Review Article

University J Dent Scie 2026; Vol. 12, Issue 2

Dental Implants: Factors affecting early loading

Abstract:
Traditionally, delayed loading protocols were employed to ensure adequate osseointegration before functional loading of dental implants. However, with advancements in implant design, surface technology, and surgical techniques, there has been a paradigm shift toward immediate and early loading approaches. Early loading, typically performed within a few weeks after implant placement, has gained popularity due to its reduced treatment time, improved patient comfort, and enhanced esthetic outcomes without compromising implant success rates. Despite these advantages, the success of early loading is highly dependent on multiple interrelated factors that influence implant stability and osseointegration. This article comprehensively reviews the various determinants affecting early loading outcomes, categorized into systemic, surgical, implant-related, and prosthetic factors. Systemic conditions such as bone metabolism and overall health status, surgical precision in implant placement, implant design and surface characteristics, and the prosthetic design all play crucial roles in achieving predictable results.

Key-words: Early loading, Immediate loading, Implant stability, Loading of dental implants

Introduction:

Loading of dental implants refers to the process of placing axial or tangential force on a dental implant by connecting it to a prosthesis after implant placement. These forces may be intentional or unintentional. The selection of the type of loading protocol for the individual patient is based on multiple factors, such as primary implant stability, bone density, and implant factors.[1]

According to Morton D. and Ganeles J., Loading protocols has been classified into three types in the ITI treatment guide, volume 2. Conventional loading (three months after the implant placement), Immediate loading (within 48 hours of implant placement) and Early loading (at least 48 hours after implant placement but no later than three months afterward.)[2]

Similarly, according to Misch's, loading protocols has been classified into four types. Conventional loading (within a period of 3 to 6 months), Immediate loading (at the time of implant placement), Early loading (between 2 to 3 weeks post-implant placement)and Delayed loading (attaching the prosthesis 6 to 12 months after implant placement.)[3]

Early loading protocols in implant dentistry has been classified into two types. Early occlusal loading refers to the delivery of occlusal load to an implant between 2 weeks and 3 months after implant placement[7] The majority of clinical studies reported that implants are most commonly loaded within 6 to 10 weeks post-surgery. This time frame appears to provide a favorable balance between maintaining sufficient primary stability and allowing the biological processes of new bone formation and early osseointegration (figure 1) to contribute to secondary stability.[8,9,10,11]

Access this article online

Website:
www.ujds.in

DOI:
https://doi.org/10.21276/ujds.2026.12.2.20

[1]DEEPESH KUMAR GUPTA, [2]AMRUTA KANGE, [3]JENIFER KERKETTA, [4]ANUMEHA JHA, [5]PRAJAKTA HUMANE
[1-5]Department of Oral and Maxillofacial Prosthodontics and Implantology, Government Dental College, Raipur, Chhattisgarh

Address for Correspondence: Dr. Amruta Kange
'Postgraduate student
Department of Oral and Maxillofacial Prosthodontics and Implantology. Government Dental College, Raipur, Chhattisgarh, India
Email: amrutakange14@gmail.com

Received : 20 Dec., 2025, **Published :** 30 June, 2026

How to cite this article: Gupta , D. D. K., Kange, D. A., Kerketta, D. J., Jha, D. A., & Humane, D. P. (2026). Dental Implants: Factors affecting early loading. UNIVERSITY JOURNAL OF DENTAL SCIENCES, 12(2).

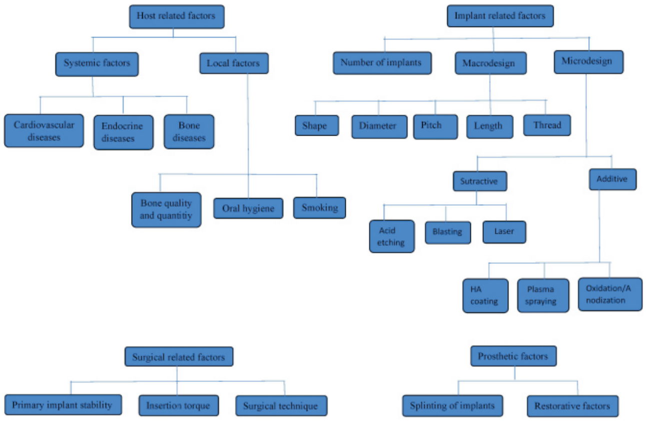
On the other hand, non-functional early restoration, involved delivering an implant prosthesis in a partially edentulous patient within 2 weeks of implant insertion without any direct occlusal load applied to the implant. [7]

Early loading offers several advantages, such as significantly shortened treatment duration while allowing adequate bone healing and remodeling, fewer surgical interventions, reduced loss of hard and soft tissue due to early stimulation, improved psychological comfort due to earlier functional and aesthetic restoration, and eliminates the need for removable provisional prostheses.[5,12,13]

Importantly, clinical data indicated that immediate and early loading result in comparable survival rates and marginal bone loss, with some studies suggested early loading may have a lower risk of failure, especially in the posterior mandible. Overall, early loading demonstrated clinical efficacy comparable to delayed loading, making it a reliable and effective treatment option.[14,15,16]

Early loading of dental implants is challenging due to the interplay of bone quality, systemic health, and clinical factors. Poor bone quality such as type IV bone or sites with recent augmentation offers reduced primary stability, making implants more susceptible to micro movement and subsequent failure during the early healing phase. Systemic factors like diabetes, cardiovascular disease, osteoporosis, and smoking negatively impact bone metabolism and wound healing, further elevating the risk of compromised osseointegration under early loading conditions. Clinically, the use of short implants, placement in the posterior maxilla, a history of periodontal disease, errors such as overheating during drilling or improper implant positioning all increase the likelihood of early failure.

The success of early loading protocols is influenced by multiple factors. Patient-related factors include systemic health, bone quality, and oral hygiene status, all of which impact healing potential. Implant-related factors, such as macrodesign and surface characteristics, play a critical role in achieving predictable outcomes. Additionally, clinician-related or surgical factors like adherence to precise surgical protocols significantly affect primary implant stability. Finally, prosthesis-related considerations, including occlusal load distribution and prosthetic design, determine the long-term success of early loading.[7,17]



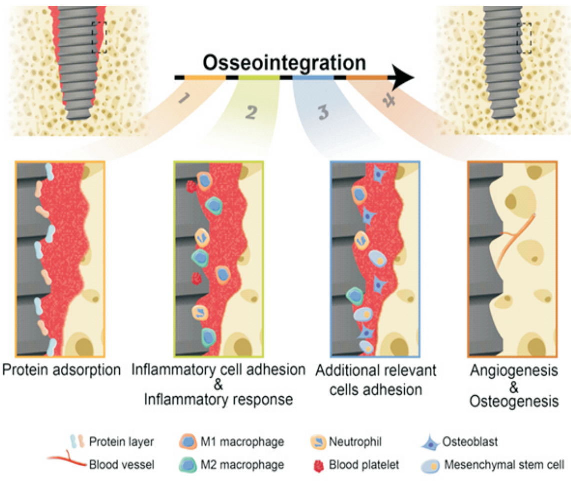


Figure 1. Osseointegration

Host/patient factors :

Cardiovascular diseases (CVDs) can impair blood supply and cause tissue hypoxia, decrease the amount of nutrients in bone, disrupting bone healing and osseointegration which may increase implant failure risk.[18]

Diabetes mellitus significantly affects the osseointegration process through multiple mechanisms driven by chronic hyperglycemia. Elevated blood glucose impairs bone healing, leading to greater bone resorption and weaker peri-implant bone, promotes chronic inflammation through the formation of advanced glycation end-products (AGEs), which trigger inflammatory cytokines that delay wound healing and compromise immune defense, increasing susceptibility to peri-implant infections. Microvascular complications characteristic of diabetes reduce blood flow and oxygen supply to the implant site, further hindering bone regeneration and implant integration. Consequently, diabetes delays osseointegration and increases failure rates, particularly in cases of poor glycemic control.[18]

Thyroid disorders affect bone health by disrupting metabolism and immune response. Hypothyroidism slows turnover, increasing bone mass but with brittle, fracture-prone bone, while hyperthyroidism accelerates turnover, causing bone loss and fragility. Both compromise bone quality and remodeling, which are key determinants of implant osseointegration.[19]

Osteoporosis is characterized by progressive loss of bone mass and microarchitectural deterioration, leading to bone fragility and higher fracture risk. The resulting increase in trabecular space compromises bone density and quality, which may reduce primary stability and heighten the risk of implant failure.[20]

Vitamin D is crucial for bone health by regulating calcium–phosphate balance and mineralization. Its active form, calcitriol, enhances intestinal absorption, maintains calcium levels, and modulates bone cells by promoting osteoclast activity and supporting osteoblast function. Adequate vitamin D is vital for implant osseointegration, while deficiency can impair bone formation and increase implant failure risk.[21,22]

Smoking adversely affects peri-implant bone healing by impairing angiogenesis, leukocyte function, and cytokine balance. It disrupts bone metabolism by reducing bone formation and altering the osteoclast–osteoblast balance, often through increased inflammatory mediators and hormonal changes. Smoking and its byproducts can suppress osteoprotegerin (OPG) expression, lower bone density, and compromise guided bone regeneration, ultimately reducing bone-implant contact (BIC) and increasing the risk of implant failure.[23]

Surgical factors:

Primary implant stability is essential for the success of early loading protocols and depends significantly on bone quantity and quality at the implant site, the surgical technique, and the design of the implant. Achieving high primary stability requires the clinician's experience and careful surgical planning. Soft bone with reduced density poses a challenge in achieving adequate initial stability, leading to a higher risk of early implant failure. To compensate, surgical technique modifications and implant design optimizations are necessary to improve stability in such conditions.[24,25,26]

Insufficient primary stability increases micromovement at the bone-implant interface, which promotes the formation of fibrous tissue rather than osseointegration, raising the risk of implant failure. The acceptable threshold of micromotion lies between 50 and 150 micrometers; micromovements within this range may still permit bone integration, whereas movement beyond this range leads to fibrous tissue formation. Various methods assess primary stability, including insertion torque measurement and non-invasive techniques such as resonance frequency analysis (RFA) and damping capacity analysis (DCA).[7,25]

Generally, an insertion torque value of at least 40 Ncm and an implant stability quotient (ISQ) over 60 considered favorable indicators of sufficient primary stability to support immediate or early loading. Recent evidence also supports that early loading has been reliably performed on well-positioned implants inserted with a torque value of at least 40 Ncm, particularly in molar extraction sites, emphasizing the necessity to delay loading for at least four months if adequate insertion torque is not achieved. Overall, careful evaluation and optimization of primary stability at placement are critical to prevent micromovements, promote successful osseointegration, and reduce early implant failure rates.[25,26]

Implant factors:

Implant macrodesign:

The implant's shape, length, and diameter are key factors determining the surface area available for transfer of compressive forces to the surrounding bone, a critical consideration especially in poor-quality bone where density is low and bone-to-implant contact is reduced. In such cases, increasing the implant surface area is essential to effectively distribute occlusal forces and enhance stability.[27]

Cylindrical implants (figure 2), due to their lower primary stability and poorer resistance to vertical and shear forces, are generally not suitable for immediate or early loading. Conversely, tapered or screw-shaped implants provide a more favorable mechanical environment, hence enhancing osseointegration and improving both primary and secondary stability, which supports predictable early and immediate loading.[28]

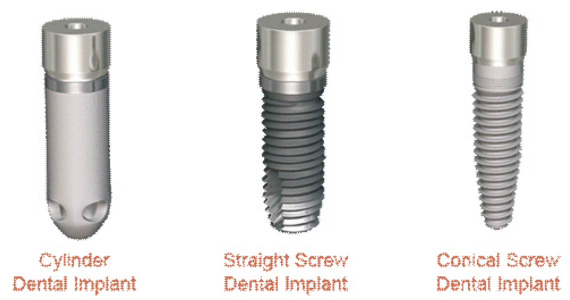


Figure 2. Implant shape

Increasing implant length significantly boosts primary stability by enlarging the contact area with the bone, with a minimal length of 10 mm generally preferred. Similarly, implant diameter strongly influences stability in low-density bone, where longer and wider implants provide better support particularly in D4 bone.[29,30]

Besides size, thread design is vital; variable-thread tapered implants offer safety and efficacy for immediate implant placement under load, with square thread shapes (figure 3) preferred for immediate loading.[3,31,32]

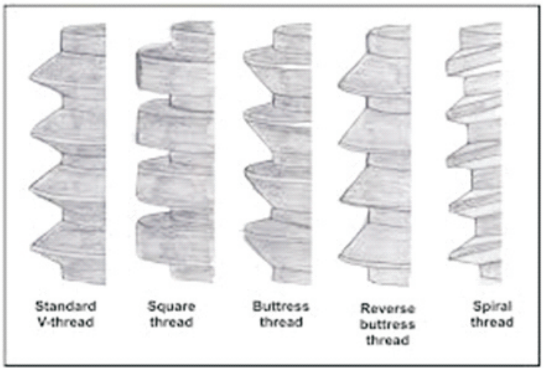


Figure 3. Implant thread types

A smaller thread pitch (below 1.7 mm) enhances bone-implant contact and primary stability, promoting new bone growth and a mature bone structure at the interface. Thread depth is also crucial, as deeper threads improve stability and force distribution in low-density bone, resulting in higher insertion torque and resonance frequency scores.[3,3]

The implant–abutment connection substantially affects micromovements under load, with conical (Morse taper) connections (figure 4) providing superior mechanical friction, sealing, and fit compared to non-conical designs. This wedge-like engagement generates high mechanical stability, permitting immediate loading even in less-than-ideal bone conditions. A final torque of about 15–20 Ncm is recommended to optimize this connection, thereby enhancing frictional stability and long-term implant success.[34,35]

Figure 4. Morse Taper implant abutment connection

Implant microdesign:

Osseointegration begins with local cell interaction with the implant surface, and implant surface roughness is key, rougher surfaces enhance osteoblast adhesion, differentiation, and bone deposition. Since the late 1980s, various surface modificationscreating microtopographies (pits, grooves, protrusions) have increased implant surface area and bone-to-implant contact (BIC), especially in areas with poor bone quality. Surface modifications have been broadly categorized into two types: subtractive processes, in which material is removed from the implant surface, such as etching with acid, blasting with an abrasive material, treatment with lasers, and additive processes, in which material is deposited onto the implant surface, such as hydroxyapatite coating and titanium plasma spraying, oxidation or anodization. These advancements have improved the predictability and success of dental implant procedures.[3]

Implant surface characteristics significantly influence clinical outcomes, particularly in immediate or early loading protocols. Rough and moderately rough surfaces enhance bone–implant contact and promote faster bone apposition compared to smooth surfaces. These surfaces improved primary stability and osseointegration, making them the gold standard in implant dentistry over the past two decades.[36,37]

Early-loaded dental implants having a moderately rough, hydrophilic endosseal surface demonstrate high reliability for rehabilitating partially edentulous patients in the posterior mandible over 9 years of function.[33] The SLActive-surfaced implants achieve high long-term success following either immediate or early loading in the posterior maxilla and mandible.[38]

Prosthetic factors:

Splinting of immediately loaded dental implants enhanced osseointegration, especially in spongy bone.[39] This technique involves connecting multiple implants, which significantly reduces mechanical stress and micromotion that can lead to implant failure. By distributing forces across several implants, splinting improves stability and supports the success of early-loaded implant-supported prostheses, making it a valuable strategy for enhancing implant outcomes.[40]

From a restorative standpoint, it is essential to control the biomechanical effects of provisional restorations to protect implant stability. This includes limiting and evenly distributing occlusal contacts during centric occlusion or maximum intercuspation, eliminating any excursive contacts, minimizing cantilever and off-axis loading, and splinting implants whenever possible.[41]

Overall, splinting combined with careful restorative planning optimizes the biomechanical environment for early-loaded implants. It ensures better force distribution, reduces micromotion, protect against mechanical overload and enhances implant survival, particularly in cases involving poor-quality bone or early loading protocols. This collaborative surgical and prosthetic approach is fundamental for predictable and successful dental implant rehabilitation in complex clinical situations.

Conclusion:

Early loading of dental implants improves patient convenience and comfort, yet it does not consistently match the clinical outcomes achieved with conventional loading methods. Careful patient and case selection remain essential, particularly since implants presenting lower insertion torque or lower implant stability quotient (ISQ) values exhibit a heightened risk of failure under immediate or early loading protocols. The attainment of optimal insertion torque, which is critical for success, is substantially influenced by the clinician's experience and surgical technique. Key factors such as precise osteotomy preparation, appropriate implant selection, and adept management of bone quality variations rely heavily on operator skill, directly impacting both the initial stability of the implant and its long-term success.[13,42,43]

Despite these considerations, early loading of dental implants offers numerous advantages, including shorter treatment time, avoidance of multiple surgical stages, better preservation of peri-implant soft and hard tissues, and improved patient satisfaction. It may also enhance bone healing while eliminating the need for removable temporary dentures. Importantly early loading achieves survival rates comparable to both immediate and conventional loading protocols, making it a reliable and efficient treatment option when applied under appropriate clinical circumstances,

References :

1. Layton DM, Morgano SM, Att W, Freilich MA, Ferro KJ, Kelly JA, et al. The Glossary of Prosthodontic Terms 2023: Tenth Edition. J Prosthet Dent. 2023 Oct;130(4 Suppl 1):e1-e126
2. Morton D, Ganeles J. ITI treatment guide. Volume 2, Loading protocols in implant dentistry: partially dentate patients. Berlin: Quintessence Publishing; 2007.
3. Resnik RR. Misch's contemporary implant dentistry. 4th ed. St. Louis: Elsevier; 2020.
4. Kanojia K, Tembhurne J, Gangurde A, Chauhan M, Jaiswal N. Review of Literature: Loading Protocol in Implant Dentistry. Int J Dent Med Sci Res. 2024;6(5):52–56. doi:10.35629/5252-06055256
5. Beldar A, Bhongade ML, Byakod G, Buregoni C. Early Loading of Single-Piece Implant for Partially Edentulous Posterior Arch: A Prospective One-Year Case Report. Case Rep Dent. 2013;2013:854062.
6. Piattelli A, Corigliano M, Scarano A, Quaranta M. Bone reactions to early occlusal loading of two-stage titanium plasma-sprayed implants: a pilot study in monkeys. Int J Periodontics Restorative Dent. 1997;17(2):163–9.
7. Ávila G, Galindo P, Ríos H, Wang HL. Immediate implant loading: current status from available literature. Implant Dent. 2007 Sep;16(3):235–45.
8. Maiorana C, King P, Quaas S, Sondell K, Worsaae N, Galindo-Moreno P. Clinical and radiographic evaluation of early loaded narrow-diameter implants: 3 years follow-up. Clin Oral Implants Res. 2015; 26(1): 77–82.
9. Beldar A, Bhongade ML, Byakod G, Buregoni C. Early loading of single-piece implant for partially edentulous posterior arch: a prospective one-year case report. Case Rep Dent. 2013 Apr 8; 2013:854062.
10. Brånemark PI, Hansson BO, Adell R, Breine U, Lindström J, Hallén O, et al. Osseointegrated implants in the treatment of the edentulous jaw: experience from a 10-year period. Scand J Plast Reconstr Surg. 1977;16:1–132.
11. Cochran DL, Buser D, ten Bruggenkate CM, Weingart D, Taylor TM, Bernard JP, et al. The use of reduced healing times on ITI® implants with a sandblasted and acid-etched (SLA) surface: early results from clinical trials on ITI® SLA implants. Clin Oral Implants Res. 2002 Apr;13(2):144–53
12. Kim YK, Lee JY, Kim JH, Yi YJ, Yun PY. Early Loading of Mandibular Molar Single Implants: 1 Year Results of a Prospective Randomized Controlled Clinical Study. J Clin Med. 2020 Sep 4;9(9):2882.
13. Zhu Y, Zheng X, Zeng G, Xu Y, Qu X, Zhu M, Lu E. Clinical efficacy of early loading versus conventional loading of dental implants. Sci Rep. 2015 Nov 6;5:15995.
14. Pigozzo MN, Rebelo da Costa T, Sesma N, Laganá DC. Immediate versus early loading of single dental implants: A systematic review and meta-analysis. J Prosthet Dent. 2018 Jul;120(1):25–34.

15. Zembić A, Glauser R, Khraisat A, Hämmerle CHF. Immediate vs. early loading of dental implants: 3-year results of a randomized controlled clinical trial. Clin Oral Implants Res. 2010 May;21(5):481–489.
16. Zhang W, Huang S, Ye Q, Wei D, Zhou X. Clinical efficacy of early and delayed loading implants: a systematic review and meta-analysis. J Prosthet Dent. 2024;132(2):343–353.
17. apski R, Wang HL, Mascarenhas P, Lang NP. Critical review of immediate implant loading. Clin Oral Implants Res. 2003 Oct;14(5):515–27.
18. Samara W, Moztarzadeh O, Hauer L, Babuska V. Dental implant placement in medically compromised patients: a literature review. Cureus. 2024 Feb;16(2):e54199.
19. Elsubeihi ES, Zarb GA. Implant prosthodontics in medically challenged patients: The University of Toronto experience. J Can Dent Assoc. 2002 Feb;68(2):103–8.
20. D'Ambrosio F, Amato A, Chiacchio A, Sisalli L, Giordano F: Do systemic diseases and medications influence dental implant osseointegration and dental implant health An umbrella review. Dent J (Basel). 2023, 11:146
21. Holick MF. Vitamin D deficiency. N Engl J Med. 2007 Jul 19;357(3):266-81.
22. harma R, Rawat S, Kumar A, Sharma M, Tyagi C, Bhagat N. Role of vitamin D supplementation in dental implant osseointegration. Int J Health Sci. 2022;6(S3):12348–55.
23. Bezerra Ferreira JD, Rodrigues JA, Piattelli A, Iezzi G, Gehrke SA, Shibli JA. The effect of cigarette smoking on early osseointegration of dental implants: a prospective controlled study. Clin Oral Implants Res. 2016 Sep;27(9):1123–1128.
24. Javed F, Ahmed HB, Crespi R, Romanos GE. Role of primary stability for successful osseointegration of dental implants: Factors of influence and evaluation. Interventional Medicine & Applied Science. 2013 Dec;5(4):162–167.
25. Botros KH, Adel-Khattab D, Eldabe AK, Abuel Ela HA. Early versus conventional loading for fully guided immediate implant placement in molar sites: a randomized controlled clinical study. Int J Implant Dent. 2025;11:39.
26. Beldar A, Bhongade ML, Byakod G, Buregon C. Early loading of single-piece implant for partially edentulous posterior arch: a prospective one-year case report. Case Rep Dent. 2013;2013:854062.
27. Tada S, Stegaroiu R, Kitamura E, Miyakawa O, Kusakari H. Influence of implant design and bone quality on stress/strain distribution in bone around implants: a 3-dimensional finite element analysis. Int J Oral Maxillofac Implants. 2003;18:357–368.
28. Pearson RG, Clement RGE, Edwards KL, Scammell BE. Do smokers have greater risk of delayed and non-union after fracture, osteotomy and arthrodesis A systematic review with meta-analysis. BMJ Open. 2016 Nov 14;6(11):e010303.
29. Bataineh AB, Al-dakes AM. The influence of length of implant on primary stability: An in vitro study using resonance frequency analysis. J Clin Exp Dent. 2017;9(1):e1–e6.
30. Baihaqi MI, Sumarsongko T, Bonifacius S. The effect of implant length and diameter on primary stability of tilted implant on D4 bone density: An in vitro study. J Int Oral Health. 2022;14(5):487–493.
31. Arnhart C, Kielbassa AM, Martinez-de Fuentes R, et al. Comparison of variable-thread tapered implant designs to a standard tapered implant design after immediate loading. A 3-year multicentre randomised controlled trial. Eur J Oral Implantol. 2012;5:123–136.
32. Chang PK, Chen YC, Huang CC, Lu WH, Chen YC, Tsai HH. Distribution of micromotion in implants and alveolar bone with different thread profiles in immediate loading: a finite element study. Int J Oral Maxillofac Implants. 2012 Nov-Dec;27(6):e96–101.
33. Cucinelli C, Pereira MS, Borges T, Figueiredo R, Leitão-Almeida B. The effect of increasing thread depth on the initial stability of dental implants: an in vitro study. Surgeries. 2024;5(3):817–825.
34. Romanos GE. The implant-abutment connection and its impact on prevention of peri-implant diseases and crestal bone stability—an academic and clinical evaluation of the literature. Front Oral Maxillofac Med. 2023;5:7.
35. Romanos GE. Bone quality and the immediate loading of implants—critical aspects based on literature, research, and clinical experience. Implant Dent. 2009 Jun; 18(3): 203–9.
36. Arghami A, Simmons D, St Germain J, Maney P. Immediate and early loading of hydrothermally treated, hydroxyapatite-coated dental implants: a 7-year prospective randomized clinical study. Int J Implant Dent. 2021 Mar 10; 7(1): 21.
37. Molinero Mourelle P, Schimmel M, Forrer FA, Hicklin SP, Raabe C, Chappuis V, et al. Clinical and radiographic performance of late placed and early loaded dental implants with a conditioned

hydrophilic surface in posterior mandible sites: a prospective case series with an 8.5-to 9.5-year follow-up.Clin Implant Dent Relat Res. 2024 Aug; 26(4):704-713.

38. Nicolau P, Guerra F, Reis R, Krafft T, Benz K, Jackowski J. 10-year outcomes with immediate and early loaded implants with a chemically modified SLA surface. Quintessence International. 2018;50(2):114-124.
39. Matsuzaka K, Nakajima Y, Soejima Y, Kido H, Matsuura M, Inoue T. Effect on the amount of bone-implant contact when splinting immediate-loaded dental implants. Implant Dent. 2007;16(3):309-316.
40. Szmukler–Moncler S, Salama H, Reingewirtz Y, Dubruille JH. Timing of loading and effect of micromotion on bone–dental implant interface: review of experimental literature. J Biomed Mater Res. 1998;43(2):192–203
41. Morton D, Jaffin R, Weber H-P. Immediate restoration and loading of dental implants: clinical considerations and protocols. Int J Oral Maxillofac Implants. 2004;19(Suppl):103–108.
42. Dhawan p, Batra P, Kakar A, Mishra P. Clinical efficacy of dental implants placement without flap elevation: a systematic review and meta-analysis comparing immediate and early loading protocols. J. Dent. Implant Res.2025;44(3):31-39.
43. Albrektsson T, Chrcanovic B, Östman P-O, Sennerby L. Initial and long-term crestal bone responses to modern dental implants. Periodontol 2000. 2017;73(1):41-50.