Journal of Esthetic and Restorative Dentistry

WILEY

CLINICAL ARTICLE

The Influence of Abutment Selection in the Tridimensional Implant Position: Considerations for Predictable Implant Restorative Long-Term Outcomes

A. Lanis[1,2] | S. Akhondi[3] | I. Pedrinaci[3,4] | L. Tavelli[5] | A. Puisys[6]

[1]Private Practice, Santiago, Chile | [2]Section of Oral & Maxillofacial Implantology, University of Chile School of Dentistry, Santiago, Chile | [3]Department of Restorative Dentistry and Biomaterials Sciences, Harvard School of Dental Medicine, Harvard University, Boston, Massachusetts, USA | [4]Section of Graduate Periodontology, School of Dentistry, University Complutense, Madrid, Spain | [5]Department of Oral Medicine, Infection, and Immunity, Harvard School of Dental Medicine, Harvard University, Boston, Massachusetts, USA | [6]Private Practice, Vilnius, Lithuania

Correspondence: A. Lanis (dr.lanis@primeclinic.cl)

Received: 2 November 2024 | **Revised:** 19 November 2024 | **Accepted:** 20 November 2024

Funding: The authors received no specific funding for this work.

Keywords: 3D imaging | computer-assisted surgery | dental implantation | dental prosthesis design | implant abutments | prosthodontics/methods | tissue preservation

ABSTRACT

Objective: To explore the influence of abutment selection on 3D implant positioning, emphasizing the synergy between surgical and prosthetic considerations for achieving predictable long-term outcomes in implant-supported restorations.

Main Considerations: Implant dentistry has transitioned from a purely surgical approach to a prosthetically driven methodology that prioritizes implant-supported restoration (ISR). This shift has been bolstered by advancements in digital technologies and abutment designs, which allow for more precise implant positioning and better management of biological, mechanical, and esthetic outcomes. The selection of appropriate abutments plays a pivotal role in optimizing the 3D implant position, influencing peri-implant tissue stability and the overall success of the restoration. This manuscript explores into the biorestorative concept, highlighting how virtual planning can preemptively assess abutment configurations and their interactions with surrounding tissues, guiding implant placement to achieve desired results.

Clinical Significance: The integration of digital planning and strategic abutment selection prior to implant placement ensures optimal 3D implant positioning respecting fundamental biological and prosthetic parameters. This approach minimizes complications, improves long-term tissue stability, and enhances patient outcomes by aligning surgical procedures with the specific prosthetic needs.

1 | Introduction

Implant dentistry has undergone significant advancements since its inception. In its early stages, implant placement was primarily driven by surgical factors, with implant positioning based on available bone rather than considering the long-term restoration [1]. This approach often led to biological, mechanical, and esthetic complications [2–4]. Over time, clinicians recognized the necessity of a three-dimensional (3D) implant positioning approach, focusing on the future restoration's analyzing specific biomechanical and esthetic demands [5–7]. This shift introduced the concept of prosthetically driven implant placement, which has been considered the standard of care in implant planning for decades [8].

A prosthetically driven approach ensures that implant placement aligns with the ISR, either through native bone anchorage or the use of reconstructive techniques to optimize the mechanical behavior between the implant and the restoration. The mentioned approach provides the framework for choosing between screw-retained and cement-retained restorations where new abutment designs favor screw-retained options due to their retrievability and avoidance of cementation-related complications [9–13].

In recent years, attention has focused on different implant connections, prosthetic materials, and abutment configurations, highlighting their collective impact on peri-implant tissue stability [14–16]. It is now widely acknowledged that these components cannot be considered in isolation, as their interaction plays a critical role in determining biological responses.

The advent of implant planning software has further refined this approach, enabling clinicians to virtually simulate implant treatments, considering each component and its interaction within a digital environment [6, 17, 18]. The use of digital technology enhances the ability to gather and analyze critical information, leading to more adequate implant positioning regarding the tissue's biological response [19, 20].

The recent introduction of the biorestorative concept for implant-supported restorations further illustrates the importance of digital technology in analyzing the interaction between components and their influence on long-term peri-implant tissue response [6]. This approach not only elaborates on proper implant 3D positioning but also emphasizes the critical role of the proper abutment design, implant macrodesign, supracrestal tissue height (STH), supra platform tissue height (SPTH), and how these concepts interact in determining the precise placement to ensure stable biological outcomes [21, 22]. Therefore, this concept and rationale could be considered the standard of care in implant treatment planning nowadays.

This article describes in detail the mentioned concepts, explores the crucial role of digital abutment selection prior to implant placement, and discusses its influences on 3D implant positioning from a surgical perspective.

2 | Concepts and Description

To fully grasp the significance of abutment selection and its impact on implant-supported therapy, several critical concepts must be explored:

2.1 | Implant Macrodesign: Tissue-Level and Bone-Level Implants

Tissue-level (TL) implants were designed to maintain the interface between the implant connection and the prosthetic components at a distance from the bone margin, ensuring long-term crestal bone stability [23]. The machined coronal collar of TL implants forms a robust and stable seal with the surrounding soft tissues [24, 25]. However, due to the transmucosal collar occupying part of the STH, correcting angulation prosthetically can be challenging [26, 27]. This design necessitates a precise three-dimensional placement to avoid functional and esthetic complications, making it technique-sensitive, particularly in demanding cases in the esthetic area [24, 28]. As a result, bone-level (BL) implants are more commonly used in the esthetic

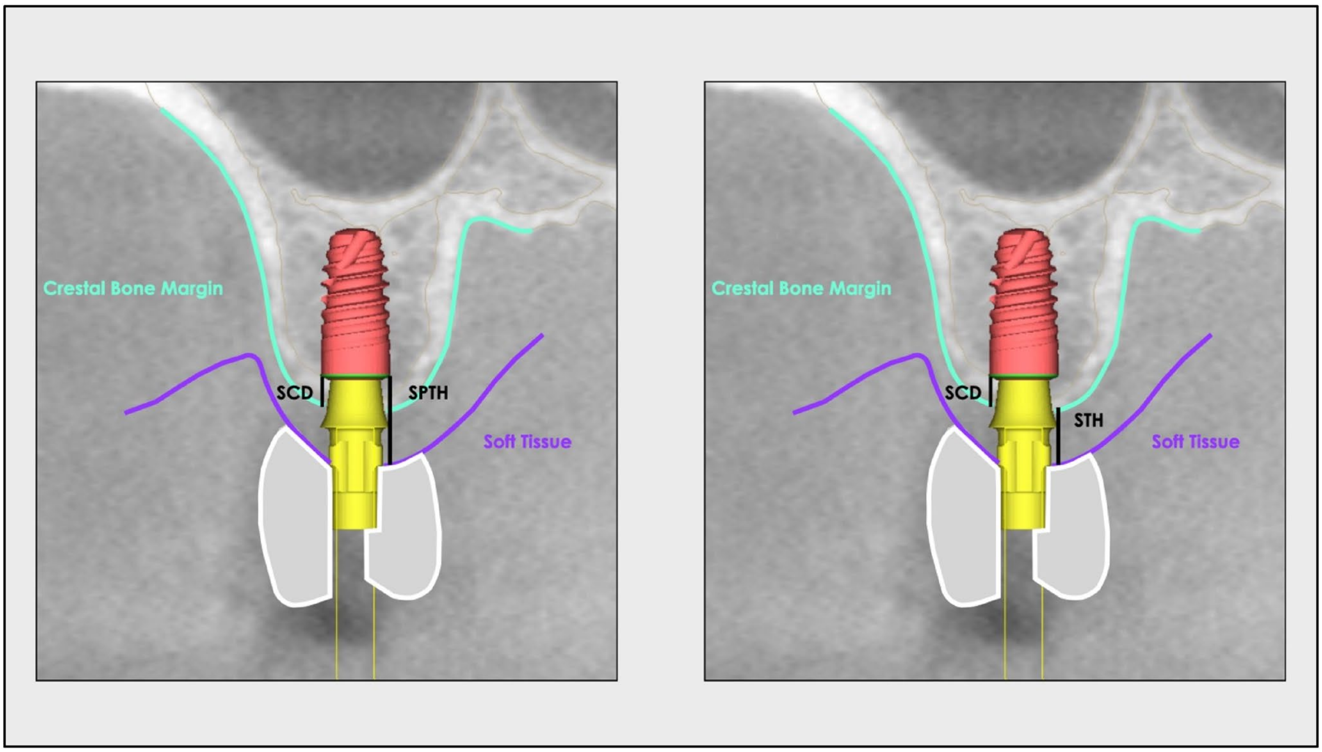

FIGURE 1 | Digital planning for implant placement in a molar site with the same digital tooth arrangement, abutment, and implant. SPTH considers the distance between the implant platform and mucosal margin of the future restoration (SPTH = SCD + STH).

zone, despite successful long-term esthetic outcomes reported with TL implants in this region [29, 30].

BL implants—originally designed for placement at the crestal BL—encountered issues with bone remodeling due to the gap between the implant platform and the prosthetic abutment [31, 32], especially in implants with matching connections [16]. It was demonstrated that BL implants in function need a minimum of 3 mm of vertical soft tissue height (STH) to be properly sealed within the oral cavity. Failure to provide this seal leads to a compensation mechanism by the organism to accommodate the required STH, resulting in bone remodeling which can potentially lead to biological and esthetic complications [33–36]. However, the development of nonmatching implant connections marked another evolution of the BL implant concept [37]. By positioning the restorative component inside the implant platform, the inflammatory process associated with the implant-abutment junction was shifted horizontally toward the center of the implant, reducing the saucerization process [38, 39].

With the advent of conometric connections, which offer more stable implant-abutment junctions, smaller microgaps, and often larger platform-switching distances, early crestal bone remodeling has been less frequently observed [14, 40–42]. As a result, implants with conometric connections and narrower horizontal offsets relative to the abutment are typically placed subcrestally [43, 44].

Although various guidelines have been proposed to determine the depth of the implant platform position, there is not enough scientific support for this standardization, and therefore, it could not be recommended. Instead, implant positioning should be personalized based on a range of factors, including restorative planning, abutment configuration, abutment height, soft tissue phenotype, STH, and the implant placement protocol.

Modern BL implants featuring conometric connections and platform-switching designs challenge the traditional notion of "BL" implants. This conceptual contradiction suggests that the term "subcrestal-level implants" maybe more appropriate for these designs. This shift in terminology has led to the introduction of a new concept—the SPTH—which provides a more accurate description of the relationship between prosthetic components, implant positioning, and the surrounding peri-implant tissues when utilizing more contemporary implant designs.

2.2 | Supracrestal Tissue Height

STH that was initially described by Avila-Ortiz, Gonzalez-Martin O and cols. in 2020 defines the vertical dimension of the soft tissue from the crestal bone to the mucosal margin [6, 33, 45]. It is regarded as a static concept since its measurement is determined by the anatomical characteristics of the region where the implant is placed and restored. This concept encompasses the sulcular epithelium, the junctional epithelium, and the supracrestal connective tissue, which typically does not adhere directly to the abutment surface [31]. Several prospective clinical trials as well as systematic reviews have consistently shown that an STH of less than 3 mm is inadequate, as such cases are often associated with marginal bone loss, which occurs to establish an adequate biologic seal and sufficient soft tissue [16, 33, 46, 47].

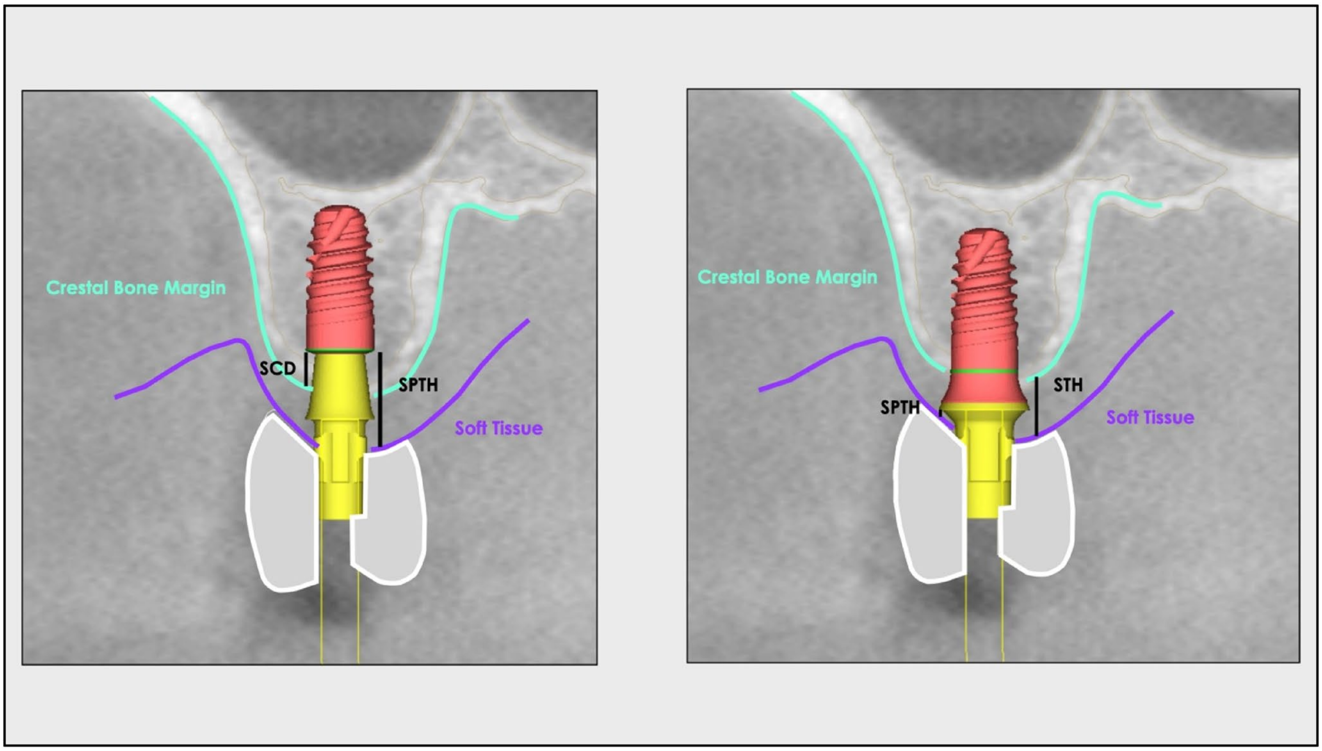

FIGURE 2 | Digital planning for implant placement in a molar site with the same digital tooth arrangement. Comparison between a BL implant placed subcrestally and a TL implant. Note how the STH remains the same in both situations, but the SPTH is almost inexistent in the TL implant situation.

2.3 | Supra Platform Tissue Height

Unlike STH, the SPTH is a dynamic concept, which is defined by the distance above the implant platform which is determined by a combination of anatomical factors and clinical decisions. The SPTH considers not only the supracrestal tissue but also the subcrestal distance (SCD) between the marginal bone and the implant platform. This distance varies depending on the 3D position of the implant, especially its platform. SPTH is directly influenced by the prosthetic plan, implant macrodesign, abutment design and length, platform position, and the site's anatomical characteristics.

The configuration of the SPTH should support an ideal prosthetic design, ensuring that the abutment shoulder is positioned at a sufficiently distance from the crestal bone to avoid bone early bone remodeling while being submucosal enough to allow for an appropriate emergence profile with an adequate angle for the future restoration [48–51]. As was mentioned, SPTH is influenced by implant design; with BL implants, a positive SPTH value is maintained, whereas with TL implants, the SPTH may significantly decrease or even become negative if the implant platform lies coronal to the mucosal margin (Figures 1 and 2).

2.4 | Abutments

Prosthetic abutments serve as the critical link between the implant and the restoration. While typically considered part of the prosthetic assembly, for the purpose of this discussion, they will be treated as a distinct unit. Over time, various abutment designs have been introduced, yet they generally share a common architecture. This includes an engagement feature that interface directly with the implant connection, an intermediate section that extends from the top of the connection to the prosthetic shoulder, a retentive feature—where the superstructure is layered, cemented, or bonded—and the prosthetic screw.

In recent years, with the introduction of titanium bases (Ti-Bases), the intermediate phase of the abutment has gained considerable attention, particularly due to its height, shape, and emergence angle, being demonstrated to impact the surrounding tissues [21, 22, 52]. This segment of the abutment is commonly referred to as the "transmucosal phase," and its dimension is often described as the "gingival height." (Figures 3 and 4).

However, much like the considerations surrounding implant platform positioning, this terminology may also be conceptually misleading, as portions of the abutment surface can be located subcrestally and surrounded by bone or dense connective tissue. The height and design of this feature are crucial for precisely determining the implant's position, preventing unwanted bone remodeling, and ensuring a biologically and aesthetically acceptable emergence profile for ISR. Therefore, a new term could also be proposed to name this phase of the abutment since "transmucosal" or "gingival height" felt short in describing the position this feature might have subcrestally. The present article suggests using the term "biological height" (BH) since it encompasses the SCD and the transmucosal area related to this abutment's subcomponent.

The retentive feature height of the abutment also plays a role in the abutment's selection since it will be related to the interocclusal space, the selected restorative material and its bonding protocol. Therefore, its height can also influence the abutment position and thus future implant location.

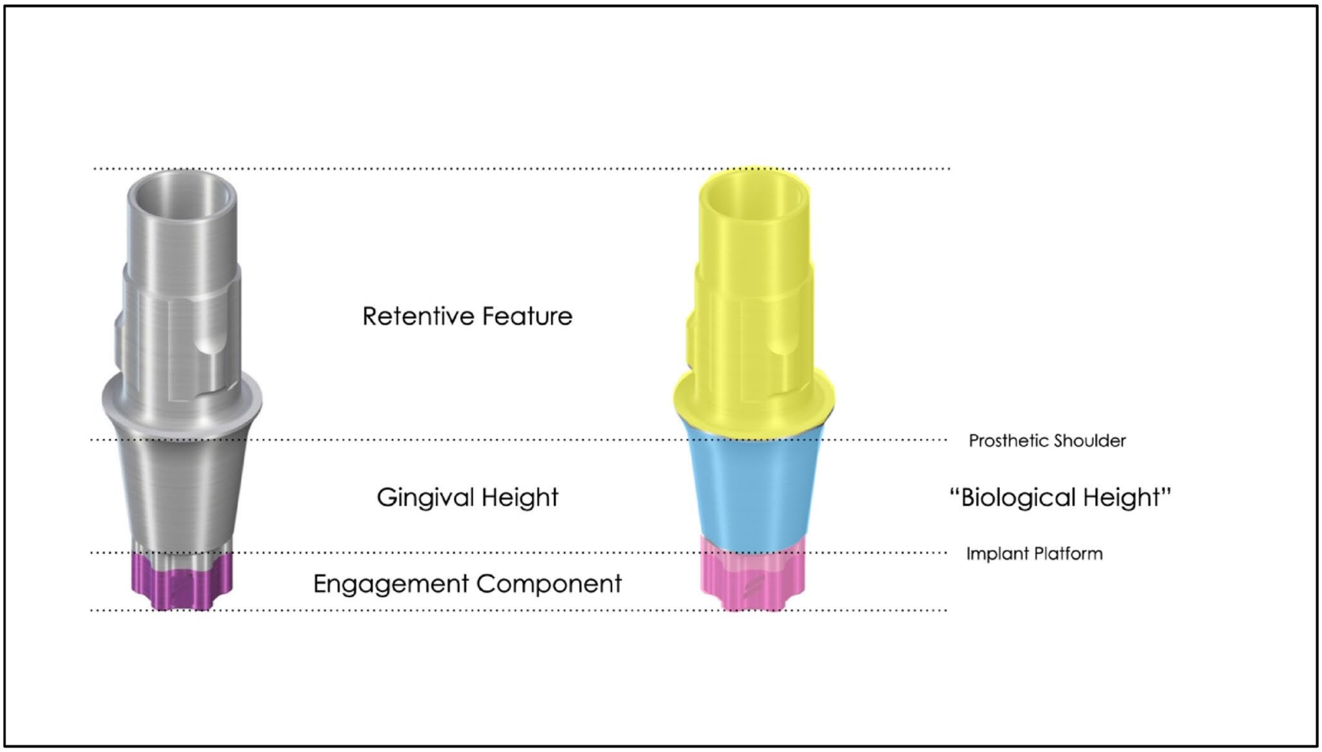

FIGURE 3 | Prosthetic abutment macrodesign (Ti-Base).

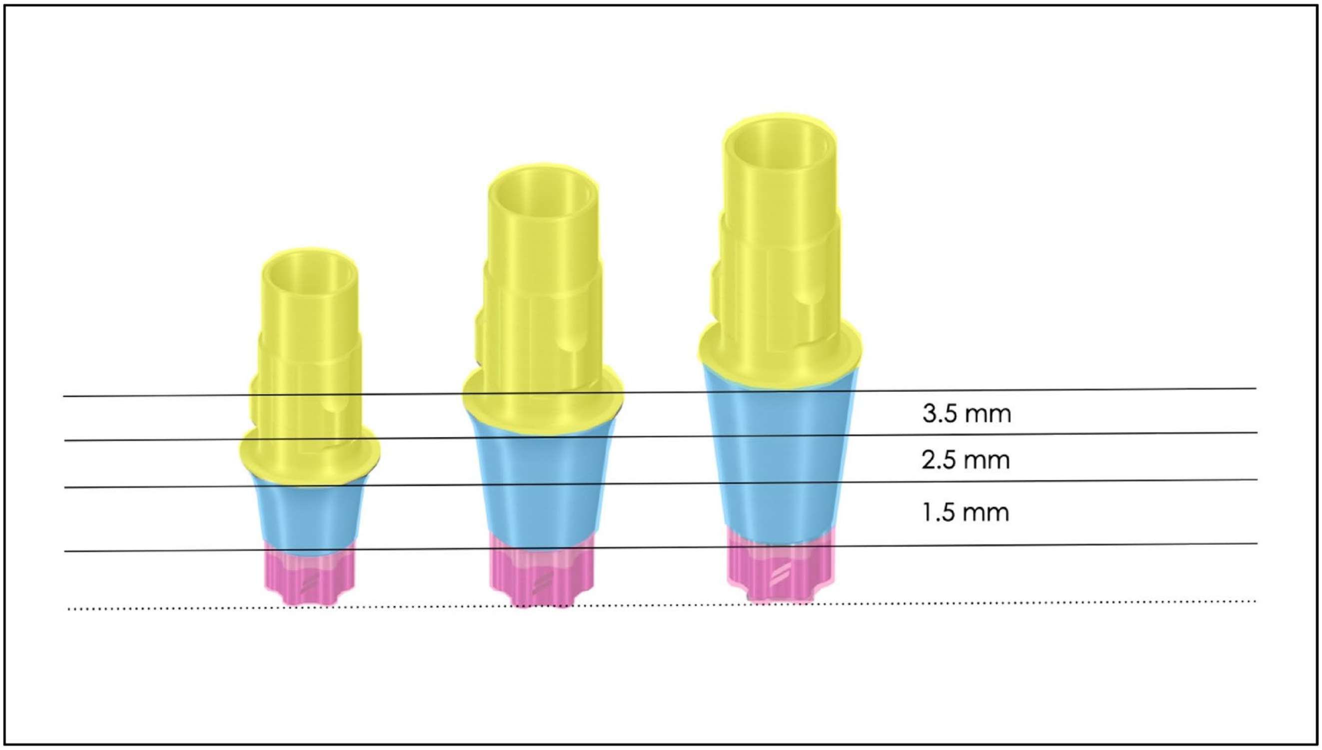

FIGURE 4 | Prosthetic abutments (Ti-Base) macrodesign in different "gingival heights".

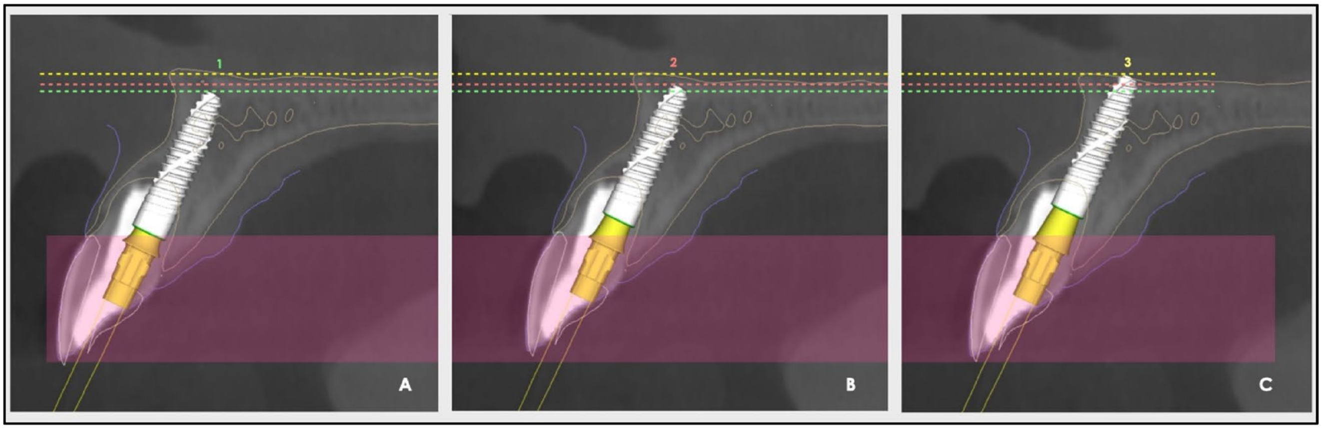

FIGURE 5 | Digital planning for immediate implant placement in the esthetic zone with the same digital tooth arrangement. Different abutment designs were positioned to respect the anatomy of the surgical site and the prosthetic space for an appropriate emergence profile. In Figure 1. 1.5 mm GH abutment was selected. In Figure 2. 2.5 GH abutment was selected. In Figure 3. 3.5 GH abutment was selected. Note how the implant position is modified depending on different abutment configurations. In Figure 3. the length of the implant is questionable, and a shorter one could be selected.

In recent years, the introduction of angulated screw channel (ASC) abutments with hexalobular screw heads have enabled clinicians to perform screw-retained restorations even when implants are placed in non-screw-retained restorative position, as long as the angulation correction needed is within 25°–30° [61]. This situation is particularly common in immediate implant placement within the esthetic zone due to the buccal positioning of roots and the limited bone availability for stable implant engagement following tooth extraction. ASC abutments take advantage of the mechanical properties of their specific screw design, allowing for angled screwdriver insertion and tightening under these circumstances. However, due to mechanical constraints in their current design, these abutments typically have a shorter vertical height (BH), which may contribute to increased peri-implant bone remodeling. Future innovations are expected to address this limitation.

All the mentioned concepts and factors not only apply for Ti-Bases since the same principles can be applied to customized or stock abutments in general.

2.5 | Biorestorative Implant Planning

Biorestorative implant planning refers to the integration of digitally assisted diagnostic tools, treatment planning, and sequencing to optimize both the biological and restorative aspects of ISRs. By managing and analyzing all relevant data in a virtual environment, clinicians can evaluate the interaction between prosthetic and surgical components with the anatomical characteristics of the surgical site. This approach enables precise planning of the most advantageous biological, mechanical, functional, and esthetic relationships, which can then be transferred to the patient's mouth using computer-assisted implant surgery systems [6].

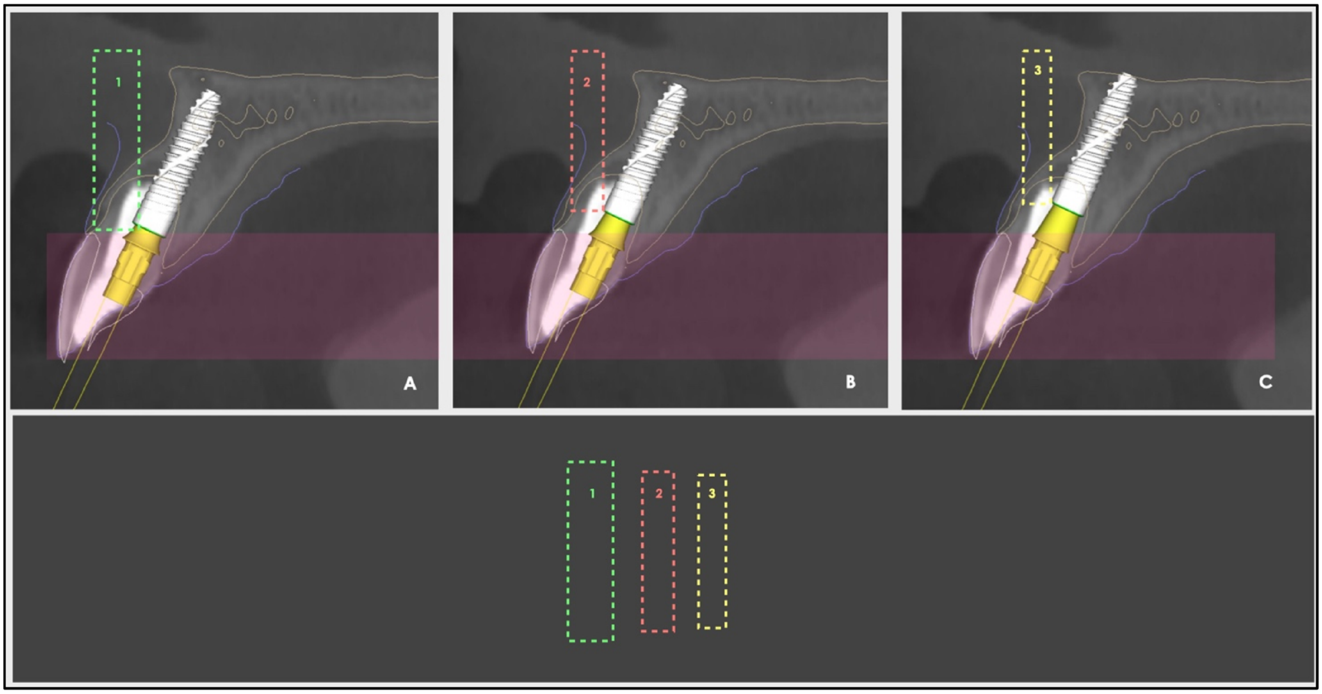

FIGURE 6 | Digital planning for immediate implant placement in the esthetic zone with the same digital tooth arrangement. Different abutment designs were positioned to respect the anatomy of the surgical site and the prosthetic space for an appropriate emergence profile. In Figure 1. 1.5 mm GH abutment was selected. In Figure 2. 2.5 GH abutment was selected. In Figure 3. 3.5 GH abutment was selected. In Figure 3. the length of the implant is questionable, and a shorter one could be selected. Note how the implant position is modified buccally palatal taking as reference the marginal bone of the buccal bone wall.

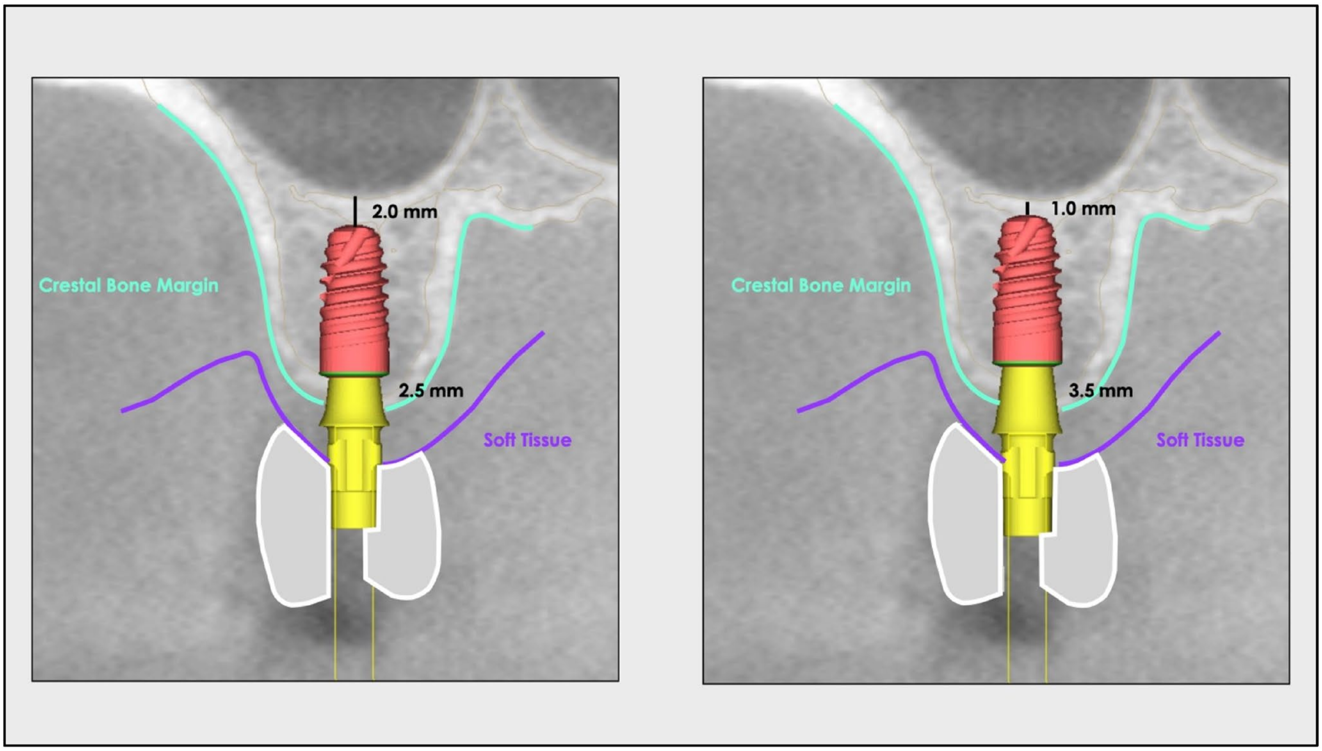

FIGURE 7 | Digital planning for implant placement in a molar site with the same digital tooth arrangement. Different abutment designs and positions to respect the anatomy of the surgical site and the prosthetic space for an appropriate emergence profile. Note how the implant position is modified apicocoronally.

Moreover, digital planning also allows for the consideration and analysis of different abutment designs during the planning phase, which directly influences the 3D positioning of the implant. This critical step, which cannot be adequately performed without digital tools, ensures that the optimal relationship between the implant, the abutment and surrounding tissues. Furthermore, the selection of the adequate restorative material can also be performed in this step since the required spaces for specific materials thickness can be easily analyzed. Thus, the selection of the prosthetic abutment should be strictly determined during the digital planning phase, as its design and size will not only affect the final implant position but may also influence the choice of implant size and the surgical procedure itself (Figures 5–7).

In essence, the future restoration's position will dictate the tentative location of the implant to achieve the desired retention method, whether screw-retained or cement-retained. Once the implant's initial virtual position is determined, the digital abutment selection allows for detailed analysis of the 3D implant

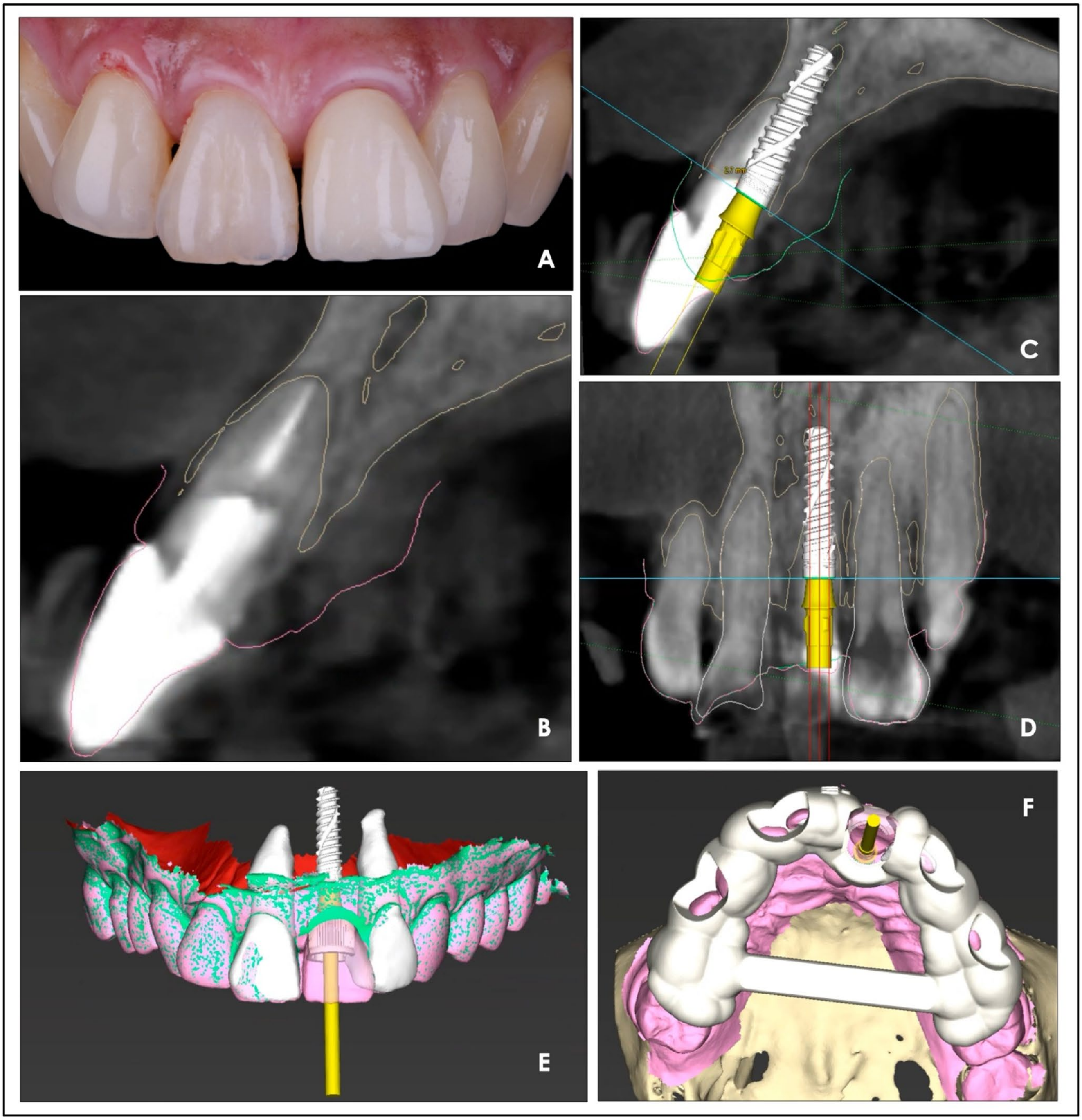

FIGURE 8 | Digital planning for immediate implant placement and immediate loading in tooth #2.1. (A) Initial situation (crown/root fracture) in tooth #2.1. (B) CBCT sagittal view of tooth #2.1. (C) Sagittal view of implant position and abutment selection based on the restorative proposal (biorestorative implant planning). (D) Sagittal view of implant position and abutment selection based on the restorative proposal (biorestorative implant planning). (E) 3D reconstruction view of the proposed biorestorative plan. (F) Occlusal view of the surgical guide design.

position, ensuring that all biological, functional, and esthetic principles are respected to achieve long-term, predictable outcomes. (Figures 8–11).

3 | Discussion

As previously discussed in the literature, the size, shape, design, and position of prosthetic abutments significantly influence the stability of peri-implant tissues [21, 22, 52–56]. This is particularly evident when marginal bone remodeling occurs due to the use of abutments that apply compression to adjacent structures [57]. It has been established in preclinical and clinical trials that wide emergence, low-profile abutments located close to the implant platform may trigger an inflammatory response in surrounding tissues, leading to bone remodeling and subsequent complications, especially in patients with thin mucosal phenotypes [50, 51]. Therefore, slim abutments with a minimum

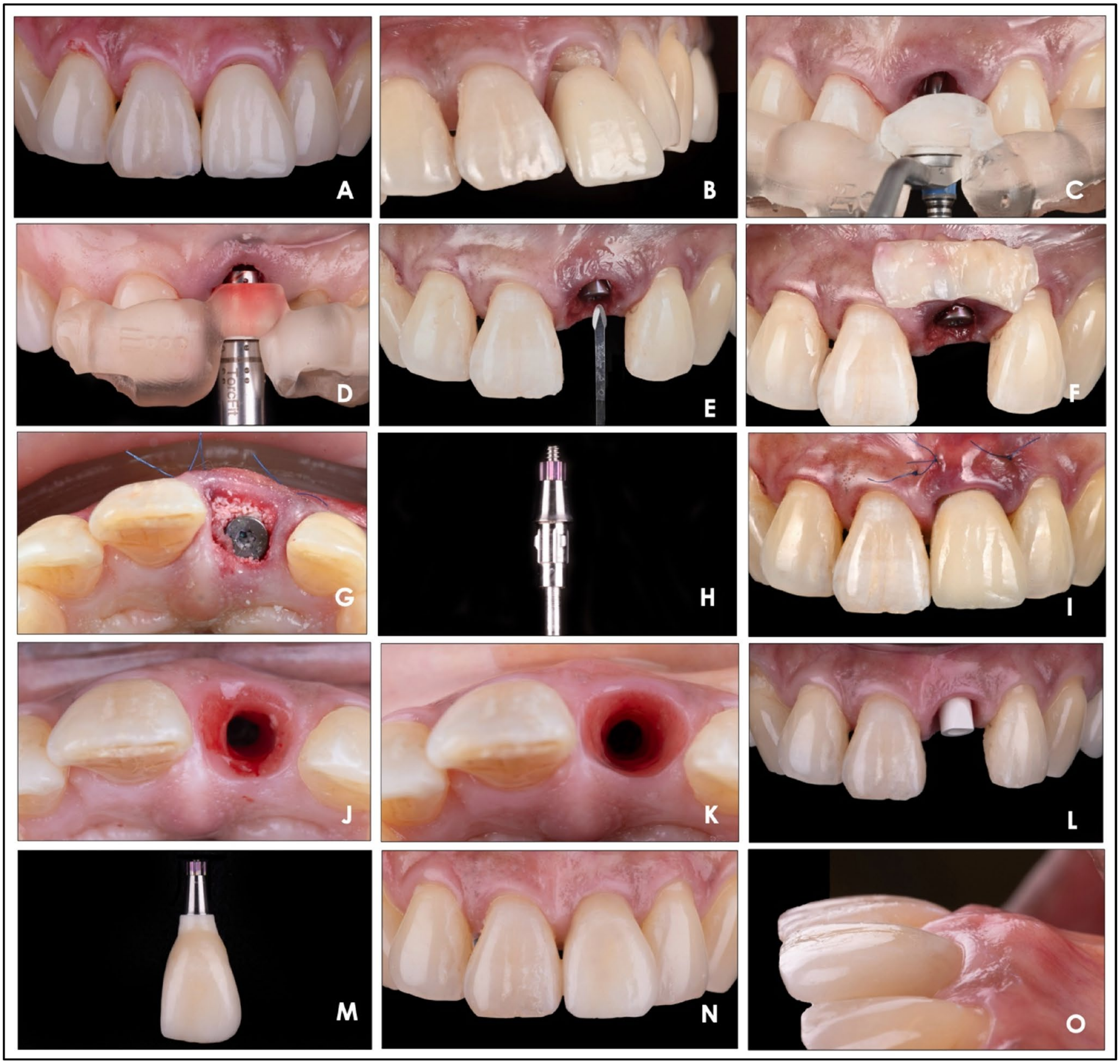

FIGURE 9 | Clinical sequence of immediate implant placement and immediate loading in tooth 2.1. (A) Initial situation (crown/root fracture). (B) Crown displacement. (C) Surgical procedure, S-CAIS. (D) Computer-guided implant placement. (E) Tunneling procedure for CTG placement. (F) CTG presented over the recipient site. (G) Occlusal view of the preselected healing abutment in position, the sutured CTG and DBBM filling the GAP. (H) Preselected 3.5 GH Ti-Base. (H) Provisional restoration in position. It was fabricated based on the extracted crown bonded to the preselected Ti-Base. (J) Occlusal view of the emergence profile 4 months after implant placement. (K) Occlusal view of the emergence profile after four 8 months after implant placement. Several provisional contouring procedures were performed during this time. (L) Scan body in position for IOS. (M) Monolithic zirconia restoration bonded over the preselected Ti-Base (same abutment configuration). (N) Delivery day of the implant-supported restoration. (O) 1-year follow-up.

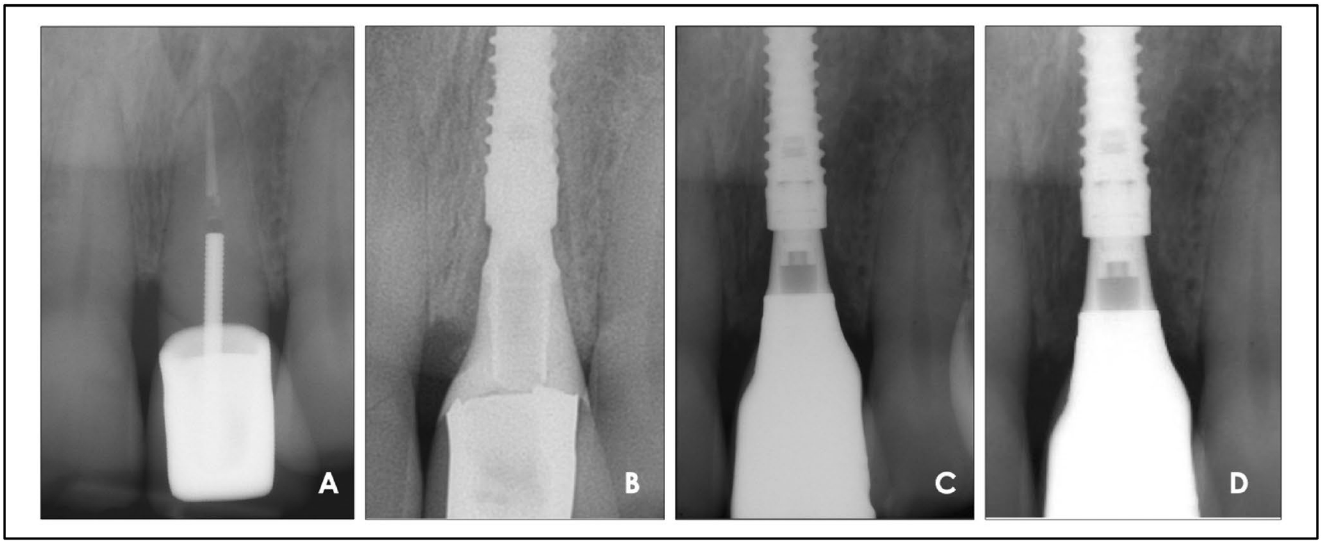

FIGURE 10 | Sequence of periapical x-rays. (A) Initial situation. (B) Immediate loading. (C) Definitive implant-supported crown installation. (D) 1-year Follow-up.

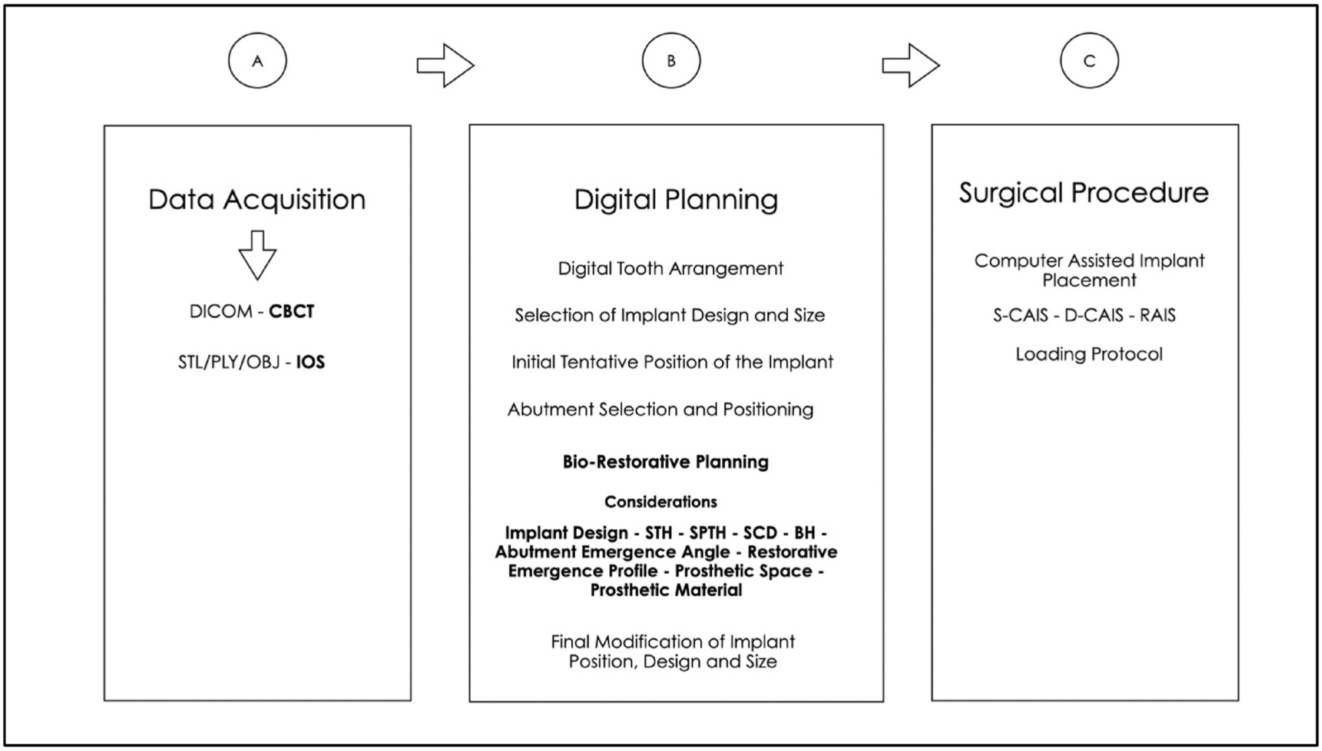

FIGURE 11 | Workflow of the digital implant-abutment planning process. (A) Data acquisition (files and method of obtention). (B) Planning sequence. Considerations for the selection of the abutment. (C) Surgical procedure alternatives.

height of 2 mm have been recommended over convex designs to prevent bone remodeling and allow space for tissue development and at the implant platform level [22, 52].

Furthermore, maintaining consistency in abutment design and height from the healing abutment to the definitive restoration is crucial. This continuity ensures that peri-implant tissues at the abutment level remain undisturbed, reducing the risk of complications caused by the repeated connection and disconnection of components with differing designs and sizes during the restorative process [50, 58].

The introduction of titanium base abutments (TBAs) has added flexibility to the implant restorative process at a lower cost compared to customized abutments. Their versatility allows for the selection of various sizes and designs, combined with different prosthetic materials, to accommodate multiple implant scenarios. However, TBAs are not universally indicated. As highlighted in the 2023 ITI Consensus Conference, customized abutments remain the gold standard for many clinical situations [59]. Ti-Bases also have predefined "transmucosal" sizes, requiring careful selection to ensure the prosthetic shoulder is positioned away from the crestal bone to prevent bone remodeling while also being submucosal enough to support an ideal emergence profile.

The choice of abutment directly affects 3D implant positioning, a consideration closely tied to the anatomical factors of the clinical site, such as mucosal phenotype. A thick mucosal phenotype serves as a protective factor for peri-implant tissue stability, whereas a thin phenotype can contribute to bone remodeling [33]. Techniques to thicken the mucosal phenotype or increase the distance between the implant platform and mucosal margin at the restoration level have been described, with subcrestal implant placement emerging as a valid option for avoiding bone remodeling in thin phenotypes [43, 60]. The digital planning allows to analyze presurgically the mucosal thickness and therefore the need to increase it horizontally with a CTG or other mucosal substitute, most of all in immediate implant cases [49, 52].

As described, the digital tooth arrangement serves as an initial guide for implant positioning, but the digital simulation of the interaction between the restoration, abutment, implant, and site anatomy ultimately defines the precise 3D implant position [19]. This interaction directly impacts the surgical protocol, underscoring the need for abutment selection during surgical implant planning [21].

When multiple implants are restored with splinted structures, the same principles can be applied. In fact, the selection of multiunit abutments configuration for screw-retained splinted restorations should also be performed during the digital planning phase since its size, shape, and angulation can directly influence the implant 3D position and its interaction with the same variables discussed for single-unit implant-supported restorations.

4 | Conclusions

Abutment design has a direct influence on 3D implant positioning. While prosthetically driven implant planning is crucial for determining implant location, the abutment selection and its interaction with the restoration, implant, and patient's anatomy, ultimately, dictate the precise placement of the implant. Digital implant planning provides the tools to simulate this interaction, enabling accurate diagnosis, planning, and the precise transfer of the planned intervention to the patient through computer-assisted implant placement.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

References

1. R. Adell, "Tissue Integrated Prostheses in Clinical Dentistry," *International Dental Journal* 35, no. 4 (1985): 259–265.

2. M. Esposito, J. M. Hirsch, U. Lekholm, and P. Thomsen, "Biological Factors Contributing to Failures of Osseointegrated Oral Implants. (II). Etiopathogenesis," *European Journal of Oral Sciences* 106, no. 3 (1998): 721–764.

3. T. G. Wilson, Jr., "The Positive Relationship Between Excess Cement and Peri-Implant Disease: A Prospective Clinical Endoscopic Study," *Journal of Periodontology* 80, no. 9 (2009): 1388–1392.

4. D. Buser, W. Martin, and U. C. Belser, "Optimizing Esthetics for Implant Restorations in the Anterior Maxilla: Anatomic and Surgical Considerations," *International Journal of Oral & Maxillofacial Implants* 19, no. Suppl (2004): 43–61.

5. J. Markovic, J. F. Peña-Cardelles, I. Pedrinaci, A. Hamilton, G. O. Gallucci, and A. Lanis, "Considerations for Predictable Outcomes in Static Computer- Aided Implant Surgery in the Esthetic Zone," *Journal of Esthetic and Restorative Dentistry* 36, no. 1 (2024): 207–219.

6. I. Pedrinaci, A. Hamilton, A. Lanis, M. Sanz, and G. O. Gallucci, "The Bio-Restorative Concept for Implant-Supported Restorations," *Journal of Esthetic and Restorative Dentistry* 36, no. 11 (2024): 1516–1527.

7. D. A. Garber and U. C. Belser, "Restoration-Driven Implant Placement With Restoration-Generated Site Development," *Compendium of Continuing Education in Dentistry* 16, no. 8 (1995): 796 798-802, 804.

8. N. Mattheos, I. Vergoullis, M. Janda, and A. Miseli, "The Implant Supracrestal Complex and Its Significance for Long-Term Successful Clinical Outcomes," *International Journal of Prosthodontics* 34, no. 1 (2021): 88–100.

9. I. Sailer, D. Karasan, A. Todorovic, M. Ligoutsikou, and B. E. Pjetursson, "Prosthetic Failures in Dental Implant Therapy," *Periodontology 2000* 88, no. 1 (2022): 130–144.

10. B. E. Pjetursson, I. Sailer, E. Merino-Higuera, B. C. Spies, F. Burkhardt, and D. Karasan, "Systematic Review Evaluating the Influence of the Prosthetic Material and Prosthetic Design on the Clinical Outcomes of Implant-Supported Multi-Unit Fixed Dental Prosthesis in the Posterior Area," *Clinical Oral Implants Research* 34, no. Suppl 26 (2023): 86–103.

11. R. D. Kraus, C. Espuelas, C. H. F. Hämmerle, R. E. Jung, I. Sailer, and D. S. Thoma, "Five-Year Randomized Controlled Clinical Study Comparing Cemented and Screw-Retained Zirconia-Based Implant-Supported Single Crowns," *Clinical Oral Implants Research* 33, no. 5 (2022): 537–547.

12. M. L. de Brandão, M. V. Vettore, and G. M. Vidigal Júnior, "Peri-Implant Bone Loss in Cement- and Screw-Retained Prostheses: Systematic Review and Meta-Analysis," *Journal of Clinical Periodontology* 40, no. 3 (2013): 287–295.

13. C. A. Lemos, V. E. de Souza Batista, D. A. Almeida, J. F. Santiago Júnior, F. R. Verri, and E. P. Pellizzer, "Evaluation of Cement-Retained Versus Screw-Retained Implant-Supported Restorations for Marginal Bone Loss: A Systematic Review and Meta-Analysis," *Journal of Prosthetic Dentistry* 115, no. 4 (2016): 419–427.

14. H. Zipprich, P. Weigl, C. Ratka, B. Lange, and H. C. Lauer, "The Micromechanical Behavior of Implant-Abutment Connections Under a Dynamic Load Protocol," *Clinical Implant Dentistry and Related Research* 20, no. 5 (2018): 814–823.

15. V. Valantijiene, A. Mazeikiene, J. Alkimavicius, L. Linkeviciene, E. Alkimaviciene, and T. Linkevicius, "Clinical and Immunological Evaluation of Peri-Implant Tissues Around Ultra-Polished and Conventionally-Polished Zirconia Abutments. A 1-Year Follow-Up Randomized Clinical Trial," *Journal of Prosthodontics* 32, no. 5 (2023): 392–400.

16. S. Zukauskas, A. Puisys, P. Andrijauskas, L. Zaleckas, E. Vindasiute-Narbute, and T. Linkevičius, "Influence of Implant Placement Depth and Soft Tissue Thickness on Crestal Bone Stability Around Implants With and Without Platform Switching: A Comparative Clinical Trial," *International Journal of Periodontics & Restorative Dentistry* 41, no. 3 (2021): 347–355.

17. T. Joda, M. Ferrari, G. O. Gallucci, J. G. Wittneben, and U. Brägger, "Digital Technology in Fixed Implant Prosthodontics," *Periodontology 2000* 73, no. 1 (2017): 178–192.

18. T. Joda and G. O. Gallucci, "The virtual patient in dental medicine," *Clinical Oral Implants Research* 26, no. 6 (2015): 725–726.

19. I. Pedrinaci, T. C. Sun, M. Sanz-Alonso, J. Sanz-Esporrin, A. Hamilton, and G. O. Gallucci, "Implant Survival in the Anterior Mandible: A Retrospective Cohort Study," *Clinical Oral Implants Research* 34, no. 5 (2023): 463–474.

20. E. K. Edmondson, P. M. Trejo, N. Soldatos, and R. L. Weltman, "The Ability to Screw-Retain Single Implant-Supported Restorations in the Anterior Maxilla: A CBCT Analysis," *Journal of Prosthetic Dentistry* 128, no. 3 (2022): 443–449.

21. I. Laleman and F. Lambert, "Implant Connection and Abutment Selection as a Predisposing and/or Precipitating Factor for Peri-Implant Diseases: A Review," *Clinical Implant Dentistry and Related Research* 25, no. 4 (2023): 723–733.

22. P. Tajti, E. Solyom, S. Váncsa, et al., "Less Marginal Bone Loss Around Bone-Level Implants Restored With Long Abutments: A Systematic Review and Meta-Analysis," *Periodontology 2000* 94, no. 1 (2024): 627–638.

23. J. Derks, D. Schaller, J. Håkansson, J. L. Wennström, C. Tomasi, and T. Berglundh, "Effectiveness of Implant Therapy Analyzed in a Swedish Population: Prevalence of Peri-Implantitis," *Journal of Dental Research* 95, no. 1 (2016): 43–49.

24. S. Kim, U. W. Jung, K. S. Cho, and J. S. Lee, "Retrospective Radiographic Observational Study of 1692 Straumann Tissue-Level Dental Implants Over 10 Years: I. Implant Survival and Loss Pattern," *Clinical Implant Dentistry and Related Research* 20, no. 5 (2018): 860–866.

25. M. Menini, E. Dellepiane, T. Deiana, E. Fulcheri, P. Pera, and P. Pesce, "Comparison of Bone-Level and Tissue-Level Implants: A Pilot Study With a Histologic Analysis and a 4-Year Follow-Up," *International Journal of Periodontics & Restorative Dentistry* 42, no. 4 (2022): 535–543.

26. H. Yang, L. Xu, J. Jiang, Y. Xu, X. Li, and F. He, "Clinical Effect of Nobel Biocare Angulated Screw Channel Crown Compared With Cement Crown in the Aesthetic Area: A Retrospective Cohort Study With a Mean 32 Months Follow-Up (Range 12 to 70 Months)," *Clinical Implant Dentistry and Related Research* 25, no. 6 (2023): 1178–1186.

27. W. Radomsutthisarn, K. Kretapirom, and P. Nakaparksin, "Incidence of Straight and Angulated Screw Channel Following Immediate Implant Placement in Esthetic Zone: A Simulated Cone-Beam Computed Tomography Study," *PLoS One* 19, no. 9 (2024): e0308158.

28. C. Siebert, D. Rieder, J. Eggert, M. G. Wichmann, and S. M. Heckmann, "Long-Term Esthetic Outcome of Tissue-Level and Bone-Level Implants in the Anterior Maxilla," *International Journal of Oral & Maxillofacial Implants* 33, no. 4 (2018): 905–912.

29. D. Buser, H. P. Weber, and N. P. Lang, "Tissue Integration of Non-submerged Implants. 1-Year Results of a Prospective Study With 100 ITI Hollow-Cylinder and Hollow-Screw Implants," *Clinical Oral Implants Research* 1, no. 1 (1990): 33–40.

30. U. C. Belser, L. Grütter, F. Vailati, M. M. Bornstein, H. P. Weber, and D. Buser, "Outcome Evaluation of Early Placed Maxillary Anterior Single-Tooth Implants Using Objective Esthetic Criteria: A Cross-Sectional, Retrospective Study in 45 Patients With a 2- to 4-Year Follow-Up Using Pink and White Esthetic Scores," *Journal of Periodontology* 80, no. 1 (2009): 140–151.

31. T. Berglundh and J. Lindhe, "Dimension of the Periimplant Mucosa. Biological Width Revisited," *Journal of Clinical Periodontology* 23, no. 10 (1996): 971–973.

32. T. Linkevicius, P. Apse, S. Grybauskas, and A. Puisys, "The Influence of Soft Tissue Thickness on Crestal Bone Changes Around Implants: A 1-Year Prospective Controlled Clinical Trial," *International Journal of Oral & Maxillofacial Implants* 24, no. 4 (2009): 712–719.

33. A. Puisys, E. Vindasiute-Narbute, D. Razukevicius, S. Akhondi, G. O. Gallucci, and I. Pedrinaci, "Influence of Mucosal Tissue Height on Implant Crestal Bone: A 10-Year Follow-Up of a Controlled Clinical Trial," *Journal of Dentistry* 148 (2024): 105224.

34. F. Bengazi, J. L. Wennström, and U. Lekholm, "Recession of the Soft Tissue Margin at Oral Implants. A 2-Year Longitudinal Prospective Study," *Clinical Oral Implants Research* 7, no. 4 (1996): 303–310.

35. M. Romandini, C. Lima, I. Pedrinaci, A. Araoz, M. C. Soldini, and M. Sanz, "Prevalence and Risk/Protective Indicators of Peri-Implant Diseases: A University-Representative Cross-Sectional Study," *Clinical Oral Implants Research* 32, no. 1 (2021): 112–122.

36. G. Zucchelli, L. Tavelli, M. Stefanini, et al., "Classification of Facial Peri-Implant Soft Tissue Dehiscence/Deficiencies at Single Implant Sites in the Esthetic Zone," *Journal of Periodontology* 90, no. 10 (2019): 1116–1124.

37. R. J. Lazzara and S. S. Porter, "Platform Switching: A New Concept in Implant Dentistry for Controlling Postrestorative Crestal Bone Levels," *International Journal of Periodontics & Restorative Dentistry* 26, no. 1 (2006): 9–17.

38. L. Prosper, S. Redaelli, M. Pasi, F. Zarone, G. Radaelli, and E. F. Gherlone, "A Randomized Prospective Multicenter Trial Evaluating the Platform-Switching Technique for the Prevention of Postrestorative Crestal Bone Loss," *International Journal of Oral & Maxillofacial Implants* 24, no. 2 (2009): 299–308.

39. B. R. Chrcanovic, T. Albrektsson, and A. Wennerberg, "Platform Switch and Dental Implants: A Meta-Analysis," *Journal of Dentistry* 43, no. 6 (2015): 629–646.

40. P. Galindo-Moreno, A. Concha-Jeronimo, L. Lopez-Chaichio, R. Rodriguez-Alvarez, E. Sanchez-Fernandez, and M. Padial-Molina, "Marginal Bone Loss Around Implants With Internal Hexagonal and Internal Conical Connections: A 12-Month Randomized Pilot Study," *Journal of Clinical Medicine* 10, no. 22 (2021): 5427.

41. S. G. Mihali, H. L. Wang, O. Karancsi, and E. A. Bratu, "Internal Hexagon vs Conical Implant-Abutment Connections: Evaluation of 3-Year Postloading Outcomes," *Journal of Oral Implantology* 47, no. 6 (2021): 485–490.

42. M. Cannata, T. Grandi, R. Samarani, L. Svezia, and G. Grandi, "A Comparison of Two Implants With Conical vs Internal Hex Connections: 1-Year Post-Loading Results From a Multicentre, Randomised Controlled Trial," *European Journal of Oral Implantology* 10, no. 2 (2017): 161–168.

43. T. Linkevicius, A. Puisys, R. Linkevicius, J. Alkimavicius, E. Gineviciute, and L. Linkeviciene, "The Influence of Submerged Healing Abutment or Subcrestal Implant Placement on Soft Tissue Thickness and Crestal Bone Stability. A 2-Year Randomized Clinical Trial," *Clinical Implant Dentistry and Related Research* 22, no. 4 (2020): 497–506.

44. T. Linkevicius, R. Linkevicius, E. Gineviciute, J. Alkimavicius, A. Mazeikiene, and L. Linkeviciene, "The Influence of New Immediate Tissue Level Abutment on Crestal Bone Stability of Subcrestally Placed Implants: A 1-Year Randomized Controlled Clinical Trial," *Clinical Implant Dentistry and Related Research* 23, no. 2 (2021): 259–269.

45. G. Avila-Ortiz, O. Gonzalez-Martin, E. Couso-Queiruga, and H. L. Wang, "The Peri-Implant Phenotype," *Journal of Periodontology* 91, no. 3 (2020): 283–288.

46. C. Valles, X. Rodríguez-Ciurana, M. Clementini, M. Baglivo, B. Paniagua, and J. Nart, "Influence of Subcrestal Implant Placement Compared With Equicrestal Position on the Peri-Implant Hard and Soft Tissues Around Platform-Switched Implants: A Systematic Review and Meta-Analysis," *Clinical Oral Investigations* 22, no. 2 (2018): 555–570.

47. T. Linkevicius, A. Puisys, M. Steigmann, E. Vindasiute, and L. Linkeviciene, "Influence of Vertical Soft Tissue Thickness on Crestal Bone Changes Around Implants With Platform Switching: A

Comparative Clinical Study," *Clinical Implant Dentistry and Related Research* 17, no. 6 (2015): 1228–1236.

48. A. Puisys, M. Janda, V. Auzbikaviciute, G. O. Gallucci, and N. Mattheos, "Contour Angle and Peri-Implant Tissue Height: Two Interrelated Features of the Implant Supracrestal Complex," *Cllinical and Experimental Dental Research* 9, no. 3 (2023): 418–424.

49. J.-W. Han, J.-W. Han, S.-W. Pyo, and S. Kim, "Impact of Profile Angle of CAD-CAM Abutment on the Marginal Bone Loss of Implant-Supported Single-Tooth Posterior Restorations," *Journal of Prosthetic Dentistry.* Published ahead of print, December 21, 2023.

50. F. J. Strauss, J. Y. Park, J. S. Lee, et al., "Wide Restorative Emergence Angle Increases Marginal Bone Loss and Impairs Integrity of the Junctional Epithelium of the Implant Supracrestal Complex: A Preclinical Study," *Journal of Clinical Periodontology.* Published ahead of print, October 9, 2024.

51. G. Finelle, D. E. V. Papadimitriou, A. B. Souza, N. Katebi, G. O. Gallucci, and M. G. Araújo, "Peri-Implant Soft Tissue and Marginal Bone Adaptation on Implant With Non-matching Healing Abutments: Micro-CT Analysis," *Clinical Oral Implants Research* 26, no. 4 (2015): e42–e46.

52. A. Pico, P. Martín-Lancharro, L. Caneiro, L. Nóvoa, P. Batalla, and J. Blanco, "Influence of Abutment Height and Implant Depth Position on Interproximal Peri-Implant Bone in Sites With Thin Mucosa: A 1-Year Randomized Clinical Trial," *Clinical Oral Implants Research* 30, no. 7 (2019): 595–602.

53. P. Galindo-Moreno, A. León-Cano, I. Ortega-Oller, et al., "Prosthetic Abutment Height Is a Key Factor in Peri-Implant Marginal Bone Loss," *Journal of Dental Research* 93, no. 7 Suppl (2014): 80s–85s.

54. T. Borges, J. Montero, B. Leitão, M. Pereira, and P. Galindo-Moreno, "Periimplant Bone Changes in Different Abutment Heights and Insertion Timing in Posterior Mandibular Areas: Three-Year Results From a Randomized Prospective Clinical Trial," *Clinical Oral Implants Research* 32, no. 2 (2021): 203–211.

55. M. H. A. Saleh, A. Ravidà, F. Suárez-López Del Amo, G. H. Lin, F. Asa'ad, and H. L. Wang, "The Effect of Implant-Abutment Junction Position on Crestal Bone Loss: A Systematic Review and Meta-Analysis," *Clinical Implant Dentistry and Related Research* 20, no. 4 (2018): 617–633.

56. J. Blanco, A. Pico, L. Caneiro, L. Nóvoa, P. Batalla, and P. Martín-Lancharro, "Effect of Abutment Height on Interproximal Implant Bone Level in the Early Healing: A Randomized Clinical Trial," *Clinical Oral Implants Research* 29, no. 1 (2018): 108–117.

57. A. B. Souza, A. Alshihri, P. W. Kämmerer, M. G. Araújo, and G. O. Gallucci, "Histological and Micro-CT Analysis of Peri-Implant Soft and Hard Tissue Healing on Implants With Different Healing Abutments Configurations," *Clinical Oral Implants Research* 29, no. 10 (2018): 1007–1015.

58. Q. Q. Wang, R. Dai, C. Y. Cao, H. Fang, M. Han, and Q. L. Li, "One-Time Versus Repeated Abutment Connection for Platform-Switched Implant: A Systematic Review and Meta-Analysis," *PLoS One* 12, no. 10 (2017): e0186385.

59. W. Derksen, T. Joda, J. Chantler, et al., "Group 2 ITI Consensus Report: Technological Developments in Implant Prosthetics," *Clinical Oral Implants Research* 34, no. Suppl 26 (2023): 104–111.

60. A. Puisys, E. Vindasiute-Narbute, D. Razukevicius, S. Akhondi, G. O. Gallucci, and I. Pedrinaci, "Clinical Efficacy of Two Vertical Soft Tissue Augmentation Techniques for Peri-Implant Crestal Bone Level Stability: A Randomized Clinical Trial," *Clinical Implant Dentistry and Related Research.* Published ahead of print, August 11, 2024.

61. J. Y. Kan, K. Rungcharassaeng, P. Kamolroongwarakul, et al., "Frequency of Screw-Retained Angulated Screw Channel Single Crown Following Immediate Implant Placement and Provisionalization in the Esthetic Zone: A Cone Beam Computed Tomography Study," *Clinical Implant Dentistry and Related Research* 25 (2023): 789–794.