Clinical and Radiographic Outcomes of Single-Unit Implant-Supported Restorations: A 12-Month Cross-Sectional Clinical Study

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Purpose: To analyze the clinical and radiographic outcomes of single-unit implant-supported restorations comprehensively. ***Materials and Methods:*** In this retrospective study, 100 patients who had undergone 12 months of implant-supported single-unit fixed prosthetic treatment were scanned from the archives and were included in this study. Implant success and survival rates were assessed according to the consensus decisions published at the International Oral Implantology Congress in 2007. Prosthetic complications such as chipping, screw loosening, and decementation were also evaluated. In addition, success rates, survival rates, and prosthetic compositions were associated with a few surgical and prosthetic parameters. ***Results:*** According to the success and survival criteria, 88% of the implants were successful, 10% had satisfactory survival, and 2% had compromised survival. The risk of satisfactory or compromised survival was 62.5 times higher in individuals with inadequately keratinized mucosa compared to those with adequately keratinized mucosa ($P < .001$). This risk was also 5.736 times greater for extractions due to periodontal disease versus endodontic reasons ($P = .010$) and 4.629 times higher for implants with diameters < 3.75 mm compared to those between 3.75 mm and 5 mm ($P = .037$). Screw loosening was observed in 15% of the evaluated restorations, decementation in 13%, and chipping in 4%; note that the risk of screw loosening was 4.444 times higher for screw-retained abutments compared to standard abutments ($P = .015$). ***Conclusions:*** Insufficient keratinized mucosa, periodontal problems leading to tooth extractions, and the use of narrow-diameter implants can negatively affect the success of implant procedures. Loosening in screw-retained restorations is due solely to screw loosening, which is a high risk for screw-retained restorations. Loosening in cement-retained restorations, on the other hand, is caused by the decementation of the prosthetic restoration or loosening of the abutment screw supporting the restoration. *Int J Oral Maxillofac Implants 2025;40:493–503. doi: 10.11607/jomi.11233*

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Implant-supported restorations are an increasingly popular treatment method due to their advantages, such as not requiring adjacent teeth preparation and protecting the bone from alveolar bone resorption over time.[1] Success in modern dental implantology depends on various factors, including surgical procedures, prosthetic stages, and the patient's systemic health and oral hygiene. Additionally, the condition of the implant surface, the internal composition of the material, and any incompatibilities between these factors can lead to complications.[2] Complications in implant treatments include mechanical issues such as decementation, screw loosening, screw, abutment, and implant fractures, as well as porcelain fractures; biological problems like peri-implantitis, peri mucositis, soft tissue inflammation, hyperplasia, and infections; and esthetic concerns such as mucosal recession, papillary loss, facial contour deficiency, and color mismatch.[3,4] Complications that may arise from dental implants are more complex and costly than other prosthetic treatment options. Understanding the causes of these complications is essential for finding rational solutions to the problem.[4]

Implant survival is defined as the ability of the implant to survive in the area where it is placed. However, as this definition does not fully encompass the biologic status of implants and surrounding tissues, it does not fully reflect implant success. For this reason, researchers have proposed criteria beyond implant survival to evaluate implant success. For the criteria to be accepted, they must be objective and scientifically based. Although most of the criteria for assessing the success of an implant treatment has been defined in the literature, the consensus decisions adopted at the International Congress of Oral Implantologists (ICOI) in 2007 are the most widely accepted. These criteria are evaluated in four groups: *(1)* success, *(2)* satisfactory survival, *(3)* compromised survival, and *(4)* failure.[5]

Replacement of a single lost tooth is a common prosthodontic treatment in dentistry. With the continuous advances in implant dentistry, treatment options

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have expanded significantly, and implant-supported single restorations have increased in popularity as an alternative to traditional fixed prostheses. It is worth noting that single-tooth implant restorations now account for a significant proportion of daily implant cases in clinical practice, accounting for approximately half of all implant cases.[6,7]

It has been reported that a high percentage of implant failures occur within the first 6 months after placement, ranging from 40% to 83.4%. Early bone loss compromises long-term bone stability and implant survival. A 10-year prospective cohort study confirmed the role of early bone loss as a predictor for peri-implantitis, so a better understanding of such failures is needed.[8–11]

Several research studies have extensively examined the survival and complication rates associated with implant-supported fixed prostheses. However, there is a notable gap in the literature regarding comprehensive analyses specifically focused on single-unit implant-supported restorations during the early phase postoperatively. This gap in research highlights the need for more detailed investigations into the outcomes and challenges specific to single-unit implant-supported restorations in the early stages, which could significantly contribute to the evaluation of the long-term success of these restorations.

The purpose of this study was to analyze early complications in single-unit implant-supported restorations retrospectively and to investigate these complications concerning anatomical factors (such as the amount of keratinized mucosa and implant placement site), surgical factors (including immediate placement, implant levelling, length, and diameter), and prosthetic factors (such as opposing arch, occlusal table, abutment, and restoration type).

MATERIALS AND METHODS

Ethics Approval

This clinical study was conducted in accordance with the World Medical Association Declaration of Helsinki and was approved by the local ethics committee of Afyonkarahisar Health Sciences University Clinical Research Ethics Committee (Decision dated 07.04.2023; No.: 2023/4). All participants gave informed written consent to participate. The study was planned using the STROBE criteria for clinical studies.

Sample Size Calculation

The G*Power program (Franz Faul; version 3.0.10) was used to calculate the sample size. With a significance level of $\alpha = .05$ (95% confidence interval), an effect size of $d = 0.5$, and a power of $(1-\beta) = 0.80$, it was determined that at least 80 patients were needed. It was decided to start the trial with 100 patients by adding at least a 25% (20 patients) replacement rate of patients in order to avoid loss of information due to patient loss during the follow-up period and to avoid reducing the power of the trial.

Subject Selection and Criteria

Patients who had undergone 12 months of implant-supported single-unit fixed prosthetic treatment in the Department of Prosthodontics at the Afyonkarahisar Health Sciences University have been scanned from the archive. The study began on April 8, 2023, and included the first 100 patients who had been treated with implant-supported single-unit restorations for a period of 12 months as of that date (Appendix Figure 1; see online). The study sample was finalized upon reaching the 100th patient. The study was conducted with the first 100 patients who met the inclusion criteria. Inclusion criteria were as follows: *(1)* participants who were over 18 years old, *(2) had* no history of systemic disorders, *(3) did* not smoke, and *(4)* provided written and verbal consent to the study. Individuals with any systemic or psychiatric disorders who did not have radiographic data immediately after prosthetic loading and/or those who were rehabilitated with implants suitable for short concept were excluded from this study. All participants underwent periodontal treatment and their periodontal health was stabilized prior to implant surgery.

Evaluation of Implant Success and Survival

Subject data were thoroughly compared according to the four main criteria in the consensus decisions (Success, satisfactory survival, compromised survival, and failure). Success and survival rates were correlated with the following: presence of keratinized mucosa, the reason for tooth extraction, immediate implant placement, implant diameter, implant length, implant level, anatomical location of the implant, type of abutment used, occlusal table status, opposing arch status, and type of restorative material used. Box 1 shows the valid clinical and radiographic evaluations for ICOI consensus decisions.

Clinical evaluation

To assess success and survival, participants were examined for clinical parameters such as pain in function, mobility, and presence of exudate. Keratinized mucosa was measured as the distance between the gingival margin and the mucogingival junction. Areas less than 2 mm wide were considered inadequate, whereas those equal to or greater than 2 mm were considered adequate. Measurements were made with a periodontal probe and recorded in mm. To ensure the reliability of

Box 1 The 2008 ICOI Accepted Success and Survival Criteria

Success	
• < 2 mm of radiographic bone loss	• No pain in function
• No mobility	• No exudate
Satisfactory survival	
• 2–4 mm of radiographic bone loss	• No pain in function
• No mobility	• No exudate
Compromised survival	
• More than 4 mm of bone loss but less than half of the implant	• Pain may be observed in function
• No mobility	• Exudate can be seen
• More than 7-mm probing depth	
Failure	
• Bone loss of more than half the implant length	• Pain in function
• Mobility	• Exudate

the measurements, the graders underwent a standardized training program and were calibrated by an agreement analysis on pilot measurements.

Radiographic evaluation

Digital radiographs (periapical and panoramic films) of the patients at the end of prosthetic treatment and the 12-month controls were captured using Planmeca Romexis software (Planmeca). ImageJ digital image analysis software (ImageJ 1.54g- Wayne Rasband and Contributions, National Institutes of Health) was used to assess marginal bone loss on the radiographs. A 200% magnification was used in the analyses of panoramic radiographs, but no magnification was used for original periapical radiographs. Before measuring marginal bone loss, a calibration was carried out using a digital image analysis software based on implant lengths. Calibration involved measuring the distance from the first groove to the implant apex in pixels and calibrating this distance in millimeters to the actual implant length. Following the calibration, marginal bone loss was measured separately at the mesial and distal parts of the implant. To measure the marginal bone loss, a line was drawn from the starting point of the first groove of the implant to the most coronal part of the bone-covered area on the implant, and this line was measured in millimeters. The net marginal bone loss in both regions was measured in millimeters by subtracting the measurements immediately after prosthetic loading from those 12 months postoperatively in the mesial and distal regions separately. The mean marginal bone loss of the implant was determined by taking the arithmetic mean of both measurements. The measurement was repeated three times, and the mean value was recorded. The same investigator (N.P.) took all measurements to ensure standardization. Panoramic and periapical radiographs were taken for each evaluated implant, and the mean bone loss was calculated by taking the arithmetic mean of the values obtained from the periapical and panoramic radiographs.

Evaluation of Prosthetic Complications

Participants were evaluated for prosthetic complications such as decementation, screw loosening, and chipping. These parameters were related to the type of abutment used, the condition of the opposing arch, and the occlusal table.

Statistical Analysis

In this study, the patient was considered the statistical unit and only one implant was considered per patient. SPSS Statistics (Version 26) (IBM SPSS Statistics) was used for statistical analyses to evaluate the results obtained in the study, and the conformity of the parameters to the normal distribution was assessed using Kolmogorov-Smirnov and Shapiro-Wilk tests. In addition to descriptive statistical methods (mean, SD, median, and frequency), the Kruskal-Wallis test was used to compare quantitative data and parameters between groups. Dunn's test was used to determine the group responsible for the difference. The Mann-Whitney *U* test was used for pairwise comparisons of parameters, and the Fisher's Exact chi-square test was used for comparisons of qualitative data. Binary logistic regression was also used to analyze the effect of each independent variable on the dependent variable. In addition, in the presence of more than one independent variable significantly affecting the dependent variable, a forward stepwise regression model was used to assess the impact of the independent variables. The significance level was set at $P < .05$.

RESULTS

Participant Details

A total of 100 patients (42 males, 58 females) with each with one implant-supported restoration (100 implants total) agreed to participate in this study. The mean ± SD of age was 55 ± 11 years (range 30 to 77 years). Of the participants, 63% reported a history of tooth loss due to endodontic causes, 25% due to periodontal causes, and 12% due to trauma (Table 1). The distribution of implants evaluated in the study is shown in Table 2.

Table 1 Patient Information

Patient information	Percentage of patients
Age	
55 ± 11 y	—
Sex	
Female	58%
Male	42%
Reason for tooth extraction	
Endodontic	63%
Periodontal	25%
Trauma	12%

Table 3 Clinical Outcomes of the Participants

Clinical outcome	Percentage of occurrence
Presence of pain in function	2%
Mobility	—
Presence of exudate	1%
Sufficient presence of keratinized mucosa	94%
Success and survival criteria	
Success	88%
Satisfactory survival	10%
Compromised survival	2%
Failure	—

Clinical and Radiographic Results

Functional pain was noted in 2% of participants, clinical exudate was present in 1%, and reports of no mobility was never pointed out. When the success and survival criteria of the restorations were evaluated, the rate of success was 88%, the rate of satisfactory survival was 10%, the rate of compromised survival was 2%, and the amount of keratinized mucosa was found to be sufficient in 94% of individuals (Table 3). The mean marginal bone loss for all implants analyzed was 1.31 ± 0.76 mm.

Implant-Related Data

A total of 11% of the implants evaluated were placed using the immediate placement protocol. In addition, 35% of participants received narrow-diameter implants (< 3.75 mm) (35.0%), 58% of participants received standard-diameter implants (≥ 3.75 mm and < 5 mm), and 7% of participants received wide-diameter implants (≥ 5 mm). Standard-length implants (≥ 10 mm) were placed in 75% of individuals, whereas the remaining participants received implants shorter than 10 mm. It was found that 94% of the participants had implants placed at the bone level, while the others had implants placed at the tissue level. It was found that 14% of the implants were placed in the maxillary anterior region, 38% were placed in the maxillary posterior region, and 48% were placed in the mandibular posterior region. All implant-abutment connection types evaluated in the study are platform-switch designs.

Table 2 Surface Characteristics of the Implants Used in the Study

Brand	Manufacturer	Surface	Percentage of use in study
Implance	AGS Medical	Improved RBM	28%
Bilimplant	Proimtech Health Products	SLA	22%
Implant Direct	Implant Direct Systems	SBM	14%
Detech	Demirtaş Dental Depot	SLA	11%
NTA	Pilatus Swiss Dental	SLA	11%
Astra	Dentsply Sirona	OsseoSpeed surface	8%
INNO	Cowellmedi	SLA + alkali solution cleaning	6%

SLA = sandblasted large-grit acid-etched; RBM = resorbable blast media; SBM = soluble blast media of hydroxyapatite particles.

Restoration-Related Data

Of the restorations analyzed, 24% had natural teeth in the opposing arch, 32% had tooth-retained fixed prostheses, 20% had implant-retained fixed prostheses, 12% had implant-retained removable prostheses, and 12% had tooth-retained removable partial dentures or conventional complete dentures. It was found that 56% of the restorations had cement-retained abutments, 23% had screw-retained abutments, and 21% had Ti-base abutments. While 36% of the participants had a narrowed occlusal plate, 89% were rehabilitated with metal-supported ceramic, 9% with cut-back monolithic zirconia, and 2% with unsupported glass-ceramic. The current or past 12-month screw loosening rate was 15% and the sedimentation rate was 13%. In addition, the rate of chipping of framework-porcelain was 4%.

Statistical Relationships

According to Pearson's chi-square test, reasons for tooth extraction, immediate implant placement, implant diameter, anatomical site of implant placement, opposing arch status, type of abutment used, occlusal table width, and restorative material had no statistically significant effect on success and survival ($P > .05$). On the other hand, a statistically significant higher rate of compromised survival was found for implants shorter than 10 mm ($P = .041$) and tissue-level placement ($P = .024$). A statistically significant correlation was also between the

Table 4 Relationships of Success and Survival Criteria with Implant and Restoration Data

		Success and survival criteria			Pearson's chi-square test	Univariate binary logistic regression analysis	
Clinical outcome data	Outcome type	Success (n)	Satisfactory survival (n)	Compromised survival (n)	*P*	OR (95% CI)	*P*
Sufficient presence of keratinized mucosa	Yes	87	7	0	< .001	0.016 (0.002–0.157)	< .001
	No	1	3	2		Reference	
Reason for tooth extraction	Endodontic	59	3	1	.077	Reference	
	Periodontal	18	6	1		5.736 (1.506–21.842)	.010
	Trauma	11	1	0		1.341 (0.137–13.161)	.801
Immediate placement	Yes	8	3	0	.119	3.333 (0.747–14.867)	.115
	No	80	7	2		Reference	
Diameter	< 3.75 mm	28	5	2	.064	Reference	
	3.75–5 mm	55	3	0		0.218 (0.052–0.909)	.037
	≥ 5 mm	5	2	0		1.6 (0.255–10.045)	.616
Length	< 10 mm	20	3	2	.041	Reference	
	≥ 10 mm	68	7	0		0.412 (0.118–1.439)	.165
Level	Bone level	84	9	1	.024	Reference	
	Tissue level	4	1	1		4.2 (0.681–25.912)	.122
Anatomical location	Anterior maxilla	13	0	1	.354	Reference	
	Posterior maxilla	34	4	0		1.529 (0.156–14.992)	.715
	Posterior mandible	41	6	1		2.22 (0.249–19.756)	.475
Abutment type	Standard	49	6	1	.715	Reference	
	Screw retention	20	3	0		1.05 (0.247–4.472)	.947
	Ti-base	19	1	1		0.737 (0.14–3.869)	.718
Occlusal table	Narrowed	30	5	1	.560	1.933 (0.574–6.512)	.287
	Normal	58	5	1		Reference	
State of the opposing arch	NT	23	1	0	.141	NA	NA
	NFP	29	2	1			
	IFP	15	5	0			
	IRP	12	0	0			
	RP	9	2	1			
Restorative material	MC	79	9	1	.346	NA	NA
	ZC	7	1	1			
	MC	2	0	0			

NT = natural tooth; NFP = tooth-supported fixed prosthesis; IFP = implant-supported fixed prosthesis; IRP = implant-supported removable prosthesis; RP = tooth-supported partial or conventional full denture; MC = metal (Ti)-ceramic; ZC = zirconia-ceramic; MC = monolithic all-ceramic; OR = odds ratio; NA = not available (because the confidence interval cannot be calculated).

amount of sufficiently attached keratinized mucosa and successful survival ($P < .05$). Healthy, successful survival rates were significantly higher ($P < .001$) in subjects with sufficient amounts of keratinized mucosa (Table 4). It was found that the type of abutment used, the status of the opposing arch, and the width of the occlusal table had no statistically significant effect on decementation and chipping ($P > .05$); however, it was the only the type of abutment that had a significant impact on screw loosening ($P = .008$). It was found to be statistically significant that the type of abutment used in patients with screw loosening was screw-retained. In contrast, the other factors had no significant effect on screw loosening ($P > .05$) (Tables 5 to 7; see also Table 4).

According to univariate binary logistic regression analysis, the amount of sufficient keratinized mucosa, periodontal extractions, and implant diameter had a statistically significant effect on survival. The risk of satisfactory or compromised survival was 62.5 times higher in those with inadequate keratinized mucosa than in those with sufficient keratinized mucosa ($P < .001$). The risk of satisfactory or compromised survival was 5.736 times higher in participants who underwent extraction for periodontal disease than in participants

Table 5 Relationships Between Decementation and Restoration Data

	Decementation, n (%)		Pearson's chi-square test	Univariate binary logistic regression analysis	
Restoration data	Yes	No	*P*	OR (95% CI)	*P*
Abutment type					
Standard	9 (69.2)	47 (54.0)	.364	Reference	.848
Ti-base	3 (23.1)	18 (20.7)		0.87 (0.211–3.583)	
State of the opposing arch					
NT	2 (15.4)	22 (25.3)	.493	NA	
NFP	6 (46.2)	26 (29.9)			
IFP	3 (23.1)	17 (19.5)			
IRP	0 (0)	12 (3.8)			
RP	2 (15.4)	10 (11.5)			
Occlusal table					
Narrowed	4 (30.8)	32 (36.8)	.765	0.854 (0.232–3.139)	.812
Normal	9 (69.2)	55 (63.2)		Reference	

NT = natural tooth; NFP = tooth-supported fixed prosthesis; IFP = implant-supported fixed prosthesis; IRP = implant-supported removable prosthesis; RP = tooth-supported partial or conventional full denture; OR = odds ratio; NA = not available (because the confidence interval cannot be calculated).

Table 6 Relationships Between Screw Loosening and Restoration Data

	Screw loosening, n (%)		Pearson's chi-square test	Univariate binary logistic regression analysis	
	Yes	No	*P*	OR (95% CI)	*P*
Abutment type					
Standard	6 (40.0)	50 (58.8)	**.008**	Reference	
Screw retention	8 (53.3)	15 (17.6)		4.444 (1.331–14.838)	.015
Ti-base	1 (6.7)	2 (23.5)		0.417 (0.047–3.684)	.431
State of the opposing arch					
NT	6 (4.0)	18 (21.2)	.271	Reference	
NFP	2(13.3)	30 (35.3)		0.2 (0.036–1.099)	.064
IFP	3 (20.0)	17 (20.0)		0.529 (0.114–2.46)	.417
IRP	3 (20.0)	9 (10.6)		1 (0.202–4.955)	1.000
RP	1 (6.7)	11 (12.9)		0.273 (0.029–2.577)	.257
Occlusal table					
Narrowed	5 (33.3)	31 (36.5)	.815	0.871 (0.273–2.781)	.816
Normal	10 (66.7)	54 (63.5)		Reference	

NT = natural tooth; NFP = tooth-supported fixed prosthesis; IFP = implant-supported fixed prosthesis; IRP = implant-supported removable prosthesis; RP = tooth-supported partial or conventional full denture; OR = odds ratio.

who underwent extraction for endodontic reasons ($P = .010$). The risk of satisfactory or compromised survival was 4.629 times higher in patients with a diameter of < 3.75 mm than in those with a diameter between 3.75 and 5 mm ($P = .037$). Confidence intervals for the parameters of opposing arch status and restorative material could not be calculated and, therefore, not included in the analysis. Other parameters had no statistically significant effect on survival risk ($P > .05$). According to the Forward Stepwise Regression analysis—in the first step—the risk of satisfactory or compromised survival was 62.5 times higher (OR: 95% CI: 0,016 [0.002 – 0.157]) in individuals with insufficient keratinized mucosa compared to those with sufficient keratinized mucosa ($P < .001$). In the second step, this risk increased to 142.857 times (OR: 95% CI: 0.007 [0 – 0.112]) in individuals with insufficient keratinized mucosa ($P = .001$). In addition, the risk of satisfactory or compromised survival was

Table 7 Relationships Between Chipping and Restoration Data

	Chipping, n (%)		Pearson's chi-square test	Univariate binary logistic regression analysis	
Restoration data	Yes	No	*P*	OR (95% CI)	*P*
Abutment type					
Standard	2 (50.0)	54 (56.3)		Reference	
Screw retention	1 (25.0)	22 (22.9)	.968	1.227 (0.106–14.238)	.870
Ti-base	1 (25.0)	20 (20.8)		1.35 (0.116–15.717)	.811
State of the opposing arch					
NT	0 (0)	24 (25.0)			
NFP	1 (25.0)	31 (32.3)			
IFP	1 (25.0)	19 (19.8)	.157	NA	
IRP	2 (50.0)	10 (10.4)			
RP	0 (0)	12 (12.5)			
Occlusal table					
Narrowed	1 (25.0)	35 (36.5)	1.000	0.581 (0.058–5.8)	.644
Normal	3 (75.0)	61 (63.5)		Reference	

NT = natural tooth; NFP = tooth-supported fixed prosthesis; IFP = implant-supported fixed prosthesis; IRP = implant-supported removable prosthesis; RP = tooth-supported partial or conventional full denture; OR = odds ratio; NA = not available (because the confidence interval cannot be calculated).

9.174 times higher (OR: 95% CI: 0.109 [0.012 – 0.98]) in individuals with a narrow-diameter implant compared to those with a medium-diameter implant ($P = .048$). Abutment type and occlusal table width parameters did not significantly affect the risk of decementation and chipping ($P > .05$). The analysis did not include the opposing arch variable because the confidence interval could not be calculated. For the abutment type variable, the risk of screw loosening was 4.444 times higher for screw retention abutments compared to standard abutments ($P = .015$). The effect of opposing arch status and occlusal table width on the risk of screw loosening was not statistically significant ($P > .05$) (see Tables 5 to 7).

DISCUSSION

A lot of the criteria used in the present study have been defined in the past and present to evaluate a functional implants' long-term survival and success. Among the specified criteria, marginal bone loss around the implant is one of the most critical parameters.[12,13] In some studies evaluating marginal bone loss, the first radiographs were taken after prosthetic loading.[14] Rutkowski et al[15] argued that marginal bone loss begins within the first week after the implant-abutment connection is placed; note that the first radiographs were taken as soon as the prosthetic treatment was completed. In the present study, periapical and panoramic radiographs were taken on the day of prosthesis delivery. The 2007 ICOI consensus decisions[5] can be used as the main criteria for evaluating implant survival. These consensus criteria were used in the present study to assess the success and survival of implants.

There is no consensus on the effect of implant position on implant survival. A study by Arisan et al[16] reported that posterior implants had a higher failure rate than anterior implants. Geçkili et al[17] reported that maxillary implants had a significantly higher failure rate than mandibular implants. On the other hand, Ghahroudi et al[18] and Wyatt et al[19] reported that the site of placement was not related to implant success; note that they reported no significant difference in bone loss around implants placed in different sites. The present study found that the anatomical location of the implant did not affect implant survival. Other results in the literature may have been reported because the implants evaluated for different anatomical sites and the restorations supported by the implants were not of a similar standard as the present study.

Many studies in the literature have reported that peri-implant disease can negatively impact implant success. The survey by Alves et al,[20] which analyzed micro-floral interactions regarding peri-implantitis and implant loss, reported that implant success decreased with an increased incidence of peri-implantitis and that inadequate keratinized mucosa was a risk factor for the development of peri-implantitis. According to Rokaya et al,[21] the presence of inadequately keratinized mucosa is an indicator of peri-implant disease, which is a risk factor for implant survival. The present study found

a significant relationship between the amount of keratinized mucosa and implant success rate, which is in accordance with previous studies.

The present study also found that periodontal reasons for tooth extraction had a statistically significant effect on implant survival. In both study's by Crespi et al[22] (24-month follow-up of implants placed in sites with and without periapical lesions) and Truninger et al[23] (36-month follow-up), the implant survival was 100% in both groups and there was no difference between the groups regarding marginal bone loss. In the study by Tarazona et al,[24] immediate implants were placed in sockets with teeth extracted for periodontal disease, periapical pathology, caries, or untreated fractures, and no difference in implant survival was found between the reasons for tooth extraction. The difference between the results of the current study and the research results in the literature may be due to the differences in the processes of controlling periodontal pathology or oral hygiene motivations of the participants. In this context, the results of the present study indicate that keeping periodontal disease under control before implant surgery is an important factor in implant survival. In addition, our study found that the most common cause of tooth extraction at implant sites was endodontic, and the survival rate of implants placed in endodontic extraction sites was higher than that of implants placed in periodontal extraction sites. This suggests that proper healing of the post-extraction site and careful management of the healing process may be more successful in endodontic extractions than in periodontal extractions and may reduce the risk of peri-implant complications. In addition, this finding suggests that endodontic extraction sites generally have better bone quality, which may positively impact implant success.

In the literature, some studies of immediate and delayed placement reported that both protocols had similar effects on peri-implant bone resorption and implant survival, while others reported that delayed placement was more successful.[25–29] This study found no significant correlation between immediate placement and implant survival. The results' inconsistency with some findings in the literature may be due to the different parameters of the implants studied.

In another study, it was reported that narrow-diameter implants are associated with increased prosthetic complications, failure in terms of prosthetic complications, and marginal bone loss.[30] On the other hand, some researchers argue that there is no difference between narrow-diameter implants and standard and wide-diameter implants regarding implant survival and prosthetic complications.[31] The present study found that implants with < 3.75 mm in diameter have a satisfactory or compromised survival risk approximately 4.5 times higher than those between 3.75 mm and 5 mm, while implants larger than 5 mm show no significant difference in satisfactory or compromised survival rates. Although improved surface preparation and implant designs in modern implantology have increased the strength and load-bearing capacity of narrow-diameter implants,[32] caution should be exercised when using narrow-diameter implants in light of the results of the present study.

Studies in the literature report that implant length is an essential factor in the survival of dental implants and the formation of marginal bone loss and that implant success improves favorably with increasing length.[33] This may be because shortening the implant length increases the loads transmitted to the alveolar bone surrounding the implant, and these loads are a risk factor for implant survival.[34] In the present study, Pearson's chi-square test concluded that 10 mm implants were more successful than 7-mm short implants. However, this test method is designed to determine a relationship between observed and expected frequencies rather than to evaluate the effect of the independent variable on the dependent variable. Moreover, according to univariate logistic regression analysis, which allows a more detailed examination of the effect of the independent variable, it was determined that implant length did not have a statistically significant effect on survival. This situation is thought to be due to improvements in implant surfaces and designs. However, the higher satisfactory or compromised survival rate observed with decreasing implant length indicates that a more cautious approach to these implants is required.

The topic of whether bone-level or tissue-level implants are more successful in implant survival has been debated, but a consensus has yet to be reached. While some studies[35,36] argue that bone-level implants are more successful in marginal bone resorption, some studies report that tissue-level implants are more successful or have similar clinical outcomes.[37] In the present study, bone-level implants had a better survival rate than tissue-level implants according to Pearson's chi-square test, but the frequency of tissue-level implants evaluated in our study was very low compared to bone-level implants. In the regression analysis performed to evaluate the effect of the implant-level variable on survival, it was concluded that the implant level did not have a statistically significant effect on survival. However, the low success rate with tissue-level implants indicates that caution should be exercised when using tissue-level implants.

The literature includes studies evaluating the effects of restorative materials on implant survival and complication rates. Many studies have reported that different restorative materials have similar effects on survival and

complication rates.[38] In the present study, there was no difference between the restorative materials regarding implant survival.

While the results of some studies evaluating the relationship between abutment type and implant survival reported that there was no difference between cement-retained and screw-retained abutments in terms of implant success[39,40]; there are also many studies that indicate that problems with implant survival may occur in restorations with cement-retained abutments due to peri-implant pathology, especially if cement residue is not cleaned.[41,42] All of the implants evaluated in this study had a platform-switch connection, and although it is difficult to remove residual cement in restorations with a platform-switch connection design due to the difference in abutment and implant diameter (which increases the risk of peri-implant pathology), the results of the present study showed no correlation between the type of abutment used and implant survival. This may be because restorations with cemented abutments showed no pathology in the cement remnants for 12 months or that the cementing protocols for cemented restorations were performed with high technical precision.

This study concluded that the condition of the structures in the counter arch region studied had no effect on implant survival. This is likely because the occlusal surface design of the studied restorations was modified and protected from destructive occlusal forces regardless of the prosthetic design in the counter arch or due to the fact that the occlusal relationships were created to protect the implant-supported restoration.

Mei et al[43] concluded that reducing the buccolingual width of implant-supported restorations had an ideal effect on bite force distribution and masticatory efficiency in implant-supported prostheses with unilateral-distal extension. Another study reported that reducing occlusal surfaces did not affect implant success and prosthetic complications.[44] Although dental implants can resist forces along their long axis, they are not sufficiently resistant to forces of the long axis. Therefore, to ensure the long-term success of implants, it is necessary to design implant-supported crowns with a suitable occlusal table to reduce forces off the long-axis.[45] The fact that the occlusal table width of implant-supported crowns had no effect on implant survival in this study may be because the forces on the examined restorations were designed to be directed in the long axis of the implant, regardless of the occlusal table width.

According to the present study's results, the most common prosthetic complication is screw loosening with a rate of 15%, and the most common abutment type is screw-retained abutments. The study by Binon et al[46] investigated the effect of implant-abutment incompatibility on screw stability. They reported that the most common prosthetic complication was screw loosening and that screw loosening was more frequent with screw-retained abutments. Larsson et al[47] also reported that screw loosening was the most common technical complication and that this risk was higher in screw-retained implant-supported single crowns; however the exact cause was unclear. This reoccurrence in the literature may be because implants and their prosthetic components are not produced by the same manufacturer, but the implants and their prosthetic components evaluated in this study were produced by the same manufacturer. The high rate of screw loosening in this study may be because the resistance to rotational forces of the screw-retained crown on the multi-unit abutment was less than that of the cement-retained restorations on the standard abutment. In other words, in implant-supported single-unit restorations, cement retention is more resistant to rotational forces than screw retention.

Complications, such as decementation, frequently arise in restorations with cement-retained abutments. Hallgren et al[48] reported a 9.8% documentation rate in cement-retained crowns over a 3-year follow-up period. In the study by Woebler et al,[49] which included at least 10 years of follow-up, the rate was approximately 8.77%. The present study included a follow-up period of 12 months, and the rate of decementation was found to be 13%. This study concluded that the decementation seen with standard abutments was proportionally higher than titanium-base (Ti) abutments. It is believed that Ti-base abutments have fewer decementation complications because the steps of Ti-base abutments start more apically than standard abutments, the restoration step compatibility is better, and they are cemented out of the mouth with resin cement.

Although no significant relationship was found between occlusal table width and decementation in this study, restorations with wide occlusal tables showed proportionally more decementation than those with narrow occlusal tables. The more pronounced decementation seen in restorations with wide occlusal tables may be due to the higher occlusal loads on these crowns. Chipping, referred to as substructure and ceramic separation, was one of the prosthetic complications. Although the literature reports that zirconia (Zr) and Ti-supported ceramic crowns have similar fracture resistance, some studies have reported that Ti-Zr restorations have higher fracture resistance.[50,51]

According to the results of this study, the fact that chipping was only observed in Ti-supported Zr crowns and that restorative materials did not significantly affect chipping may be because all the Zr restorations included in the study were in the anterior region and were exposed to lower occlusal forces compared to the posterior region.

The small sample size is one of the major limitations of this study. Although a sufficient number of patients were selected based on the power analysis results performed to see statistical significance in the study, the number of patients should be increased to achieve more accurate measurements. Another limitation of the present study is that marginal bone loss was measured using 2D radiographs and only one image analysis program. Different measurement programs should be used and compared to obtain more accurate results, and buccal and lingual bone loss should also be assessed using 3D imaging. Another important limitation is that the study results are based on a short period of 12 months. As this study aimed to evaluate early complications, the evaluation of parameters that indicate outcomes over longer periods of time, such as bone loss or the effects of excess cement, may not be objective. In addition, the parafunctional status of the participants was not assessed. Parafunctional habits can play an important role in both prosthetic and biologic complications.

CONCLUSIONS

Insufficient keratinized mucosa, tooth extractions due to periodontal issues, and the use of narrow-diameter implants can negatively impact the success of implant procedures. Care should be taken with implants that are smaller than the standard size and are placed at the tissue level. Factors such as immediate implant placement, the anatomical location of the implants, the type of abutment used, the width of the occlusal table, the condition of the opposing arch, and the restorative materials used have not significantly affected implant survival.

The use of screw-retained abutments was associated with an increased risk of screw loosening and was found ineffective in porcelain chipping. Additionally, the status of the opposing arch and the width of the occlusal table did not impact occurrences of screw loosening, decementation, or porcelain chipping.

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Author contributions: Ö.İ. and N.P. conceived the idea and wrote the manuscript. N.P. collected the data, conducted the study, analyzed the data, and performed statistical analysis.

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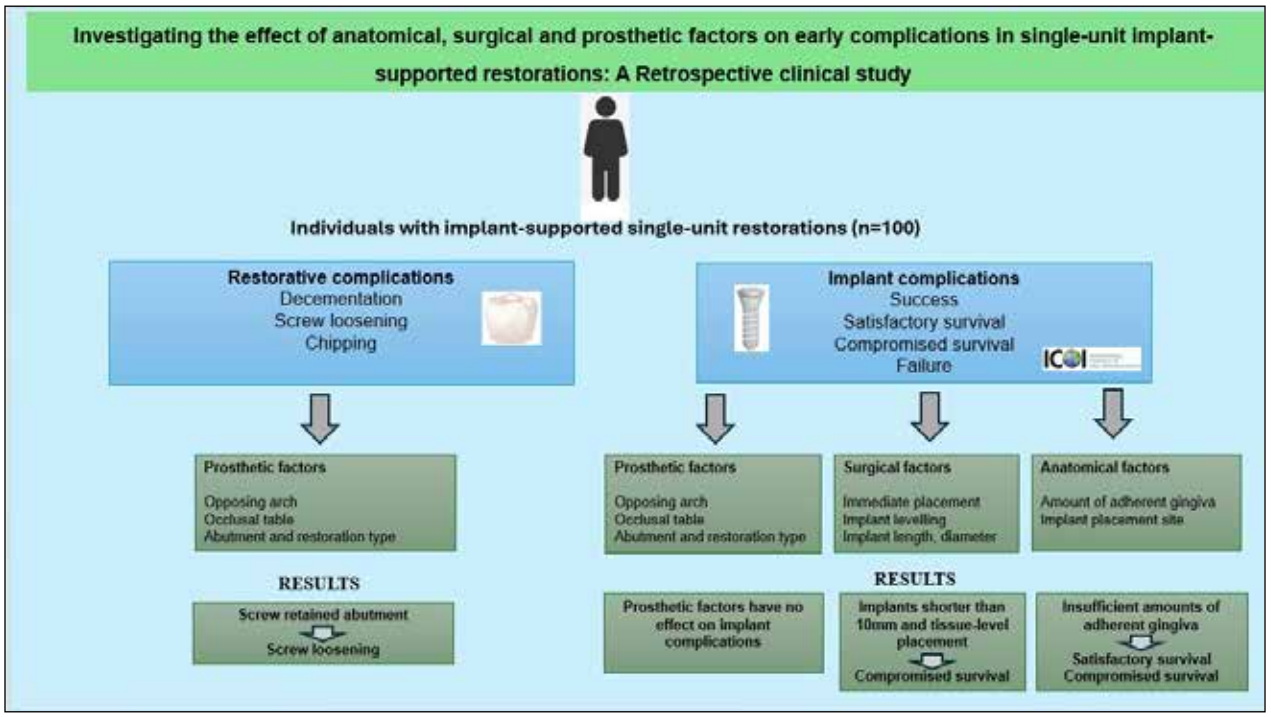
APPENDIX



Appendix Fig 1 Graphic abstract of the study.