomes of immediate and early loading protocols for single-tooth implants. IL refers to placing the dental restoration on the implant within 48 h of surgery, whereas early loading occurs after a short recovery period but before the typical 3 to 6-month restoration time. This analysis included numerous studies and showed that immediate and early loading protocols indicated high implant survival rates and satisfactory functional results. There was no significant difference in implant success, marginal bone loss, or soft tissue health between the two techniques, indicating that immediate and early loading protocols can be effectively and safely employed in appropriate cases and provide flexibility in treatment plans.[31]

Gjelvold *et al*. conducted a randomized clinical trial comparing the clinical outcomes of immediate and delayed loading of single-tooth implants over 5 years. This study showed that immediate and delayed loading procedures have high survival rates (100% and 95.8%, respectively) with no significant difference in marginal bone loss or aesthetic outcomes, suggesting that IL can be as effective as delayed loading in the long term.[32]

Zhao *et al*. performed a systematic review and meta-analysis on the long-term results of immediate versus NIL in single-implant restorations. This review included 10 randomized controlled trials. The results revealed that IL showed predictable and reliable results, with no significant difference in implant failure rates or marginal bone loss compared to NIL. This study emphasized that careful case selection is critical to the success of IL protocols.[33]

This umbrella review aimed to fill the knowledge gap by systematically evaluating and comparing the long-term clinical outcomes of immediate versus NIL in single-implant restorations. By examining critical parameters such as implant survival rate, marginal bone loss, prosthetic complications, and patient-reported outcomes, this review provides valuable insights to clinicians and researchers, guides clinical decision-making, and highlights areas for future research. This comprehensive approach ensures that the nuances of each loading protocol are fully understood, ultimately helping to improve patient outcomes and advance the field of dental implantology.

MATERIALS AND METHODS

Study design

This umbrella review systematically covers the evidence from existing systematic reviews and meta-analyses that have compared, analyzed, and combined the clinical outcomes of immediate and nonimmediate (delayed or early) single-implant restorations. The aim is to provide a comprehensive overview of the current evidence and assess the quality and consistency of findings across studies.

Inclusion criteria

The inclusion criteria for this review focused on selecting studies and patient populations that provided relevant data on the immediate and delayed loading of implant restorations. These criteria included studies in English and Farsi language, *in vitro* studies, direct comparison of immediate and NIL in single-tooth implants, and high-quality systematic reviews.

Exclusion criteria

The following exclusion criteria were applied to ensure the relevance and quality of the studies included in this review: (1) Studies focusing on multiple implants or full arch restorations. (2) Collections of case studies, expert opinions, and studies with insufficient follow-up data. (3) Observational studies, case reports, case series, and descriptive reviews.

Search strategy

A comprehensive and systematic search of electronic data was performed to identify relevant studies on immediate and delayed loading of implant veneers. The search was conducted in several national and international databases, including PubMed, Scopus, Web of Science, Embase, Science Direct, ProQuest, Cochrane Library, Magiran, and MOH Articles, as well as Gray literature, including Open Grey, World Cat, ProQuest (dissertations and theses), and MOH Thesis.

This search included all relevant sources till the end of August 2024 and covered all available systematic review and meta-analysis articles published in reputable journals. A comprehensive and detailed

search strategy, including a combination of standard keywords (MeSH) in addition to common specialized concepts, was used to ensure the comprehensive retrieval of studies as follows:

((“immediate loading” OR “non-immediate loading” OR “delayed loading”) AND (“single-implant restoration*” OR “tooth implant*” OR “Dental Implant*”)) IN TITLE.

((“immediate loading” OR “nonimmediate loading” OR “delayed loading”) AND (“single-implant restoration*” OR “tooth implant*” OR “Dental Implant*”)) IN KEYWORDS.

((“immediate loading” OR “non-immediate loading” OR “delayed loading”) AND (“single-implant restoration*” OR “tooth implant*” OR “Dental Implant*”)) IN ABSTRACT.

Data extraction

Three independent researchers reviewed the titles and abstracts for relevance and then reviewed the full text of eligible articles. Data extraction form, which is shown in Table 1 based on the team previus research.,[34-37] included checking the characteristics (author’s name, publication year, number of included studies, and type of implant loading compared), population characteristics (sample size and demographic information), and outcome measures (implant survival rate, marginal bone loss, soft-tissue outcomes, patient satisfaction, and complications).

Evaluating the validity of articles and sources (scoring method)

The quality assessment of each included study was done independently by three researchers using a measurement tool to assess systematic reviews checklist. The parameters included randomization of samples, use of articles published 10–20 years ago to ensure that the data reflect current implant technologies and loading protocols, articles with at least 6 months of follow-up to obtain long-term results of implant loading protocols, different geographical regions to ensure the applicability of the findings to the wider population, and meta-analysis reviews that report effect sizes, heterogeneity, and sensitivity assessment for the outcomes of interest to ensure a robust conclusion. Articles for which it was possible to find information were given the “Y” response and vice versa. Studies reporting one to three cases were classified as high risk of bias, four or five cases as moderate risk of bias, and six or seven cases as low risk of bias. Any disagreements were resolved through discussion with the fourth reviewer.

Table 1: Data extraction

Number	Author’s name	Publication year	Search period	Database	Follow-up	Sample size	Groups (number of samples)		Measurement method (unit)	Results				Relevance of article to research questions
							Group 1	Group 2		Marginal bone loss	Survival rate	Prosthetics failure	Other	
1														
2														
3														
4														

Data analysis

Data obtained from the analyses were combined qualitatively. Results and key findings were summarized in tables.

RESULTS

The results of this umbrella review were reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. Based on the Figure 1, this review provides a comprehensive summary of the evidence and identifies areas of agreement, disagreement, and gaps in the literature to guide clinical decision-making in implant dentistry.

This umbrella review combined findings from various systematic reviews and meta-analyses comparing immediate and nonimmediate single-implant loading outcomes. As Figure 2 show, a total of 24 systematic reviews with a cumulative sample size of 8063 patients and 18,373 implants were included in the study.

Survival rate

The data analysis showed comparable implant survival rates between immediate and NIL protocols. Survival rates for IL ranged from (92%) to (97.8%) over the follow-up period, whereas NIL protocols showed survival rates between (95%) and (99%). The difference in survival rate for similar time intervals was not statistically significant ($P > 0.05$), indicating that both loading protocols are suitable options for a single implant. Of the articles included, 18 evaluated the survival rate as the second goal.[2] No significant difference was found in the meta-analysis of eight trials ($P = 1.92$, 95% confidence interval [CI]: 0.70–5.22).[3] There was a statistically significant difference between different loading strategies, with a higher risk of implant failure in the IL implants, even when the temporary crown was placed in nonocclusal contact (relative risk [RR]: 4.76, 95% CI: 1.74–13.02, $P = 0.002$).[4] There was also no significant difference between immediate and delayed loading in molar sites (CI: 0.05–1.61; $P = 0.16$, 95% CI: 0.982–0.995).[5] There was no evidence of failure rate differences between immediate and conventional loading implants (RR: 1.50; 95% CI: 0.60–3.77).[6] The 1-year, 2-year, and 5-year analyses of studies showed no significant difference between immediate and NIL regarding implant survival rate (1-year = i = 96.8% c = 97.9% OR = 0.75; 95% CI: 0.32–1.76); 2-year = i = 97.8% c = 97.1% OR = 0.75; 95% CI: 0.33–4.80; and 5-year = 96.7%).[7] Did not significantly affect the implant failure rate (RR: 0.87; 95% CI: 0.44–1.75, $P = 0.70$).[8] The implant failure rate of IL was not statistically significantly different from that of early loading (OR: 0.19; 95% CI: 0.01–4.11).[9] In IL, there was a statistically significantly higher risk of implant failure (RR: 1.92; 95% CI: 1.04–3.54; $P = 0.036$),[10] indicating no direct effect of loading protocol on implant survival.

There was no statistically significant difference between immediate and conventional loading protocols in implant survival rate (OR: 1.71, 95% CI: 0.40–7.36; $P = 0.47$).[15] There was no significant difference in survival rate between early and IL protocols in single implant restorations (risk difference: −0.00; 95% CI: −0.04–0.04; $P = 0.990$).[17] A statistically significantly lower survival rate was observed in immediately loaded dental implants (RR: 0.974; 95% CI: 0.954–0.994; $P = 0.012$).[18] There was also no significant difference between immediate and conventional loading protocols in implant survival (RR: 0.99; 95% CI: 0.95–1.02).[20] Further, significant difference was found between different loading protocols (Immediate Placement, Immediate Loading (IPIL) = 99.6%, 95% CI: 98.5–100); Immediate Placement, Delayed Loading (IPDL) = 97.9%, 95% CI: 95.6–100; Early Placement, Early Loading (EPEL) = 100%, 95% CI: 94.5–100; Early Placement Delayed Loading (EPDL) = 95.8%, 95% CI: 85.0–100; Delayed Placement, Immediate Loading (DPIL) = 99.1%, 95% CI: 96.0–100); Delayed Placement, Early Loading (DPEL) = 92.4%, 95% CI: 85.4–99.9; Delayed Placement, Delayed Loading (DPDL) = 100%, 95% CI: 97.6–100).[21] Moreover, there was no significant difference between immediate and delayed dental implants (−0.03, 95% CI: −0.05, $P <-0.001$).[22] The implant survival rate was similar in early and delayed loading protocols (1.03 [0.99–1.07], 1.01 [0.94–1.08]).[23] There was no significant difference in any of the outcomes of interest between immediate and NIL protocols (RR: 1.29, 95% CI: 0.35–4.78, $P = 0.71$) (RR: 1.19, 95% CI: 0.40–3.51, $P = 0.75$).[24] The survival rate was not significantly different between the two loading groups (RR = 1.00; 95% CI: 0.97–1.03; $P = 1.00$).

Marginal bone loss

Marginal bone loss was a critical parameter evaluated in the studies. The pooled data showed slightly greater bone loss in the IL group, with a mean of (0.2–1) mm, compared to (0.1–0.8) mm in the NIL

group. However, this difference was not statistically significant ($P > 0.05$), indicating that both loading protocols effectively maintain the peri-implant bone surfaces.

Prosthetic complications

Prosthetic complications, such as crown loosening and fracture, occurred similarly in both groups without statistically significant differences ($P > 0.05$).

DISCUSSION

The findings of this review confirm that both IL and NIL protocols offer successful long-term outcomes for single-implant restorations, with comparable survival rates and soft-tissue responses. This is consistent with previous studies, such as Buser *et al*. (2017), which found no significant difference in implant survival between the two protocols after long-term follow-up.[16] In both IL and NIL, proper osseointegration and soft-tissue health were maintained, emphasizing that both approaches can lead to stable and predictable outcomes when managed correctly. These findings align with the conclusions of various meta-analyses, including those by Pjetursson *et al*. (2008), who demonstrated similar success rates for both loading protocols over extended periods, regardless of the approach used.[38]

One of the key advantages of IL highlighted in our study is its ability to deliver faster results and higher patient satisfaction. This finding is consistent with the work of Carosi *et al.* (2023), who reported that IL significantly shortened treatment times without compromising implant survival or aesthetics.[39] However, as we noted, IL requires strict clinical conditions to ensure success, such as adequate bone density and initial implant stability. In contrast,

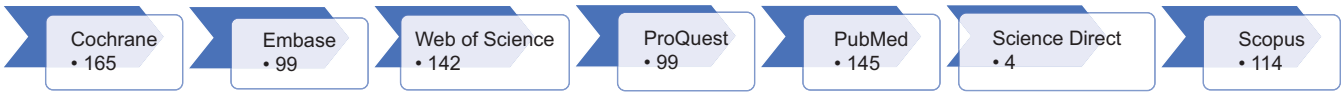

Figure 1: Number of studies retrieved from the initial search.

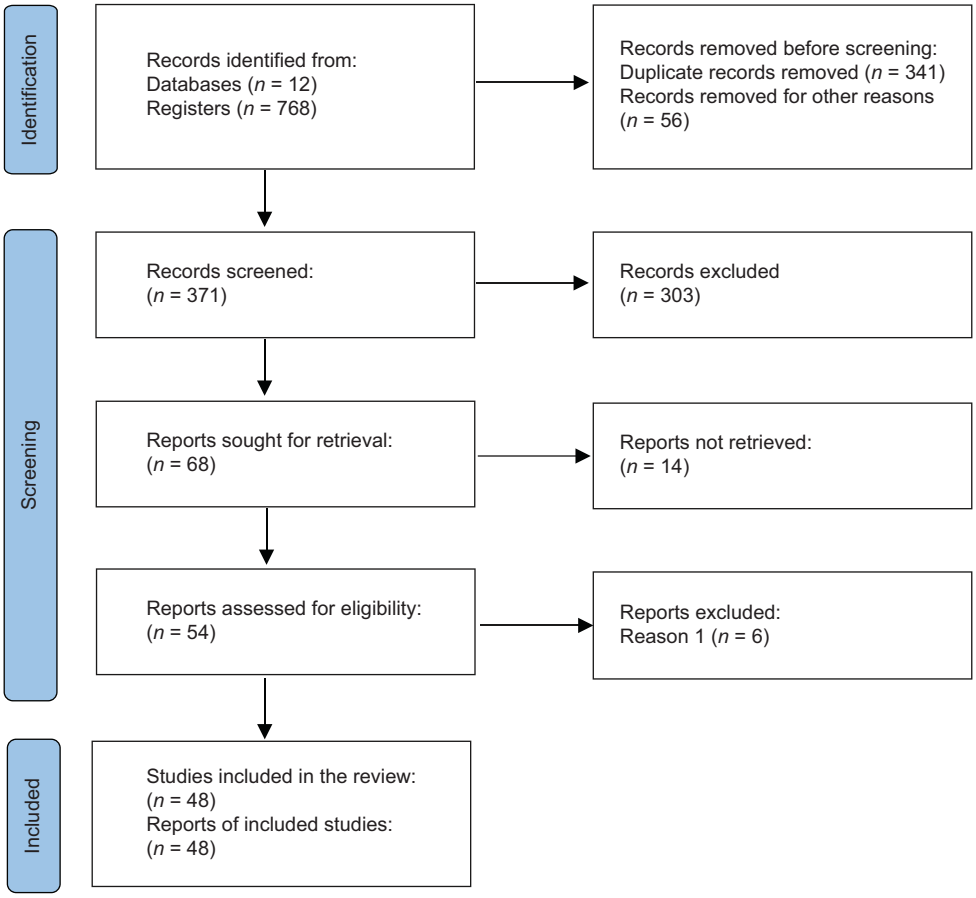

Figure 2: Flowchart of searching the studies based on preferred reporting items for systematic reviews and meta-analyses.

studies like those by Chen *et al*. (2020) and Pjetursson *et al*. (2008) have emphasized that NIL is a more predictable option, especially for patients with compromised bone quality or when a more conservative approach is desire.[40,38] NIL allows for more time for osseointegration before functional loading, which can reduce the risk of early complications, such as implant mobility or failure, in less-than-ideal clinical scenarios.

Ultimately, the choice between immediate and NIL should be individualized based on the patient's specific clinical circumstances, as emphasized in several studies. For instance, Lemos *et al*. (2016) suggested that the decision should be based on factors such as bone quality, the level of initial implant stability, and the patient's overall health.[41] Our findings support this notion, as we observed that NIL is particularly suitable for cases where low-risk procedures or poorer bone quality are concerns. While IL can provide faster outcomes and improved patient satisfaction, NIL remains a reliable and safe choice for ensuring long-term implant success, especially in patients with more challenging clinical conditions. The ability to tailor the loading protocol to the patient's needs is critical for achieving optimal outcomes.

CONCLUSION

The present study reports the improvements made in immediate or delayed loading of dental implants with more accuracy. New findings indicate the role of bone density, implant surface changes, and patient-specific characteristics in the success rates of both protocols. In addition, new implant materials and designs have facilitated faster osseointegration and early stability, thereby increasing the possibility of IL. This research provides clinicians with updated evidence-based guidelines to select an appropriate loading protocol. Therefore, this study would inform physicians of correct clinical decision-making regarding loading protocols. Such findings enable clinicians to confidently recommend IL at patients' requests for faster restoration but with careful case selection to ensure long-term success. Conversely, delayed loading remains a reliable option for complex cases, balancing rapid recovery with clinical predictability and safety.

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Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial, or nonfinancial in this article.

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