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COMPARISON BETWEEN IMMEDIATE AND DELAYED LOADING IN THE ALL-ON-4 PROTOCOL FOR ATROPHIC MAXILLAE

COMPARAÇÃO ENTRE CARGA IMEDIATA E CARGA TARDIA NO PROTOCOLO ALL-ON-4 EM MAXILAS ATRÓFICAS

COMPARACIÓN ENTRE CARGA INMEDIATA Y RETARDADA EN EL PROTOCOLO ALL-ON-4 EN MAXILARES ATRÓFICOS

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ABSTRACT

Oral rehabilitation of patients with atrophic maxillae represents a clinical challenge in implant dentistry due to the limited bone availability for the placement of conventional implants. Although the All-on-4 protocol is widely used as a predictable and minimally invasive alternative, controversies remain in the literature regarding the ideal timing for prosthetic loading. This study aimed to analyze and compare scientific evidence published over the past ten years on the effectiveness of immediate and delayed loading protocols applied to the All-on-4 concept in atrophic maxillae. This is a narrative literature review conducted between September and November 2025 in the PubMed, SciELO, SpringerLink, MDPI, and Research, Society and Development Journal databases, using descriptors defined by MeSH and DeCS in both Portuguese and English. Original articles, systematic reviews, and clinical reports published between 2015 and 2025 comparing both loading protocols were included. Data were analyzed descriptively and comparatively, focusing on implant survival rates, marginal bone loss, and patient satisfaction. The results showed high implant survival rates (93.8%–99.3%) and mean marginal bone loss ranging from 0.8 to 1.5 mm, with high patient satisfaction in both protocols. It was concluded that both immediate and delayed loading are safe and effective approaches, and the choice of protocol should be individualized according to the patient's clinical conditions. The findings contribute to improving treatment planning and evidence-based clinical practice in implant dentistry.

Keywords: All-on-4. Immediate Loading. Delayed Loading. Atrophic Maxilla. Implant Dentistry.

RESUMO

A reabilitação oral de pacientes portadores de maxilas atróficas representa um desafio clínico na implantodontia, devido à limitada disponibilidade óssea para instalação de implantes convencionais. Embora o protocolo All-on-4 seja amplamente utilizado como alternativa previsível e minimamente invasiva, ainda existem controvérsias na literatura quanto ao momento ideal de carregamento protético. Este estudo teve como objetivo analisar e comparar evidências científicas publicadas nos últimos dez anos acerca da eficácia dos protocolos de carga imediata e carga tardia aplicados ao conceito All-on-4 em maxilas atróficas. Trata-se de uma revisão narrativa da literatura, realizada entre setembro e novembro de 2025, nas bases de dados PubMed, SciELO, SpringerLink, MDPI e Research, Society and Development Journal, utilizando descritores definidos pelo MeSH e DeCS em português e inglês. Foram incluídos estudos originais, revisões sistemáticas e relatos clínicos publicados entre 2015 e 2025 que compararam os dois protocolos de carga. Os dados foram analisados de forma descritiva e comparativa, com foco em taxas de sucesso, perda óssea marginal e satisfação do paciente. Os resultados demonstraram elevadas taxas de sobrevivência dos implantes (93,8%–99,3%) e perdas ósseas médias de 0,8 a 1,5 mm, com alta satisfação dos pacientes em ambos os protocolos. Conclui-se que tanto a carga imediata quanto a carga tardia são abordagens seguras e eficazes, devendo a escolha ser

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individualizada conforme as condições clínicas do paciente. Os achados contribuem para o aprimoramento do planejamento reabilitador e da prática odontológica baseada em evidências.

Palavras-chave: All-on-4. Carga Imediata. Carga Tardia. Maxila Atrófica. Implantodontia.

RESUMEN
La rehabilitación oral de pacientes con maxilares atróficos representa un desafío clínico en implantología dental debido a la limitada disponibilidad ósea para la colocación convencional de implantes. Si bien el protocolo All-on-4 se utiliza ampliamente como una alternativa predecible y mínimamente invasiva, aún existen controversias en la literatura sobre el momento ideal para la carga protésica. Este estudio tuvo como objetivo analizar y comparar la evidencia científica publicada en los últimos diez años sobre la efectividad de los protocolos de carga inmediata y diferida aplicados al concepto All-on-4 en maxilares atróficos. Se trata de una revisión narrativa de la literatura, realizada entre septiembre y noviembre de 2025, en las bases de datos PubMed, SciELO, SpringerLink, MDPI y Research, Society and Development Journal, utilizando descriptores definidos por MeSH y DeCS en portugués e inglés. Se incluyeron estudios originales, revisiones sistemáticas e informes clínicos publicados entre 2015 y 2025 que compararon los dos protocolos de carga. Los datos se analizaron descriptiva y comparativamente, centrándose en las tasas de éxito, la pérdida ósea marginal y la satisfacción del paciente. Los resultados demostraron altas tasas de supervivencia de los implantes (93,8%–99,3%) y una pérdida ósea promedio de 0,8 a 1,5 mm, con una alta satisfacción del paciente en ambos protocolos. Se concluye que tanto la carga inmediata como la diferida son enfoques seguros y eficaces, y que la elección debe individualizarse según las condiciones clínicas del paciente. Los hallazgos contribuyen a la mejora de la planificación de la rehabilitación y la práctica odontológica basada en la evidencia.

Palabras clave: All-on-4. Carga Inmediata. Carga Diferida. Maxilar Atrófico. Implantología.

1 INTRODUCTION

Oral rehabilitation of patients with atrophic maxillae represents a significant clinical challenge in modern implantology, mainly due to the reduced quantity and quality of bone available for the installation of conventional implants. Maxillary atrophy is a frequent condition among edentulous patients, and can compromise both facial aesthetics and masticatory function, with a direct impact on quality of life (SOTO-PENALOZA et al., 2017). The evolution of surgical and prosthetic techniques over the last decades has allowed the development of minimally invasive approaches, among which the All-on-4 protocol, designed by Paulo Malo in 1998, stands out, which proposes the installation of four strategically positioned implants, two anterior straight and two posterior inclined, enabling total fixed rehabilitation without the need for bone grafts (SOTO-PENALOZA et al., 2017; UESUGI et al., 2023).

The main advantage of the All-on-4 protocol lies in the possibility of immediate loading, that is, the installation of the fixed prosthesis within 72 hours after surgery, which provides a reduction in treatment time and a significant improvement in patient satisfaction (NAJAFI et al., 2016; ATIEH et al., 2017). This treatment modality, however, requires high primary implant stability (≥35 N·cm) and strict control of biomechanical and occlusal factors, and is indicated in cases of good bone density and absence of active infections (EL-DIN GOMAA; OSAMA, 2019; PATEL et al., 2023). On the other hand, late loading, applied after the complete osseointegration period (usually between three and six months), remains a widely adopted protocol, especially in patients with low-density bones, such as in atrophic maxillae (ABDUNABI et al., 2019).

Comparative studies indicate that the success rates of All-on-4 implants subjected to immediate and delayed loading are clinically equivalent, provided that patient selection criteria and prosthetic planning are adequate. Najafi et al. (2016), in a prospective study, observed no statistically significant difference in the implant survival rate between the immediate and late loading groups after one year of follow-up. Similar results were reported by El-Din Gomaa and Osama (2019), who verified comparable marginal bone loss between protocols in a controlled clinical study. Recent systematic reviews reinforce these findings, showing that both approaches are predictable and safe, with survival rates greater than 94% (SRISUTHEP et al., 2019; PATEL et al., 2023).

In the context of severely resorbed maxillae, the All-on-4 protocol has been shown to be an alternative with high clinical predictability, even in situations of advanced bone resorption. Uesugi et al. (2023) reported survival rates between 94.4% and 98.3% in follow-

ups of up to 17 years, even in cases of severe maxillary atrophy. Brazilian studies reinforce these results, showing that immediate rehabilitation with All-on-4 in atrophic maxillae provides high aesthetic and functional satisfaction, associated with minimal marginal bone loss (ROSA et al., 2018; ARAÚJO, 2025; RAINERI, 2024). These data consolidate the protocol as a predictable clinical option compared to conventional techniques involving bone grafting.

Despite the favorable evidence, the literature still presents divergences regarding the clinical superiority between immediate and delayed loading protocols, especially when applied to atrophic maxillae, in which reduced bone density can interfere with primary stability and the osseointegration process (PEITSINIS et al., 2025). This knowledge gap justifies the need for reviews that comparatively analyze the clinical and radiographic results of these modalities, seeking to provide scientific support to guide the choice of the most appropriate protocol for each case.

Thus, the present study aims to compare, based on recent scientific literature, the clinical results of the immediate loading and delayed loading protocols applied to All-on-4 in atrophic maxillae, identifying their advantages, limitations and clinical implications.

2 METHODOLOGY

The present study is a **narrative review of the literature**, whose objective was to gather, analyze and discuss scientific evidence published in the last ten years about the **comparison between immediate and delayed loading in the All-on-4 protocol applied to atrophic maxillae**.

The option for **narrative review** is justified by the exploratory and interpretative nature of the theme, which involves **clinical studies with heterogeneous methodologies** and different experimental designs. According to Rother (2007), this type of review allows for a **broad and critical approach to the literature**, integrating studies with different levels of evidence and promoting an **interpretative synthesis** of the most relevant findings. In addition, the narrative review is appropriate when there are **limitations in the methodological standardization of the available studies**, as occurs in the field of advanced implantology (MENDES; SILVEIRA; GALVÃO, 2008).

The search for studies was carried out between **September and November 2025**, in the **PubMed (U.S. National Library of Medicine), SciELO (Scientific Electronic Library Online), SpringerLink**, **MDPI Journals,** and **Research, Society and Development**

Journal (RSD) databases. These databases were selected for their **international scope and scientific credibility**, including peer-reviewed and open access articles.

Original scientific articles, systematic reviews, narrative reviews, and clinical case reports **that directly or indirectly addressed the** All-on-4 protocol **were included**, with a focus on **the comparison between immediate and delayed loading protocols**.

The **descriptors** used in the search, defined according to the *Medical Subject Headings (MeSH)* and *the DeCS – Health Sciences Descriptors*, were combined in Portuguese and English as follows:

("All-on-4" OR "All on Four") AND ("immediate loading" OR "immediate loading") AND ("delayed loading" OR "late loading") AND ("atrophic maxilla" OR "atrophic maxilla").

The **inclusion criteria** adopted were: a) articles published between **2015 and 2025**; b) available in **full text and for public access**; c) studies carried out on **human beings**; d) publications that addressed the **All-on-4 protocol in maxillae or atrophic mandibles**; e) texts written in **Portuguese, English or Spanish**.

Duplicate studies, non-scientific publications (conference abstracts, editorials, and letters to the editor), and articles with **insufficient methodology, outdated, or unrelated to the proposed objective** were **excluded**.

The **selection of articles** occurred in three stages:

1. **Reading of the titles**, to identify the initial alignment with the theme;
2. **Analysis of abstracts**, to verify the relevance of the objectives and type of study;
3. **Full reading**, to confirm the methodological adequacy and relevant content to the research.

Screening was performed by two reviewers independently, and any disagreements regarding the inclusion or exclusion of studies were resolved by consensus.

The evaluation of the methodological quality of the included articles considered criteria such as: clarity of objectives, coherence between methodology and results, clinical relevance, and adequacy of the study design to the proposed theme (MENDES; SILVEIRA; GALVÃO, 2008).

The initial selection resulted in 37 articles, of which 12 fully met the inclusion criteria, and were incorporated into the present review.

The selected articles were organized in an evidence table, containing the following variables: author, year of publication, type of study, database, sample/population, main

findings, and reference link. The analysis was conducted in a descriptive and interpretative manner, with emphasis on the comparison of outcomes related to implant survival rate, marginal bone loss, patient satisfaction, and clinical predictability between immediate and late loading protocols.

The findings were grouped and discussed according to convergences and divergences between the studies, seeking to identify clinical trends and practical implications for oral rehabilitation of atrophic maxillae.

The fact that the narrative review does not follow systematic search and selection criteria is recognized as a methodological limitation, which can introduce selection bias and limit the reproducibility of the results. However, this approach was chosen because it allows for greater analytical depth and clinical contextualization of the reviewed studies.

As this is a literature review, this study did not involve human beings directly, and therefore it was exempt from submission to the Research Ethics Committee. Even so, the principles of scientific integrity, copyright, and fidelity to the sources consulted were respected.

3 RESULTS AND DISCUSSION

The present narrative review brought together 12 scientific studies published between 2015 and 2025, addressing the comparison between the immediate loading and late loading protocols in the All-on-4 concept applied to atrophic maxillae. The publications analyzed included prospective clinical studies, systematic reviews, meta-analyses, narrative reviews, and case reports, from indexed databases such as PubMed, SciELO, SpringerLink, MDPI, and RSD Journal.

In general, a high implant success rate was observed in both protocols, ranging from 93.8% to 99.3%, which demonstrates the high clinical predictability of the All-on-4 protocol in maxillae with advanced bone resorption (SOTO-PENALOZA et al., 2017; UESUGI et al., 2023; RAINERI, 2024).

3.1 SURVIVAL RATE AND STABILITY OF IMPLANTS

Prospective clinical studies, such as the one by Najafi et al. (2016), compared the results between **immediate loading (prosthesis installation within 72 hours)** and **late loading (installation after four months)** in edentulous patients rehabilitated with the All-on-4 protocol. The authors observed **a statistically significant similarity in implant survival**

rates and marginal bone loss after one year of follow-up, reinforcing that both approaches can be considered predictable when the criteria of primary stability and controlled occlusion are respected.

Similarly, Atieh et al. (2017) and El-Din Gomaa and Osama (2019) corroborate these findings, reporting **mean marginal bone loss of less than 1.0 mm** in the two load groups. These results demonstrate that the **biomechanical stability of the inclined implants and the rigidity of the fixed prosthesis** are determining factors for the success of the rehabilitation, more than the loading time itself.

Recent systematic reviews, such as those conducted by Srisuthep et al. (2019) and Patel et al. (2023), reinforce that **there is no clinically significant difference in implant survival** between immediate and delayed loading protocols, as long as a **minimum insertion torque of 35 N·cm** is achieved and uniform distribution of occlusal loads is maintained. Patel et al. (2023), however, report a slight trend of longer implant survival in late loads, although without statistical relevance.

3.2 MARGINAL BONE LOSS AND BIOLOGICAL ASPECTS

The preservation of the marginal bone crest is one of the most important parameters for the long-term success of rehabilitations with the All-on-4 protocol. In the studies included in this review, it was observed that mean bone loss ranged between 0.8 mm and 1.5 mm after follow-up periods of 12 to 36 months, for both immediate and delayed loading protocols (EL-DIN GOMAA; OSAMA, 2019; UESUGI et al., 2023). This variation is considered clinically acceptable, according to the criteria established by Albrektsson and Zarb (1986), reinforcing the biological predictability of the protocol.

Uesugi et al. (2023), in a longitudinal study with a follow-up of up to 17 years, reported survival rates between 94.4% and 98.3% in severely atrophic maxillae, with stable bone crest maintenance and absence of significant peri-implant inflammation. Similar results were reported by Najafi et al. (2016) and Atieh et al. (2017), who observed physiological bone remodeling compatible between the immediate and delayed loading groups, with no statistically significant difference.

The literature also points out that the angulation of posterior implants and the elimination of the need for bone grafts are factors that favor biomechanical balance and marginal bone stability (SOTO-PENALOZA et al., 2017; ARAÚJO, 2025). According to Araújo (2025), the use of inclined implants allows for a better distribution of masticatory loads, reducing tensions concentrated in the vestibular cortical and preserving the bone crest. Thus,

immediate loading, when correctly indicated, does not represent an additional risk of bone resorption, as long as there is adequate primary stability and occlusal control.

However, the differences observed between the studies regarding the magnitude of bone loss may be related to methodological and clinical factors, such as the initial bone density that varies among the patients, the different insertion torque between the implants, the type of prosthesis used (acrylic or metal-ceramic), and the follow-up time. These variables explain the heterogeneity of the results and reinforce the need for standardization in the criteria for measuring marginal bone loss.

Despite the favorable results, most studies have small samples and follow-ups of less than three years, which limits the generalization of the findings. Future studies with larger samples and longitudinal follow-up of more than five years are recommended to confirm long-term marginal bone stability in the different loading protocols.

3.3 PATIENT SATISFACTION AND PROSTHETIC IMPLICATIONS

The reviewed literature shows consensus regarding the significant improvement in quality of life and high satisfaction of patients undergoing the All-on-4 protocol, especially in cases treated with immediate loading. This rehabilitation modality allows the patient to return early to mastication, phonetic, and aesthetic functions, reducing the psychosocial impact resulting from total edentulia. Rosa et al. (2018) and Raineri (2024) observed that patients treated with immediate loading reported greater masticatory comfort, prosthetic stability, and aesthetic satisfaction, attributing these results to the immediate installation of the fixed prosthesis and the consequent elimination of the period of use of removable prostheses.

Immediate loading is also associated with a more positive perception of treatment time and functionality, directly reflecting on adherence to postoperative follow-up. However, the authors emphasize that the clinical success and durability of prostheses are closely linked to the quality of prosthetic execution and strict occlusal control. Complications such as acrylic resin fractures, screw loosening, and premature wear of components are reported as possible events, especially in patients with parafunctional habits or high masticatory forces (ROSA et al., 2018; RAINERI, 2024).

On the other hand, Abdunabi et al. (2019) highlight that, although immediate loading has clear functional and psychological advantages, late loading should still be considered a safe and predictable alternative in more challenging clinical cases, such as in patients with reduced bone density, primary stability less than 30 N·cm, or systemic factors that may

compromise osseointegration. Peitsinis et al. (2025) corroborate this perspective, reinforcing that, in severely atrophic maxillae, late loading offers an additional margin of biological safety, allowing a more stable period of bone remodeling before the installation of the definitive prosthesis.

In general, evidence suggests that both protocols, when correctly indicated and executed, provide high levels of satisfaction and clinical predictability. The choice between immediate loading and delayed loading should consider individual factors, such as bone density and volume, insertion torque, type of prosthesis, in addition to systemic conditions and patient expectations. The integration between surgical and prosthetic planning is crucial for long-term success, and a protocol that balances biomechanical stability, functional comfort, and facial aesthetics should be prioritized.

Although the reviewed studies report high patient satisfaction, some lack standardized instruments for assessing oral health-related quality of life, such as the OHIP-14 (*Oral Health Impact Profile*), which makes it difficult to quantitatively compare the results. Thus, it is recommended that future studies adopt validated methodologies and include follow-up periods longer than five years, in order to establish more robust evidence on the durability and subjective perception of success of treatments with immediate and late loading in the All-on-4 protocol.

3.4 INTEGRATION OF FINDINGS AND CRITICAL ANALYSIS

The integrated analysis of the 12 studies included in this review shows a **significant consistency in clinical and biological outcomes** between the immediate loading and delayed loading protocols applied to the All-on-4 concept in atrophic maxillae. Most of the studies analyzed reported **survival rates above 94%,** controlled marginal bone loss**,** and **high patient satisfaction**, regardless of the prosthesis loading time (SOTO-PENALOZA et al., 2017; UESUGI et al., 2023; ARAÚJO, 2025). These results reinforce that the success of rehabilitation is strongly associated with the **technical and biomechanical execution of the treatment**, rather than with the load protocol adopted.

In general, the reviewed studies demonstrate that **immediate loading** has relevant clinical advantages, such as **reduced treatment time**, **improved self-esteem and functional comfort,** and **elimination of prolonged use of removable prostheses**, which positively impacts the patient's quality of life (ROSA et al., 2018; RAINERI, 2024). On the other hand, **late loading** continues to be indicated in situations of **reduced bone density**,

low primary stability, or **unfavorable systemic conditions**, offering greater biological safety during the osseointegration process (ABDUNABI et al., 2019; PEITSINIS et al., 2025).

The literature also shows that the discrepant results found among some studies are due to **methodological heterogeneities**, such as differences in the type of prosthesis used (acrylic or metal-ceramic), variations in the implant insertion torque, and different follow-up periods. This lack of standardization limits the direct comparison of results and prevents the consolidation of a definitive clinical consensus on the superiority of one protocol over the other. In addition, some of the studies reviewed have **small sample sizes and a follow-up of less than three years**, which can generate **selection bias and restriction in the generalization of findings**.

Despite these limitations, the critical analysis of the data allows us to conclude that both loading protocols offer **predictable and clinically equivalent results**, provided that the criteria of **individualized planning**, **adequate occlusal control**, **minimum primary stability of 35 N·cm,** and **precise prosthetic execution are respected**. The choice between immediate and delayed loading should therefore be based on the **clinical condition of the patient** and the **surgeon's experience**, taking into account factors such as bone quality, remaining volume, and systemic risk profile.

From a scientific point of view, there is a growing trend in the contemporary literature to **favor immediate loading**, especially when associated with digital planning technologies and implants with bioactive surfaces that accelerate osseointegration. However, there is still a need for **long-term randomized controlled trials** that standardize variables such as marginal bone loss, prosthetic failure rates, and patient satisfaction in order to consolidate the scientific evidence on comparative efficacy between protocols.

Thus, this review contributes to the advancement of knowledge in modern implantology by gathering and critically interpreting evidence that confirms the **feasibility and predictability of the All-on-4 protocol**, demonstrating that both immediate and delayed loading, when well indicated, are safe and effective alternatives for the functional and aesthetic rehabilitation of atrophic maxillae.

4 CONCLUSION

The present narrative review of the literature allowed us to analyze and compare scientific evidence published in the last ten years about the application of the protocols of immediate loading and late loading in the All-on-4 concept, especially in cases of atrophic

maxillae. Based on the twelve studies reviewed, it was observed that both protocols have high rates of clinical success and implant survival, ranging from 93.8% to 99.3%, which demonstrates the predictability and biomechanical stability of the system, provided that strict criteria for surgical-prosthetic planning and execution are followed.

The results analyzed indicate that immediate loading offers significant advantages, such as reduction of the total treatment time, early functional and aesthetic restoration, and greater patient satisfaction, without compromising marginal bone stability or implant longevity, provided that adequate primary stability (≥35 N·cm) is achieved and precise occlusal control is performed. On the other hand, delayed loading remains a safe and conservative alternative in clinical situations of reduced bone density, insufficient stability, or the presence of unfavorable systemic conditions, providing greater predictability during the initial phase of osseointegration.

The study achieved its specific objectives by comparing implant survival rates, marginal bone loss, and patient satisfaction rates between the two protocols, confirming the clinical equivalence and predictability of the All-on-4 concept, even in severely resorbed maxillas. This review stands out for bringing together evidence published in the last decade, consolidating and updating scientific knowledge on the subject, in addition to contributing to evidence-based clinical practice in contemporary implant dentistry.

However, limitations inherent to both the reviewed literature and the methodological nature of this research are recognized, since, as it is a narrative review, systematic search and selection criteria were not applied, which may result in inclusion bias. In addition, some of the studies analyzed have small samples, clinical follow-up of less than three years, and lack of standardization in the evaluation criteria, which restricts the generalization of the results.

In view of these limitations, the development of randomized, controlled, multicenter clinical trials with long-term follow-up is recommended, which allow for a more robust validation of the clinical, biological, and psychosocial outcomes associated with immediate and late loading protocols in the context of All-on-4.

It is concluded, therefore, that both immediate and delayed loading in the All-on-4 protocol represent effective, safe, and scientifically based approaches for the treatment of atrophic maxillae. The choice of the protocol should be based on the individualized clinical evaluation of the patient, considering anatomical, biomechanical, and systemic aspects, as well as ethical and technical principles that ensure predictability, functionality, and quality

aesthetic rehabilitation. Thus, the All-on-4 concept is consolidated as a modern and humanized alternative in the oral rehabilitation of patients with atrophic maxillae, promoting lasting results in line with evidence-based dental practice.

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