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How Long Does It Take for Implant Success to Be Truly Successful?

Since it was first introduced with substantial documentation through the work of P-I Branemark's group, along with Prof Schroeder's Swiss group and others, dental implants have served as a vital treatment option for close to half a century. Over this time, our focus has shifted from survival to success. The classical implant success criteria proposed by Albrektsson et al in this very journal in 1986 included immobility, absence of peri-implant radiolucency, adequate width of the attached gingiva, and absence of infection.¹ Others have defined success as no progressive relative bone loss (RBL) after physiologic bone remodeling and no exudate/suppurative. Although maintaining osseointegration is the minimum prerequisite, a surviving implant in situ with an exposed abutment and threads is not considered successful in 2024. Modern-day implant success has been extended to include the maintenance of surrounding hard and soft tissues and the restorations supported by the implant, founded on our ability to evaluate functional implant therapy over longer periods of time.

In a recent retrospective radiographic study evaluating the All-on-4 technique over 5 to 14 years of follow-up, Tironi et al analyzed changes in the marginal bone level and the occurrence of peri-implantitis.² A 10-year prospective study by Rocuzzo et al evaluated the outcomes of soft tissue grafting in single maxillary buccal sites with peri-implant soft tissue dehiscences.³ Patients with a single implant-supported restoration in the maxilla that exhibited apical displacement of the soft tissue margin were enrolled, and it was found that short-term esthetic improvements following grafting were maintained over a 10-year period.

French et al analyzed marginal bone level loss in a recent retrospective study on a cohort of 4,247 patients over 22 years.⁴ Although the study only reported marginal bone loss in combination with bleeding on probing and a few other factors, observing outcomes from more than 20 years of follow-up in over 10,000 implants is revealing. The study found that bone levels were relatively stable over longer periods of time, with smoking and autoimmune conditions predictive of greater bone loss.

Investigating a more specific treatment modality, Donker et al studied immediate placement with (1) immediate and (2) delayed provisionalization in the anterior maxilla after 10 years of function. The study measured marginal bone level, buccal bone thickness by CBCT, and esthetic parameters (Papilla Index and Pink Esthetic Score).⁵ Both groups showed similar changes. Despite the relatively small number of participants at the 10-year mark (18 and 16, respectively), incorporating esthetic parameters and CBCT measurements was significant in defining long-term success.

Implant esthetics is often an important patient-related outcome, and interdental papilla presence and midbuccal mucosa maintenance are increasingly being considered over longer periods of time. A recent 10-year prospective case series of two adjacent implant-supported prostheses reported marginal bone level, Pink and White Esthetic Scores, and patient satisfaction. This study showed that both the initial positive and negative treatment outcomes remained stable and patients were satisfied with esthetics over 10 years.⁶

A retrospective study by Chen et al⁷ examined the socket shield technique in conjunction with immediate

implant placement and provisionalization in preserving interdental papilla for up to 10 years. Although this study reported the maintenance of interimplant papilla and bone height, socket shield exposure was found in one of every four cases, mainly occurring within the first year.

True implant success should encompass the overall functional considerations for the patient, including prosthetic outcomes. A systematic review by Sailer et al summarized the outcomes and outcome measures being reported for single and partial fixed implant-supported prostheses over the last 10 years.⁸ They found that assessments related to peri-implant tissue stability and patient esthetic satisfaction are not consistently used and that the outcomes defining success vary widely between studies.

Goldstein et al mention that the inevitable changes accompanied by aging or skeletal remodeling can cause implant complications, such as the loss of interproximal contact between an implant crown and adjacent natural teeth and the intrusion of a natural tooth when the tooth is between two implant-supported restorations reinforce the need for longer term considerations.⁹

We are clearly investing in implant therapy for the long term, and it is important that we fully appreciate the benefits and limitations of this approach as we view our clinical success. Going forward, the way we define success will continue to change and be added upon. As we aim for longer-term successes for implant therapy, it is clear that there remains a need for more robust examination of outcomes, greater understanding of the underlying mechanisms related to adverse occurrences, and higher-quality prospective studies that better define when implant success is truly successful.

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Tironi F, Orlando F, Azzola F, Vitelli C, Francetti LA. Implants placed with the All-On-4 technique: A radiographic retrospective study on 156 implants with a 5- to 14-year follow-up. *Int J Periodontics Restorative Dent* 2023;43:606–613.

The aim of this retrospective study was to evaluate the performance of implants placed with the All-on-4 technique after a mean time in function of 9 years. A total of 34 patients with 156 implants were selected for this study: 18 patients underwent tooth extraction on the day of implant placement (Group D), and 16 patients were already edentulous (Group E). A periapical radiograph was taken at a mean follow-up of 9 years (range: 5 to 14 years). Success and survival rates and the prevalence of peri-implantitis were calculated. Statistical analysis was used to assess comparisons between groups. After a mean follow-up

of 9 years, the cumulative survival rate was 97.4% and the success rate was 77.4%. The difference between the initial and final radiographs resulted in a mean marginal bone loss (MBL) of 1.3 ± 1.06 mm (range: 0.1 to 5.3 mm). No differences were seen between Groups D and E. Peri-implantitis affected 15 implants (9.6%) in 9 patients (26.5%). This study shows that the All-on-4 technique is a reliable treatment method for both edentulous patients and patients requiring tooth extractions, with results maintained over a long follow-up period. The present MBL results are similar to those around implants in other rehabilitation types.

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Rocuzzo A, Mancini L, Marruganti C, Ramieri G, Salvi AG, Sculean A, Rocuzzo M. Long-term treatment outcomes of single maxillary buccal peri-implant soft tissue dehiscences: A 10-year prospective study. Clin Implant Dent Relat Res 2024;26:150–157.

Aim: To evaluate the 10-year clinical outcomes following surgical treatment of shallow isolated peri-implant soft-tissue dehiscences (PSTDs) at single tissue-level dental implants. The baseline population included 16 patients (16 implants) displaying an isolated peri-implant maxillary buccal soft-tissue dehiscence. The recipient bed was prepared with a minimally invasive split-thickness flap limited to the buccal aspect to stabilize the tuberosity connective tissue graft (CTG) onto the periosteum. At the end of treatment, patients were enrolled in an individualized supportive peri-implant care (SPC) program. The aesthetic outcome was evaluated on photographs by three clinicians using a visual analog scale (VAS). SPC during the 10 years proceeded uneventfully in all patients. A total of 12 patients completed the 10-year examination, as 3 patients dropped out and 1 implant was lost. Complete PSTD coverage was obtained at 7 implant sites (ie, 58%) while the mean PSTD coverage amounted to $89.6\% \pm 17.1\%$ without statistically significant differences between 1 and 10 years ($P > 0.05$). Stable peri-implant parameters (ie, PD and BoP) and full-mouth scores (ie, FMPS, FMBS) were recorded throughout the observation period ($P > 0.05$). The aesthetic improvements obtained in the short-term were maintained up to 10 years. Within their limits, the present results indicate that the proposed surgical technique is a simple and reliable treatment option for the treatment of single maxillary buccal PSTDs in selected cases with positive results up to 10 years in patients under regular SPC.

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French D, Clark-Perry D, Ofec R, Levin L. Radiographic bone loss around dental implants: A large-cohort, long-term follow-up revealing prevalence and predictive factors. Quintessence Int 2024;55:296–303.

This retrospective study analyzed radiographic bone levels of 10,871 dental implants in a cohort of 4,247 patients over a 22-year period. The objectives of the study were to assess and explore risk factors associated with the radiographic bone level of dental implants. A longitudinal observational cohort study based on data collected from 1995 to 2019 was conducted on implants placed by a single periodontist. Inclusion criteria included both partially and fully edentulous sites. Exclusion criteria were patients who were considered ASA 3 or greater. Information on medical and dental status prior to implant placement, such as diabetes and smoking, were included in the analysis. Implant factors, such as the implant characteristics (length and diameter) and surgical site, were recorded. The outcome assessed was the prevalence of bone loss around implants and any associative factors related to the bone loss. Overall, dental implants lost an average of 0.05 ± 0.38 mm of bone 2 to 3 years after placement and 0.21 ± 0.64 mm 8 years

after placement. The soft tissue condition was evaluated using the Implant Mucosal Index (IMI), and bone loss around dental implants was significantly higher when bleeding on probing was multi-point and moderate, multi-point and profuse, and when infection with suppuration was recorded. The mean difference in bone level between smokers and nonsmokers was 0.26 mm ($P < 0.01$) over a 4-year period. A mean difference of 0.10 mm ($P = 0.04$) in bone loss over 4 years was found between those with an autoimmune disease compared to those without. The diameter of the implant and immediate loading of the dental implant did not influence the radiographic bone levels over time. This large data set of dental implants highlights predictive risk factors for bone loss around dental implants and the impact these risk factors have on the implant bone level. Consideration of these risk factors by both the dental team and the patient prior to dental implant placement will promote success of the treatment.

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Donker VJJ, Raghoobar GM, Slagter KW, Hentenaar DFM, Vissink A, Meijer HJA. Immediate implant placement with immediate or delayed provisionalization in the maxillary aesthetic zone: A 10-year randomized trial. J Clin Periodontol 2024;51:722–732.

To compare the marginal bone level of immediately placed implants, with either immediate or delayed provisionalization (IP or DP), in the maxillary aesthetic zone after 10 years of function. Participants with a failing tooth in the maxillary aesthetic zone were randomly assigned to immediate implant placement with either IP ($n = 20$) or DP ($n = 20$) after primary wound closure with a free gingival graft. The final restoration was placed 3 months after provisionalization. The primary outcome was change in marginal bone level. In addition, implant survival, restoration survival and success, peri-implant tissue health, mucosa levels, aesthetic indices, buccal bone thickness, and patient satisfaction were evaluated. After 10 years, the mean mesial and distal changes in marginal bone level were -0.47 ± 0.45 mm and -0.49 ± 0.52 mm in the IP group and -0.58 ± 0.76 mm and -0.41 ± 0.72 mm in the DP group ($P = .61$; $P = .71$). The survival rate was 100% for the implants; for the restorations, it was 88.9% in the IP group and 87.5% in the DP group. Restoration success, according to modified USPHS criteria, was 77.8% in the IP group and 75.0% in the DP group. The prevalence of peri-implant mucositis was 38.9% and 35.7% and of peri-implantitis 0.0% and 6.3%, respectively, in the IP group and DP group ($P = 1.0$; $P = .40$). The Pink Esthetic Score and White Esthetic Score was 15.28 ± 2.32 in the IP group and 14.64 ± 2.74 in the DP group, both clinically acceptable ($P = .48$). The buccal bone thickness was lower in the DP group. Patient satisfaction was similar in both groups ($P = .75$). The mean marginal bone level changes after immediate implant placement with IP were similar to those after immediate placement with DP.

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Meijer HJA, Stellingsma K, Vissink A, Raghoobar GM. Two adjacent implant-supported restorations in the aesthetic region: A 10-year prospective case series. *Clin Implant Dent Relat Res* 2023;25:1216–1224.

The treatment outcome of two adjacent implant-supported restorations in the maxillary aesthetic region was assessed regarding peri-implant soft and hard tissues, and satisfaction during a 10-year follow-up period. Twenty patients missing two adjacent teeth in the maxillary aesthetic region and treated with two implant-supported restorations were followed prospectively. The patients' clinical and radiographic parameters, as well as their satisfaction, were scored for a 10-year follow-up period. Seventeen patients' data were available for the 10-year follow-up. The survival rate of the implants and restorations was 100%. The 10-year mean peri-implant bone change at the side facing the adjacent tooth was 0.11 ± 0.57 mm and at the side facing the adjacent implant was -0.08 ± 0.50 mm. The peri-implant soft tissues were healthy and the patients' satisfaction was high, but the papilla index showed compromised interimplant papillae and low Pink Esthetic Scores. These figures were of the same magnitude at all time points. While it is difficult to obtain sufficient interimplant papillae and satisfactory Pink Esthetic Scores, the initial treatment results remained stable and the patients were satisfied with the final result throughout the 10-year follow-up period.

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Chen JT, Kan JYK, Rungcharassaeng K, et al. Inter-implant papilla changes following anterior immediate tooth replacement with socket shields: A 1- to 10-year retrospective study. *Int J Periodontics Restorative Dent* 2023;43:451–460.

This retrospective study investigates the efficacy of the socket shield (SS) in preserving inter-implant papilla and bone in anterior adjacent implant sites. Clinical and radiographic records of 23 patients were evaluated. A total of 31 implants were placed immediately into extraction sockets with SS, resulting in 26 interimplant sites, and 7 implants were placed without SS. After a mean follow-up of 41.5 months (range: 12 to 124 months), 30/31 (96.8%) implants with SS and 7/7 (100%) implants without SS were clinically successful. The mean changes in interimplant papilla and bone heights were -0.40 mm and -0.46 mm, respectively. The effects of implant placement timing and the socket shield number, shape, and crestal level on interimplant tissue height changes were found to be insignificant ($P > .05$). Supracrestal shield level (31.6% vs 16.6% in eucrestal), U-shape shield (41.2% vs 7.1% in C-shape), and shield-to-implant contact (40.0% vs 12.5% in no contact) were associated with increased occurrence of exposures. The application of SS in adjacent anterior implant situations is a viable treatment option for maintaining interimplant papilla.

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Sailer I, Luigi Barbato L, Mojon P, et al. Single and partial tooth replacement with fixed dental prostheses supported by dental implants: A systematic review of outcomes and outcome measures used in clinical trials in the last 10 years. *Clin Oral Implants Res* 2023;34(suppl 25):22–37.

Aim: To evaluate outcome measures, methods of assessment, and analysis in clinical studies on fixed single- and multiple-unit implant restorations. Three independent electronic database searches (MEDLINE, EMBASE, and Cochrane) were done to identify prospective and retrospective clinical studies published from January 2011 up to June 2021 with ≥ 20 patients and minimum 1-year follow-up period on technical and clinical outcomes of implant-supported single crowns (SCs) and partial fixed dental prostheses (P-FDPs). An entire data extraction was performed to identify primarily the most reported outcome measures and later to define the choice of assessment methods of those outcome measures. The outcomes were analyzed descriptively, and the strength of association was evaluated using the Pearson chi-square test ($P \leq .05$). In a total 531 studies, 368 on SCs (69.3%), 70 on P-FDPs (13.1%), and 93 on both restoration types (17.5%) were included; 56.3% of all studies did not clearly define a primary outcome. The most frequent primary outcome was marginal bone level (MBL) (55.2%), followed by implant survival (5.3%), professional aesthetic evaluation (3.4%), and technical complications (2.1%). Peri-implant indices were the most-reported secondary outcome (55.1%), followed by implant survival (39.9%), MBL (36%), and implant success (26.4%). Prosthetic failure (7 studies [3.9%]) was one of the least-reported outcome measures. Outcome measures and their assessment methods showed high heterogeneity among studies. Primary outcomes were not often defined clearly, and the most frequently selected primary outcome was marginal bone loss. Prosthetic outcomes, implant survival, and patient-related outcomes were only infrequently reported.

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Goldstein G, Goodacre C, Brown MS, Tarnow DP. Proposal regarding potential causes related to certain complications with dental implants and adjacent natural teeth: Physics applied to prosthodontics. *J Prosthodont* 2024. Epub ahead of print.

Complications can and do occur with implants and their restorations, with causes having been proposed for some single implant complications but not for others. A review of pertinent literature was conducted. A PubMed search of vibration, movement, and dentistry had 175 citations, while stress waves, movement, and dentistry had zero citations, as did stress waves and movement. This paper discusses the physics of vibration, elastic and inelastic collision, and stress waves as potentially causative factors related to clinical complications. Multiple potential causes for interproximal contact loss have been presented, but it has not been fully understood. Likewise, theories have been suggested regarding the intrusion of natural teeth when they are connected to an implant as part of a fixed partial denture as

well as intrusion when a tooth is located between adjacent implants, but the process of intrusion, and resultant extrusion, is not fully understood. A third complication with single implants and their crowns is abutment screw loosening, with several of the clinical characteristics having been discussed but without determining the underlying process(es). Interproximal contact loss, natural tooth intrusion, and abutment screw loosening are common complications that occur with implant-retained restorations. Occlusion is a significant confounding variable. The hypothesis is that vibration, or possibly stress waves, generated from occlusal impact forces on implant crowns and transmitted to adjacent teeth, are the causative factors in these events. Since occlusion appears to play a role in these complications, it is recommended that occlusal contacts provide centralized stability on implant crowns and not be located on any inclined surfaces that transmit lateral forces that could be transmitted to an adjacent tooth and cause interproximal contact loss or intrusion. The intensity, form, and location of proximal contacts between a natural tooth located between adjacent single implant crowns seem to play a role in the intrusion of the natural tooth. Currently, there is a lack of information about the underlying mechanisms related to these occurrences and research is needed to define any confounding variables.

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