Review Article

FACTORS AFFECTING THE PROGNOSIS OF DENTAL IMPLANTS; A SYSTEMATIC REVIEW

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ABSTRACT

Since Branemark's debut in the 1970s, dental implants have gained popularity as a therapy option for rehabilitating lost teeth. This treatment option has its drawbacks, too, since prior studies have shown that dental implant failure rates may range from 1% to 19%. Depending on when the abutment was connected, these failures could be categorized as early or late failures: early failures happened before functional loading was applied, and late failures happened after occlusal loading was applied or, in situations where immediate implant loading was used after the provisional restoration was first removed. Three categories of factors affect bone loss around implants: social, systemic, and local. The implant body, occlusal loading, implant size, and biological characteristics are examples of the local variables. Structure-related factors that lead to bone loss include the type of connection (internal hex, external hex, conical, and their variations) and the size of a micro gap between the implant and abutment. Abutment height, smoking habits, and bone substratum are crucial factors influencing marginal bone loss, with mismatching distances having no substantial impact. Abutment height is pivotal in preserving implant bone in the early stages. Time efficiency in digital workflows for implant crowns varies significantly based on materials. Overall, these findings contribute valuable information for optimizing the success and longevity of dental implant treatments.

Key words: Dental implants, Factors, Success rate, Systematic review.

Introduction

Since Branemark's debut in the 1970s, dental implants have gained popularity as a therapy option for rehabilitating lost teeth [1]. This treatment option has its drawbacks, too, since prior studies have shown that dental implant failure rates may range from 1% to 19% [2, 3]. These failures could be classified as either early or late, depending on when the abutment was connected. Early failures occurred prior to the application of functional loading, while late failures occurred following the application of occlusal loading [4]. Early failure pertains to the inability of dental implants to develop osseointegration, while late failure refers to the inability of dental implants to establish osseointegration or function [5]. If there are just biological consequences in an early failure, there may be both biological and mechanical difficulties in a late failure. Biologic consequences may arise from peri-implantitis, which often includes soft and hard tissue resorption. Inadequate implant loading design may result in mechanical issues, which may fracture the implant's superstructure, screw body, or implant body [4]. Inadequate osseointegration results in implant slacking, which may result in movement or bone loss. It is well-recognized that all dental implants experience bone loss over time. Bone loss happens in two phases. The degree of early bone loss is contingent upon the duration of implant exposure and the prosthetic connection. The parameters of dental implants (diameter, surface treatment, connection type, and overloading), as well as prosthesis (retention technique and number of pieces), may all have an impact on marginal bone loss [5].

Three categories of factors affect bone loss around implants: social, systemic, and local. Among the local factors are the implant's size, biological properties, occlusal stress, and body. Structure-related factors that lead to bone loss include the type of connection (internal hex, external hex, conical, and their variations) and the size of a micro gap between the implant and abutment. One-piece, two-piece, and multi-part implants, as well as their shapes, diameters, lengths, stiffness, and surface topography—which is created by etching, oxidizing, sandblasting, and laser patterning—as well as the threads—V-thread, buttress, and reverse buttress—all have a substantial impact on the process [6]. When applied to prostheses supported by implants, occlusal loading has the potential to cause peri-implantitis and implant loss. Implant diameter primarily affects cortical peri-implant zones, which are prone to overloading, regardless of the length of the bone-implant contact. But implant length and diameter may also impact bone loss around implants [7].

Although prior research has shown that implant overloading and peri-implantitis are major risk factors for late failure [8], little is known about additional variables influencing the maintenance of implant osseointegration. Only one analysis this decade examined the risk factors for late dental implant failure, in contrast to others that focused on the risk factors for early implant failure [9]. According to reports, the risk factors for late failure include prosthesis overloading, peri-implantitis, and incorrect prosthesis fit [8]. However, given the absence of reporting on the methodology and the other details on the selected research, it seems probable that the review was an author's commentary [10, 11]. With reference to the PRISMA (Preferred reporting items for systematic reviews and meta-analyses) criteria, the goal of the current study was to do a systematic evaluation of the literature published during the previous ten years on likely factors associated with dental implant prognosis.

Materials and Methods

A systematic literature review from 2000 to 2023 was performed using PubMed, Medline, and ScienceDirect databases. The keywords used were "prognosis," "implants," and "systematic review." The procedure for selecting articles from the search was outlined using a PRISMA flowchart **(Figure 1)**.

The following requirements must be met:

- Published in English between 2000 and 2023
- Case-control and randomized control studies
- In vivo (humans)

Exclusion criteria

- Systematic reviews, meta-analyses, expert opinions, or narrative reviews
- Survey-based studies
- Out of the specified time range
- Language other than English
- In vitro

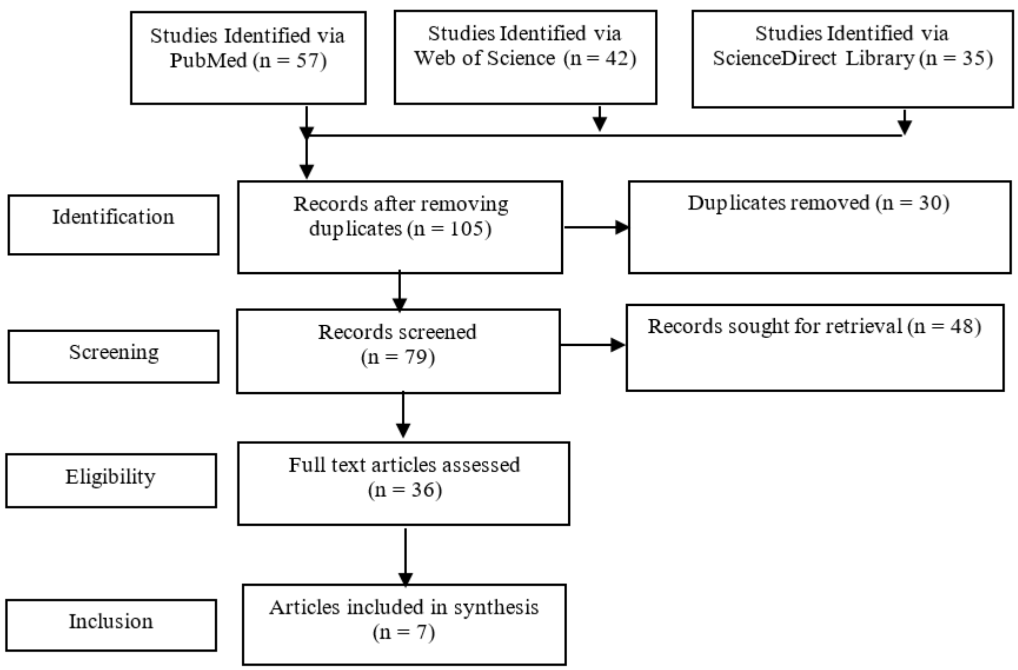

Figure 1. PRISMA Flow Diagram

Risk of bias assessment

The quality of the included studies was evaluated using the Cochrane risk of bias assessment technique **(Table 1)**.

Table 1. Summary of Cochrane Risk of Bias Assessment

Study	Selection Bias/Appropriate control selection/baseline characteristics similarity	Selection bias in randomization	Selection bias in allocation concealment	Performance-related bias in blinding	Reporting bias/Selective reporting of outcomes	Detection bias Blinding outcome assessors	Accounting for confounding bias
Blanco (2018) [7]	-	+	+	+	+	+	+
Galindo-Moreno (2016) [8]	+	+	+	+	+	+	-
Tan *et al*. (2011) [9]	+	+	+	+	+	+	+
Jokstad (2015) [10]	+	+	+	+	+	+	+
Schmidt (2020) [12]	+	+	+	+	-	+	+

Cappare (2019) [13]	+	+	+	+	+	+	+
Joda *et al*. (2016) [14]	-	+	+	+	+	+	+

Results and Discussion

Table 2. Summary of the included studies with their findings

Study	Objective	Participants	Key Factors Studied	Main Findings
Blanco (2018) [7]	Impact of abutment height on MBL	108 patients, 228 implants	Abutment height, smoking, bone substratum, follow-up duration, implant diameter	Short abutments, smoking, and bone substratum influence MBL in the short- and medium-term. Increased mismatching does not reduce MBL.
Galindo-Moreno (2016) [8]	Impact of abutment height on IBL	22 patients, 44 implants	Abutment height	Short abutments result in more interproximal bone loss after six months.
Tan *et al*. (2011) [9]	Healing around tissue-level implants with different neck shapes	18 patients, 2 implants each	Neck shape	Compared to implants with a 2.8 mm turned neck, those with a 1.8 mm turned neck have reduced crestal bone loss one year later.
Jokstad (2015) [10]	Implant: Supra structure mismatch and adverse events	30 individuals with implant-retained FDP	Supra structure mismatch	There is no significant difference in adverse events based on different metal alloys used for frameworks.
Schmidt (2020) [12]	Comparison of intraoral scanners (IOS) and traditional impressions	5 patients	IOS vs. traditional impressions	IOS devices with recent software show reduced deviation for short-span distances. Traditional impressions have lower variation over large span distances.
Cappare (2019) [13]	Time-efficiency of porcelain fused to ZrO2 vs. monolithic LS2 + titanium base for implant crowns	20 participants	Crown material and workflow	Monolithic LS2 crowns with titanium base in a digital workflow are more time-efficient than porcelain fused to ZrO2.
Joda *et al*. (2016) [14]	Therapy for monolithic LS2 single-unit restorations	44 patients, 50 implant LS2 crowns	Monolithic LS2 restorations	Two clinical visits effectively treat patients. LS2 restorations show 100% survival rates with no issues after two years.

The purpose of Blanco's study (2018) [7] was to compare and radiographically analyze the marginal bone loss (MBL) across implants with different mismatching distances and to look at how the prosthetic abutment height affects MBL in relation to those distances. The 108 patients in this retrospective analysis had 228 implants inserted; 180 of the implants had a 4.5 mm diameter, and 48 had a 5 mm diameter. We collected information on smoking behaviors, age, gender, bone substratum, prior periodontitis history, and prosthetic characteristics. After loading, MBL underwent radiographic analysis six and eighteen months later. The results of the mixed linear analysis of the mesial and distal MBL values showed that the following factors had a significant impact: smoking, bone substratum, follow-up duration, abutment × time interaction, and implant diameter. For implants with a diameter of 5.0 mm compared to 4.5 mm, grafted vs unmodified bone, and short versus long abutments, MBL was greater after 18 months compared to 6 months. In the short- and medium-term, abutment height, smoking habit, and bone substratum may all be significant variables; increased mismatching does not lower the MBL **(Table 2)**.

Galindo-Moreno (2016) [8] has out randomized clinical research to investigate the effect of two different heights (1 and 3 mm) of definitive abutments placed at bone-level implants with a platform-switched design on the interproximal implant bone loss (IBL). Twenty-two patients received 44 implants (6.5–10 mm in length and 3.5–4 mm in diameter) to replace at least two neighboring lost teeth. One bridge set, consisting of two implants per bridge, was given to each patient. Patients were randomly allocated to one of two unique abutment heights (1 or 3 mm), with only one abutment height per bridge. Measurements were taken clinically and radiologically three and six months after surgery. During the IBL investigation, there were no appreciable alterations in the correlation between patient characteristics and clinical variables, except for smoking.

The abutment height is a critical factor in maintaining implant bone level throughout the early phases of recovery. After six months, there was more interproximal bone loss with short abutments than with long abutments.

After at least a year of functional stress, the study by Tan *et al*. (2011) [9, 15] examined how different neck shapes' tissue-level implants affected the remodeling and repair of soft and hard tissues. Two implants were positioned in the same sextant for eighteen patients whose backs had several missing teeth. Two implants were randomly assigned: one control (C) had a turned neck measuring 2.8 mm, and the other test (T) had a turned neck measuring 1.8 mm. Every implant was positioned transmucosal to a sink depth of around 1.8 mm. Additionally, a frequency study conducted a year after loading revealed that a higher percentage of T implants (50%) than C implants (5.6%) had crestal bone levels 1-2 mm below the implant shoulder. Implants featuring a 1.8 mm reduced height turned neck can reduce crestal bone resorption and preserve higher amounts of crestal bone when immersed to the same depth as implants featuring a 2.8 mm turned neck. Furthermore, after a year of operation, crestal bone levels may be influenced by several variables besides the vertical orientation of the rather rough SLA surface.

The purpose of Jokstad's study (2015) [10, 16] is to evaluate the relationship between implant: supra structure mismatch and long-term biological and mechanical adverse events in patients who have had an implant-retained fixed dental prosthesis (FDP) placed in their edentulous jaw. 2012 saw a clinical examination of thirty individuals who had undergone treatment for an edentulous mandible using implant-supported prosthesis prior to 2000. Each patient had four to six implants placed to maintain an acrylic FDP with three distinct metal alloys—Ag-Pd, Pd-Ag, and Au type IV. Fourteen out of thirty patients experienced at least one screw loosening, abutment, or prosthetic screw fracture during the follow-up. Fisher's exact test showed that the incidence of the frameworks composed of different metal alloys did not change ($P > 0.05$).

In order to update the literature's data on the transfer accuracy (trueness/precision) of four contemporary intraoral scanners (IOS) equipped with the latest software versions and compare it with traditional impressions (CVI), Schmidt (2020) [12] carried out a clinical investigation. Four digital impressions (Trios3Cart, Trios3Pod, Trios4Pod, and Primescan) were analyzed, and five patients had one CVI. The scan data was analyzed using three-dimensional analysis tools and conventional models using a coordinate measurement instrument. One is to classify any statistically significant differences with $p < 0.05$. Within the parameters of this experiment, current IOS devices with the latest software versions demonstrated lower deviation for short-span distances when compared to the conventional impression technique. However, the traditional imprint approach yielded the lowest variation over large span distances. The IOS systems that are now on the market have improved the accuracy of patient transfers of full-arch scans.

The objective of Cappare's randomized controlled experiment (2019) [13] was to compare the time-efficiency of using porcelain fused to zirconium dioxide (ZrO_2) vs monolithic lithium disilicate (LS2) + titanium base for implant crowns in a digital workflow. In the premolar and molar sites, twenty research participants had single-tooth replacements. The beginning of the prosthetic therapy was baseline. All patients had transocclusal screw-retained implant reconstructions on a soft tissue level-type implant. The three-dimensional position of the implant was recorded using intraoral optical scanning (IOS). It took two clinical visits to fit all implant crowns and perform IOS. As the total clinical and laboratory work stages, the mean total production time varied significantly: it was 75.3 min (SD ± 2.1) for the test and 156.6 min (SD ± 4.6) for the control group ($P = 0.0001$).

Joda *et al*. prospective clinical study (2016) [14] set out to investigate the concept of therapy in a comprehensive digital procedure for monolithic lithium disilicate (LS2) single-unit restorations. In order to restore 44 patients, 50 screw-retained monolithic implant LS2 crowns connected to prefabricated titanium abutments in the premolar and molar positions were placed using soft tissue level implants (Institut Straumann AG, Basel, Switzerland). All implant restorations were created digitally after intraoral optical scanning (IOS) and CAD/CAM processing without the usage of real model settings. The "Functional Implant Prosthodontic Score" (FIPS) was utilized for an objective outcome evaluation following a two-year loading period. For the FIPS assessment, five factors were developed, and each implant restoration could get a maximum score of 10. It was possible to treat every patient effectively in only two clinical visits. There were no clinical changes needed for the seating of the monolithic crowns at either the occlusal or interproximal locations. The implant LS2 restorations exhibited 100% survival rates after two years, with no biological or technical issues. The FIPS score varied between 6 and 10, averaging 7.7 ± 1.0.

The systematic review of various studies on factors affecting the prognosis of dental implants reveals significant insights. Abutment height, smoking habits, and bone substratum emerge as crucial factors influencing marginal bone loss, with mismatching distances having no substantial impact. Abutment height plays a pivotal role in preserving implant bone in the early stages. Time efficiency in digital workflows for implant crowns varies significantly based on materials. Overall, these findings contribute valuable information for optimizing the success and longevity of dental implant treatments.

Previous research has shown how scan route affects full-arch scan accuracy [17-19]. Recently, Passos *et al*. discovered that using a more complex scan approach increased accuracy. In dental practice, it is still unclear how much the practitioner must understand about various scanning pathways or how to utilize the best scanning path for the particular scanner. A constant scan route was kept to improve IOS system compatibility [20]. To our knowledge, only two prior investigations have examined full-arch impressions in patients using a reference [10, 21, 22], which makes it difficult to draw comparisons between our research's findings and those found in the literature. Most studies superimposed datasets of digital scans and scanned models created from a conventional impression using a best-fit approach [9, 23]. However, this configuration permits a comparison between the two digital data sources. They don't address the issue of whether an individual's actual circumstances match the digital information. Moreover, it is still being determined whether using a compensation computation like the best-fit approach eliminates any discrepancies between the two sets of data [21]. In previous research, O'Toole *et al*. examined several alignment techniques and strongly advised reference alignment to lower measurement errors [24-26].

The procedure of restoring edentulous or partially edentulous jaws with osseointegrated implants is difficult in the eyes of both patients and doctors. Scientific advances and the body of available data have contributed to the agreement that, instead of invasive treatments like bone grafting, it may increase complications, illness, and expenses and reduce patients' willingness [4, 27]. The limitations of bone quality can be overcome by rehabilitations that combine axial [1] and non-axial implants implanted with rapid loading procedures, especially in the maxillary and posterior regions most of all. The advantages of this procedure, such as its minimal invasiveness, quick functional and aesthetic results [1], and shorter treatment times overall [5], match the real expectations of the consumers. The traditional approach of implant prosthetic rehabilitation, which has long been considered the gold standard in clinical practice, entails several manually operated generating phases, specialist dental technicians, and imprint materials prone to dimensional discrepancies [6].

A study of the literature [7] found that the primary element affecting the fit of the structures is the precision of the impression, which is influenced by the impression material, impression method, implant angulation, and implant quantity. The long-term effectiveness of the implant-fixed prosthesis depends on an ideal fit [8]. Any improper framework might result in biological issues that could jeopardize the homogeneity of the occlusal load as well as mechanical issues like screw loosening or breakage [8, 9].

The findings of this radiological study refute our theory that a greater horizontal mismatching distance corresponds to a smaller MBL. One interesting observation was that implants with larger (5.0 mm) diameters had a greater MBL than those with narrower (4.5 mm) diameters when the abutment was 2 mm or more. When data for all implants (with both diameters) were merged, it was demonstrated that the abutment height substantially influenced the peri-implant MBL and that it was larger when this was 2 mm or higher, in keeping with other reports. After the prosthesis is delivered, a small amount of bone loss is still seen as a positive result and as inevitable because of the biological width. Recent research indicated that a bone loss >0.45 mm at 6 months post-loading was a clear indication of bone loss progression, regardless of the etiology of the MBL. This emphasizes the necessity for the physician to take all feasible actions to decrease the initial MBL [25, 28, 29].

According to recent investigations, switching platforms did not stop marginal bone resorption when a thin mucosa was present. We have excluded this element from our analysis by focusing exclusively on patients where the thickness of the mucosa at the surgical site was at least 3 mm. Research has shown that implant-abutment contact is one of the main causes of marginal bone alterations [30-32]. The bacterial colonization of the interior surfaces of the various components and the micro-gap in external abutment connection implants may account for the presence of germs at this stage. The creation of the biological width will, therefore, lead to an anticipated infiltration of inflammatory cells and bone remodeling. Implants using internal abutment connections, like the ones used in this investigation, have successfully addressed this issue [33, 34].

Clinical and radiological data did not significantly vary between the test and control locations in the current investigation due to the patient's randomization. As a result, the RCT baseline offered the best circumstances for testing postoperative bone loss. In the present study, the bone loss seen in the Standards Straumann implants was similar to that observed in other research with the same implant system. Furthermore, compared to the same circumstances (control) in the current investigation, the clinical experimental trial conducted to examine the impact of an increased sink depth indicated comparable levels of radiographic bone loss [35, 36].

Most writers have tried to quantify the distance between the framework and abutments in order to evaluate the impact of mismatch in clinical research. Since assessing the internal stress distribution in a superstructure and implants is impossible, this is primarily a practical decision. The suggestion is that after tightening the retaining screws, vertical gaps as small as 100 micrometers may be quickly filled. One may presume that standard methods for evaluating the vertical gap between the framework and abutments need to capture the internal stress in the superstructure better. A modern 3D intra-oral scanner combined with a lab scanner and software designed to compute the difference between the virtual 3D models of the framework and abutments can successfully address the aforementioned problem [37].

In the present research group, the total misfit value of the FDP on its supporting implants fell between 95 and 232 lm. Nineteen years of follow-up, on average, did not reveal a correlation between the mismatch and the degree of marginal bone loss. It is uncertain how much static stress the non-passive superstructures in this investigation applied to the surrounding bone and implants. It is possible to speculate that the artificial gold screws may have absorbed [38].

Most studies superimposed datasets of digital scans and scanned models created from a conventional impression using a best-fit approach. However, this configuration permits a comparison between the two digital data sources. They don't address the issue of whether the patient's actual circumstances match the digital information. Moreover, it is still being determined whether using a compensation computation like the best-fit approach eliminates any discrepancies between two datasets [23]. Digital impressions yielded more accurate findings than traditional impressions for the two short lengths in the posterior segments (D1_2 and D3_4). These results are comparable to what Keul *et al*. [23] reported.

However, Ender *et al*. found that the CVI technique had the highest accuracy, even at small distances [21]. More accurate results for short-term spans are comparable to those of earlier studies, even though more exact findings for transfer accuracy were seen across shorter distances. This could be explained by the increasing matching or stitching error with scan time [38, 39]. Longer distances, including those that span the whole quadrant (D1_4), showed more accurate trueness and precision findings from the CVI. These findings align with those of previous research [3, 10]. The Trios 3 Pod and the Primescan in this clinical study had more significant total deviations than the laboratory results reported by Ender *et al*. [21] and Torres-Alemany *et al*. [40]. This might be explained by the in vivo environments, the potential of employing different evaluation methods (percentiles), the presence of saliva, oral structures, and patient movement(s) that could impair accuracy [39].

Time resources are precious in day-to-day operations. Patients want top-notch care that is also focused on their convenience. More specifically, this entails fewer visits and shorter clinical sequences. The main goal of the economical study of the two distinct workflows for treating and producing implant crowns—"monolithic LS2 plus titanium base" and "porcelain fuse to ZrO2"—was time efficiency. The results of this RCT demonstrated the monolithic LS2 plus titanium base process's clear superiority. Test reconstructions thus took around half as long for the whole clinical and laboratory course of therapy. It is possible to verify the idea that monolithic LS2 with a titanium base would have a faster workflow than porcelain fuse to ZrO2. Comparatively, relatively few prospective or retrospective clinical studies in the dentistry literature today examine digital implant processes based on time analysis. Only two clinical studies evaluated all implant prosthetic procedures with time-efficient results [40].

Monolithic crowns connected to prefabricated abutments simplify the total treatment for implant-supported single-unit restorations, which begins clinically with IOS and proceeds digitally without the need for physical models. Then, given a complete collection of bits and bytes, this procedure is really "digital." Standardized manufacturing quality ensures material-specific benefits and streamlines labor-intensive laboratory work procedures. The particular digital protocol and used technologies, such as the IOS device, together with further data processing, significantly impact the quality of the (prosthodontic) therapy. The technicians and physicians must also complete training and learn about the various software programs and applications. There are restrictions on the restoration's expansion nowadays. In fixed implant prosthodontics, the precision of IOS in conjunction with its application is a well-proven concept for single units. What kind of CAD/CAM material would be best for monolithic implant restorations is a topic of much debate [40].

On the other hand, since these materials must endure strong loading pressures, there is a greater chance of abrasions developing at the opponent over time, particularly with natural teeth. Furthermore, the aesthetic look of monolithic implant restorations needs to meet the standards for the treatment in the aesthetic zone, independent of the materials presently on the market. Standardized protocols provide advantages in terms of workflow cost-effectiveness, predictability of the end output, and process simplicity. However, implementing customized aesthetics with full digital techniques might be challenging. For monolithic implant restorations, preliminary in vitro experiments have shown encouraging outcomes. These laboratory tests yielded consistent stiffness and strength values for prefabricated titanium abutments combined with bonded full-contoured superstructures composed of hybrid ceramics and LS2, with the former having a stronger value than the average occlusal force of naturally dentate patients under quasistatic loading. With a single assessment technique, FIPS aims to address all clinically and radiographically significant elements of fixed implant restoration evaluation while keeping things as straightforward as possible. Neither the mixed ceramics nor LS2 showed any signs of bonding connection loosening in these trials [41]. This innovative method has the potential to serve as an extra evaluation tool for analyzing patient satisfaction, spotting treatment failure risks early on, and comparing follow-up observations. A prosthodontist handled every stage of the surgical plan and the follow-up exams in this clinical study. Future clinical trials are required to reassess and, ideally, validate the use of FIPS. It would be essential to conduct a trial-setting analysis of the repeatability across various specialized dentists in order to determine the benefits and potential drawbacks of the new score [42, 43].

Conclusion

Abutment height is pivotal in preserving implant bone in the early stages. Time efficiency in digital workflows for implant crowns varies significantly based on materials. Overall, these findings contribute valuable information for optimizing the success and longevity of dental implant treatments.

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