

A Retrospective Evaluation of the Success of Zygomatic Implants Applied Using Different Techniques

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Abstract

Background

Alveolar bone resorption, which occurs both as a result of aging and tooth loss, particularly in the maxilla, makes dental implant treatment challenging. Zygomatic implants, as an effective treatment option, can reduce treatment time, enable maxillary dental rehabilitation, and minimize potential morbidity in patients without the need for advanced surgical procedures. In recent years, the use of zygomatic implants has gained considerable popularity. The aim of this retrospective study was to evaluate the success of zygomatic implants applied using three different techniques: intrasinus, sinus-slot, and extrasinus.

Methods

In this study, 57 patients of both sexes, encompassing a total of 189 zygomatic implants, were evaluated. The distribution of implants according to the applied technique was as follows: extrasinus (78 implants), intrasinus (44 implants), and sinus-slot (67 implants). Implant success was assessed based on prosthetic criteria, implant brand, patient age and sex, and the applied surgical technique.

Results

The findings indicated that the success of zygomatic implants was associated with the technique used (extrasinus, intrasinus, or sinus-slot). However, no significant differences were observed between implant success and implant brand, patient age or sex, or type of prosthesis.

Conclusion

The surgical technique used for zygomatic implant placement is the most important factor influencing clinical success, whereas other demographic factors and implant brand do not have a significant impact on outcomes.

Introduction

Rehabilitation of the atrophic maxilla represents one of the most challenging issues in implantology, as severe alveolar bone resorption limits the placement of standard implants and often necessitates complex reconstructive procedures (1). Zygomatic implants, as a graftless treatment option, allow prosthetic rehabilitation of patients with severely resorbed maxillae and have demonstrated high clinical survival rates in multiple studies (2). This approach can eliminate the need for additional surgeries and complex bone augmentation procedures, thereby shortening the overall treatment duration (3). The use of zygomatic implants, particularly in patients who cannot benefit from conventional implants due to severe bone loss or a history of extensive surgeries, has been continuously investigated in the scientific literature, with their success in the complete rehabilitation of the atrophic maxilla reported as remarkable (1).

Zygomatic implants were first introduced as a graftless approach for the treatment of severely resorbed maxillae and quickly gained attention as an effective alternative to conventional reconstructive methods (4). Clinical studies and systematic reviews have shown that these implants can provide full-arch rehabilitation with high survival rates and long-term stability, even in patients with significant maxillary bone loss (5). Furthermore, the development of various surgical techniques, including intrasinus, extrasinus, and sinus-slot approaches, has enhanced surgical safety, improved implant positioning, and reduced sinus-related complications (6). Recent systematic reviews have also demonstrated that zygomatic implants are not only successful in terms of survival and prosthetic function but are also associated with lower morbidity and shorter treatment times compared to conventional bone reconstruction methods (7).

Despite favorable clinical outcomes, the success of zygomatic implants depends on multiple factors, including the surgical technique, implant trajectory, anatomical conditions of the maxillary sinus, type of prosthesis, and surgeon experience (8). Studies have shown that improper selection of the surgical technique can lead to complications such as maxillary sinusitis, infection, prosthetic problems, and even orbital complications, highlighting the importance of proper surgical approach selection and meticulous treatment planning (9).

Furthermore, the development of specific indices and criteria for evaluating the success of zygomatic implants, such as the Zygomatic Success Code, has enabled comprehensive assessment of clinical outcomes, prosthetic performance, and biological consequences (10). Retrospective studies and long-term cohort studies have also indicated that, although zygomatic implants exhibit high survival rates, significant differences in clinical outcomes exist depending on the surgical technique employed, emphasizing the need for comparative studies (11).

Considering the variety of surgical techniques used for zygomatic implant placement and the differing results reported in clinical studies, there is still no clear consensus regarding the optimal surgical approach in terms of clinical success, prosthetic stability, and complication reduction (12). Although numerous studies have reported high survival rates for zygomatic implants, many were descriptive in nature and did not perform structured direct comparisons between different surgical techniques (13). Recent systematic reviews have also emphasized the necessity of analytical and comparative studies to determine the precise role of surgical technique in the success of zygomatic implants (14).

Accordingly, the present study was designed and conducted to retrospectively evaluate the success of zygomatic implants applied using different techniques (intrasinus, extrasinus, and sinus-slot) and to assess the relationship between the surgical method and clinical outcomes, including prosthetic success, patient demographic factors, and implant characteristics.

Methods

This research was designed and conducted as a retrospective observational study. The study was approved by the Ethics Committee of Istanbul City Hospital, under the supervision of Professor Dr. Cemil Tayouoglu, with approval number 48670771-514.10. All study procedures were carried out in accordance with the ethical principles outlined in the Declaration of Helsinki. Patient information was extracted confidentially, and no personally identifiable data were used during analysis or in the final report.

The study population consisted of patients who received zygomatic implant treatment between March 2021 and February 2022. In total, 57 patients of both sexes, encompassing 189 zygomatic implants, were included in the study, and all implants were analyzed in the final statistical evaluation.

The sample size was calculated based on a Chi-square test with 4 degrees of freedom, a type I error of $\alpha = 0.05$, a statistical power of 0.80, and a medium effect size (Effect size = 0.3), which estimated a minimum requirement of 189 zygomatic implants. This number was fully achieved in the study, ensuring adequate statistical power for testing the primary hypothesis.

Inclusion and Exclusion Criteria

Eligible patients for the study were individuals over 18 years of age with severe maxillary atrophy, significant maxillary bone loss following trauma, congenital maxillary defects, failure of conventional implant treatment after sinus lift, absence of maxillary sinus pathology, and no active acute or chronic oral diseases.

Exclusion criteria included patients classified as ASA III to VI, individuals with immunodeficiencies, alcohol or substance dependence, patients undergoing chemotherapy or radiotherapy, those with medication-related osteonecrosis of the jaw (MRONJ), patients with systemic conditions impairing healing (e.g., uncontrolled diabetes), individuals with epilepsy or Parkinson's disease, and pregnant women.

Surgical Procedures

Three surgical approaches for zygomatic implant placement were evaluated in this study: the intrasinus technique, the sinus-slot technique, and the extrasinus technique. A fourth approach, computer-assisted surgery, was not included in the study due to the limited number of patients and the inability to perform meaningful statistical analysis.

All surgeries were performed under general anesthesia by maxillofacial surgeons. The choice of surgical technique was based on the anatomy of the maxillary and zygomatic bones, the volume and quality of the remaining bone, and the condition of the maxillary sinus.

Implant Characteristics

In this study, three implant brands were used: Nobel Biocare, Implantance, and Southern. Two types of zygomatic implant designs were employed: standard and atrophic designs. The choice of implant type was determined based on the anatomy of the zygomatic bone, as well as the volume and quality of the maxillary bone. Oncologic zygomatic implants were not included in this study.

Outcome Measures and Success Criteria

Outcome Measures and Success Criteria

The success of zygomatic implants was evaluated according to the revised criteria of Aparicio et al. (2020) and the ORIS classification system. This system comprises four main indicators: prosthetic offset, rhinosinus-associated pathology, peri-implant soft tissue condition, and implant stability.

According to this system, implants were classified into three groups: Groups I, II, and III were considered successful implants (Success), Group IV was categorized as surviving implants (Survival), and Group V as failed implants (Failure). Each implant was independently and separately evaluated for each of the ORIS criteria.

Data Collection

Data for this study were extracted from patients' medical records. Collected information included age, sex, implant brand, type of prosthesis (fixed or hybrid), number of implants placed, surgical technique used, and clinical complications. In addition to the primary center, records from patients treated at collaborating academic centers were also reviewed, and the data were analyzed cumulatively.

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics, version 30.0. The normality of data distribution was assessed using the Kolmogorov–Smirnov and Shapiro–Wilk tests, as well as Q–Q plots. Quantitative variables were reported as mean $\pm$ standard deviation, and qualitative variables as frequency and percentage. A significance level of $\alpha = 0.05$ was considered.

In multivariate tables, if more than 20% of cells had expected frequencies less than 5, the Pearson Chi-square test with Monte Carlo simulation (10,000 samples) was used. To assess linear relationships in ordinal tables, the Linear-by-Linear Association (Mantel–Haenszel Chi-square) test was employed. The

Kruskal–Wallis test was applied to compare continuous variables between independent groups.

Results

Descriptive and Analytical Statistical Findings

The results of statistical analyses indicated that the type of zygomatic implant surgical technique was the only variable significantly associated with implant success. According to the Pearson Chi-square test with Monte Carlo simulation (10,000 iterations), a statistically significant relationship was observed between the surgical technique and implant success level ($p < 0.001$). This finding demonstrates that the success rate of zygomatic implants is significantly influenced by the surgical approach employed.

In contrast, no statistically significant relationship was found between implant success and other variables, including implant brand, prosthesis type, patient sex, and patient age ($p > 0.05$). Furthermore, the Linear-by-Linear Association (Mantel–Haenszel) test confirmed the absence of a significant linear trend for all these variables.

1. Relationship Between Surgical Technique and Implant Success

Based on the results of the Pearson Chi-square test with Monte Carlo simulation (10,000 samples), a statistically significant association was observed between the type of surgical technique (Extrasinus, Intrasinus, Sinus-Slot) and the success level of zygomatic implants ($p < 0.001$). This finding indicates that the choice of surgical technique plays a decisive role in implant success.

Linear trend analysis (Fig. 1) using the Mantel–Haenszel Linear-by-Linear Association test demonstrated that:

- For the Intrasinus technique compared to Extrasinus, implant success was significantly higher ($p = 0.034$) (Table 1).
- For the Sinus-Slot technique compared to Intrasinus, a significant increase in implant success was also observed ($p = 0.034$) (Table 1).

Table 1 Distribution of implant success levels according to surgical technique									
		Implant Success Level						2	p-Value
		Success I		Success II		Success III + Survive + Failure		<i>XMH</i>	
		Frequency	Percentage	Frequency	Percentage	Frequency	Percentage		
Technique	Extra Sinus	49	57.00%	17	24.30%	12	36.36%	4.474	0.034
	Intra Sinus	10	11.60%	25	35.70%	9	27.27%		
	Sinus Slot	27	31.40%	28	40.00%	12	36.36%		

These changes indicate that cases initially classified in lower success levels (Success III + Survival + Failure) were shifted to a higher success level (Success I), reflecting the highest clinical success rate observed with the Sinus-Slot technique (Fig. 2).

Based on the Pearson Chi-square test with Monte Carlo simulation (10,000 samples), a statistically significant association was found between the type of surgical technique and implant success level ($p < 0.001$). In other words, the success levels differed significantly across the various surgical techniques (Fig. 3).

Implant Success Level

Figure 2. Cumulative success levels according to surgical technique

2. Relationship Between Implant Brand and Success Level

Based on the Pearson Chi-square test with Monte Carlo simulation, no statistically significant association was observed between implant brand (Fig. 4, 5) (Implance, Nobel Biocare, Southern) and implant success level ($p = 0.538$) (Table 2). The Mantel–Haenszel test also confirmed the absence of a significant linear relationship ($p = 0.867$) (Table 3).

Table 2 Distribution of implant success levels according to implant brand										
Brand	Success I		Success II		Success III		Survive		Failure	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Implance	32	37.20%	24	34.00%	9	39.10%	0	0.00%	2	40.00%
Nobel Biocare	29	33.70%	31	44.10%	10	43.00%	2	40.00%	2	41.00%
Southern	25	29.10%	15	21.40%	4	17.40%	3	60.00%	1	21.00%

Table 3
Mantel-Haenszel Test for the Relationship Between Implant Brand and Success Level

Brand	Success I		Success II		Success III + Survive + Failure		χ^2 (X ² MH) Value	p-value
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage		
Implance	32	37.20%	24	34.30%	11	33.33%	0.028	0.867
Nobel Biocare	29	33.70%	31	44.30%	14	42.42%		
Southern	25	29.10%	15	21.40%	8	24.24%		

Implant Success Level

Implant Success Level

Figure 5. Cumulative Success Levels According to Implant Brands

3. Relationship Between Prosthesis Type and Success Level

The Pearson Chi-square test indicated no statistically significant association between prosthesis type (fixed/hybrid) and implant success level ($p = 0.140$) (Table 4). Mantel-Haenszel analysis also confirmed the absence of a significant linear relationship ($p = 0.097$) (Table 5).

Table 4
Distribution of Implant Success Levels According to Prosthesis Type (Fig. 6, 7)

Implant Success Level											
		Success I		Success II		Success III		Survive		Failure	
		Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Variable	fixed	61	17, %	49	10,00	13	36	3	00,00%	1	100,0a
	hybrid	19	n,10	11	30,00%	10	43	1	41,00%	0	0,0

Table 5
Distribution of Implant Success Levels According to Prosthesis Type

		Implant Success Level						2	p-value
		Success1		Successil		Success111 + Survive+Failure		XMH	
		Frequency	Percentage	Frequency	Percentage	Frequency	Percentage		
Prosthesis	Fixed	67	77,90%	49	70,00%	21	63,64%	2,753	0,097
	Hybrid	19	22,10%	21	30,00%	12	36,36%		

Implant Success Level

Implant Success Level

Figure 7. Cumulative Success Levels According to Prosthesis Type

4. Relationship Between Patient Sex and Implant Success Level

Based on the Pearson Chi-square test with Monte Carlo simulation, no statistically significant association was observed between patient sex and implant success level ($p = 0.975$) (Table 6). Mantel-Haenszel analysis also confirmed the absence of a significant linear relationship ($p = 0.766$) (Table 7).

Table 6
Distribution of Implant Success Levels According to Patient Sex (Fig. 8,9)

Implant Success Levels											
		Success I		Success II		Success III		Survive		Failure	
		Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Gender:	Male	41	47,70%	33	47,10%	12	32,10%	2	5,00%	3	10,00%
	Female	45	52,30%	37	52,90%	11	30,30%	1	2,20%	2	5,50%

Table 7
Mantel–Haenszel Test for the Relationship Between Patient Sex and Implant Success Level

Mantel-Haenszel Test for the Relationship Between Patient Sex and Implant Success Level								
	Implant Success Levels						2	p-value
	Success 1		Success II		Success III + Survival + Failure		XMH	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage		
Gender: Male	41	47,70%	33	47,10%	17	51,52%	0,088	0,766
Female	45	52,30%A.	37	52,90%	16	48,48%		

Implant Success Level

Implant Success Level

Figure 9. Cumulative Success Levels According to Patient Sex

5. Relationship Between Patient Age and Implant Success Level

The Kruskal–Wallis test indicated no statistically significant association between patient age and implant success level ($p = 0.766$).

Table 8
Mean Patient Age Across Different Implant Success Levels (Fig. 10)

Implant Success Level										N	p-value	
Success I		Success II		Success III		Survival		Failure				
Mean	Standard Deviation (SD)	Mean	Standard Deviation (SD)	Mean	Standard Deviation (SD)	Mean	Standard Deviation (SD)	Mean	Standard Deviation (SD)			
Age	55	10	56	9	58	10	54	15	49	15	8,143	0,086

Implant Success Level

Figure 10. Distribution of Implant Success Levels According to Patient Age

Discussion

The increase in human life expectancy and improvements in economic status have shifted patient expectations regarding dental aesthetics and function. Alveolar ridge resorption due to tooth loss and maxillary sinus pneumatization make the placement of axial implants in the posterior maxilla challenging (15, 16). Under such conditions, maxillary reconstruction can be performed using additional surgical procedures, such as sinus augmentation, block grafting, or nerve lateralization, as well as modified implant placement techniques; however, these approaches are associated with increased morbidity and prolonged treatment duration (17–19).

Despite the high success rates of grafting procedures, the use of autogenous bone can cause donor site morbidity, and the use of alloplastic bone often requires a long healing period, which may prolong fixed prosthetic treatment and even lead patients to abandon therapy (20, 21). In such cases, the use of angled implants, zygomatic implants, and pterygoid implants can reduce treatment duration and result in lower morbidity (22).

Zygomatic implants were initially used to enhance obturator retention in maxillectomy patients. For example, Butterworth et al. placed 131 zygomatic implants in 49 maxillectomy patients and reported only eight implant failures during a five-year follow-up, corresponding to an overall implant success rate of 92% (23). Subsequently, the use of zygomatic implants was extended to patients with severely atrophic maxillae. Implant placement techniques vary depending on the curvature of the anterior sinus wall and the severity of maxillary atrophy and include the Intrasinus, Sinus-Slot, Extrasinus, and computer-guided surgical approaches (24).

The Intrasinus technique, which was the first introduced method, results in the implant emergence profile being located in the palatal region, potentially causing phonetic difficulties and challenges in prosthetic hygiene. In the Sinus-Slot, Intrasinus, and Extrasinus techniques, the implant emergence profile is positioned more buccally, reducing prosthetic complications; however, the anchorage from cortical bone is lower, which may lead to biomechanical issues. Aparicio et al., in the computer-guided ZAGA approach, classified the implant emergence profile into five categories (Tip 0 to 4) (25).

The present study evaluated the success of zygomatic implants placed using three different techniques (Intrasinus, Sinus-Slot, and Extrasinus) according to the ORIS criteria, including prosthetic failure, presence of rhinosinusitis, peri-implant soft tissue health, and implant stability (26). Similarly, Göker et al. examined 302 implants placed with the Extrasinus technique in 110 patients and reported implant success using the same criteria, achieving an overall success rate of 98.34%; failures were attributed to bruxism and improper occlusal forces (27).

Other long-term studies have also demonstrated high success rates for zygomatic implants: Agliardi et al., in a follow-up of 34 patients with 90 zygomatic implants and 53 conventional implants over 11 years, reported 100% success for zygomatic implants and 96.2% for conventional implants (28). Moraschini et al., in a systematic review and meta-analysis of 1,709 patients with 2,972 zygomatic implants and a mean follow-up of 78 months, reported a success rate

of 96.5% (22). Kosola et al., in 33 patients with 67 implants and a 12-year follow-up, assessed the success of zygomatic implants and found that immediately loaded implants had fewer complications compared to delayed loading (29).

Other long-term studies also reported notable success: Chana et al., in 45 patients with 88 implants and an 18-year follow-up, reported an overall success rate of 94% (30). Borgonovo et al., with 98 implants in 23 patients and a one-year follow-up, reported a 100% success rate (31). Regarding complications, the most common issues associated with zygomatic implants are sinusitis and prosthetic problems (19, 32, 33). Treatment of implant-related sinusitis typically involves antibiotics and, if necessary, endoscopic sinus surgery (32).

Comparative studies have shown that zygomatic implants are a suitable alternative to conventional implants for maxillary reconstruction without the need for extensive surgery. Aparicio et al. demonstrated that the use of zygomatic and conventional implants can replace bone grafting techniques while achieving similar clinical success (18, 24).

Overall, the findings of the present study are consistent with previous research, indicating that zygomatic implants placed using different techniques achieve acceptable clinical success with limited complications. The use of the ORIS criteria for evaluating implant success provides a more precise and objective assessment compared to other studies and highlights that zygomatic implants can serve as a reliable option for the rehabilitation of atrophic maxillae.

Conclusion

The results of this study indicated that zygomatic implants placed using the Intrasinus, Sinus-Slot, and Extrasinus techniques did not differ significantly in terms of success, survival, or failure rates, although the highest success was observed with the Sinus-Slot technique and the lowest with the Extrasinus technique. Implant success was independent of prosthesis type (fixed or hybrid), implant brand, and patient demographic characteristics. Given the greater cortical bone contact in the Sinus-Slot technique, this approach demonstrated superior clinical performance. This study represents the first direct comparison of different zygomatic implant placement techniques, and larger clinical studies are recommended to validate these findings.

Declarations

Disclosure statement

No potential conflict of interest was reported by author(s).

All study procedures were carried out in accordance with the ethical principles outlined in the Declaration of Helsinki. All content was reviewed and verified by author(s), who take whole full responsibility for the manuscript's accuracy and integrity.

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Consent to Participate declaration: Informed consent was taken from the participants.

Ethics declaration: Ethic approval was obtained from Ethics Committee of Istanbul City Hospital, under the supervision of Professor Dr. Cemil Tayouoglu, with approval number 48670771-514.10.

Author Contributions: Concept: M.A; Design: Z.K; Supervision: M.A; Data Collection: M.A; Writing Manuscript: Z.K, Critical Review: Z.K, M.A

Declaration of Interests: The authors declared no conflict of interest

Data availability Declaration: Yes

All data generated or analysed during this study are included in this published article.

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Figures

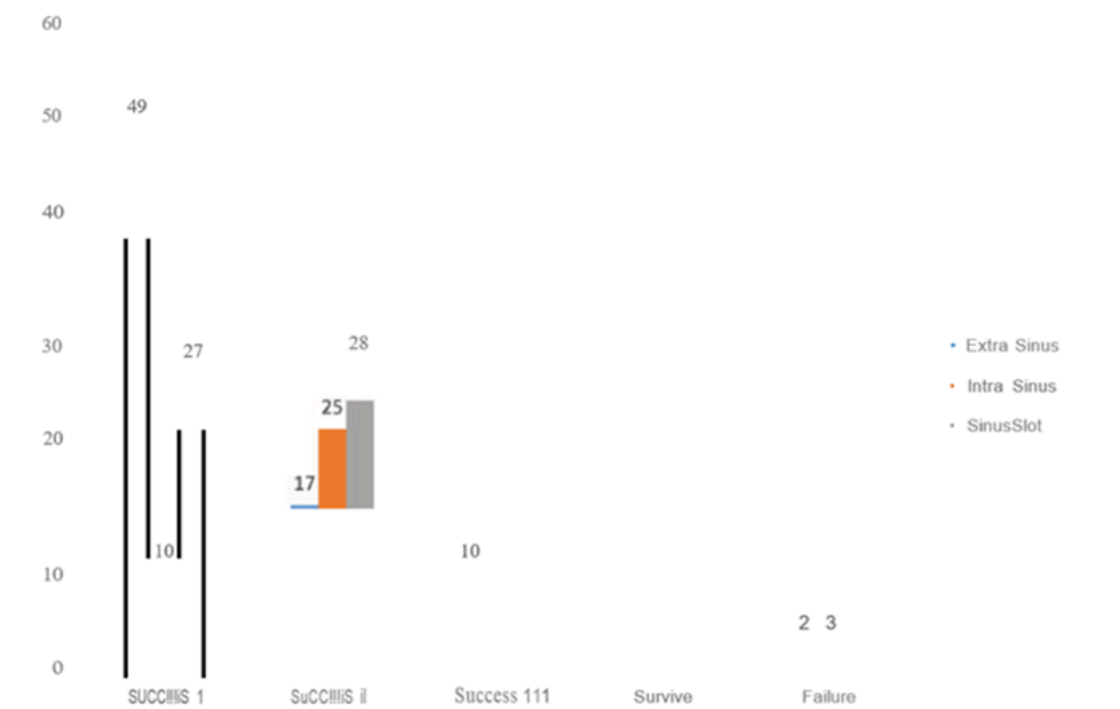


Figure 1
Distribution of success levels by surgical technique

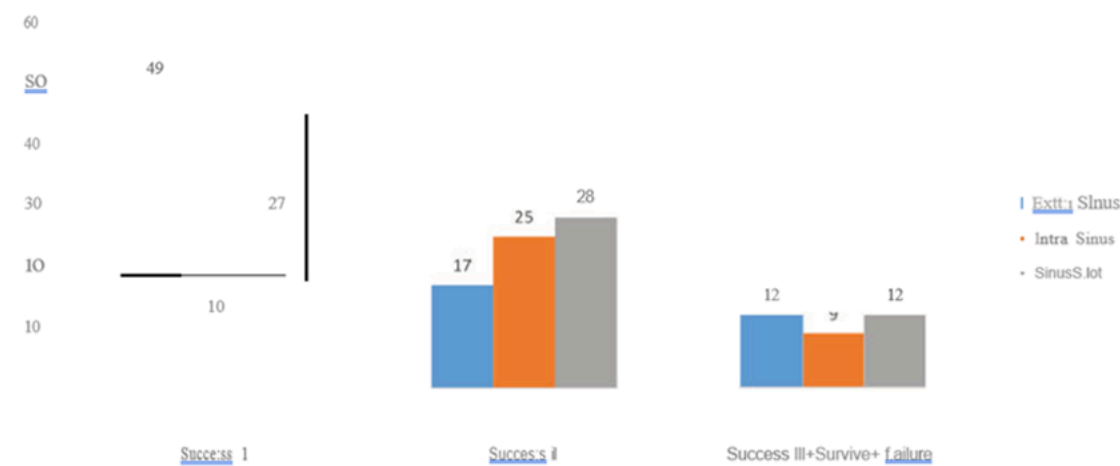


Figure 2
Cumulative success levels according to surgical technique

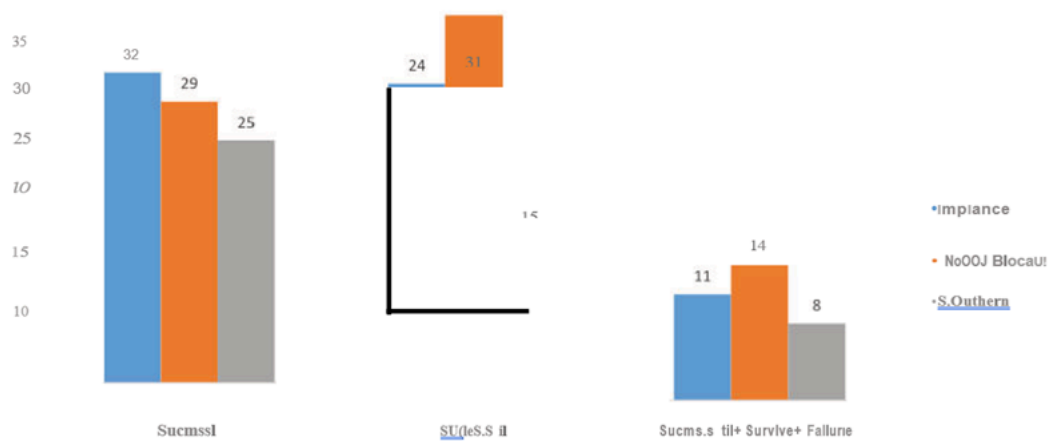


Figure 3

Combined Success Levels According to Surgical Technique

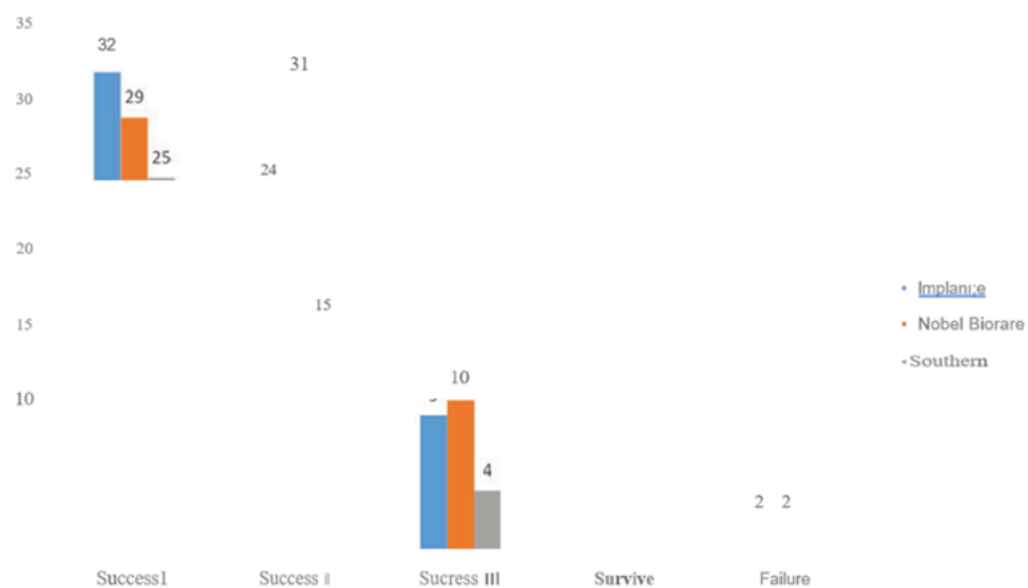


Figure 4

Implant Success Levels According to Implant Brands

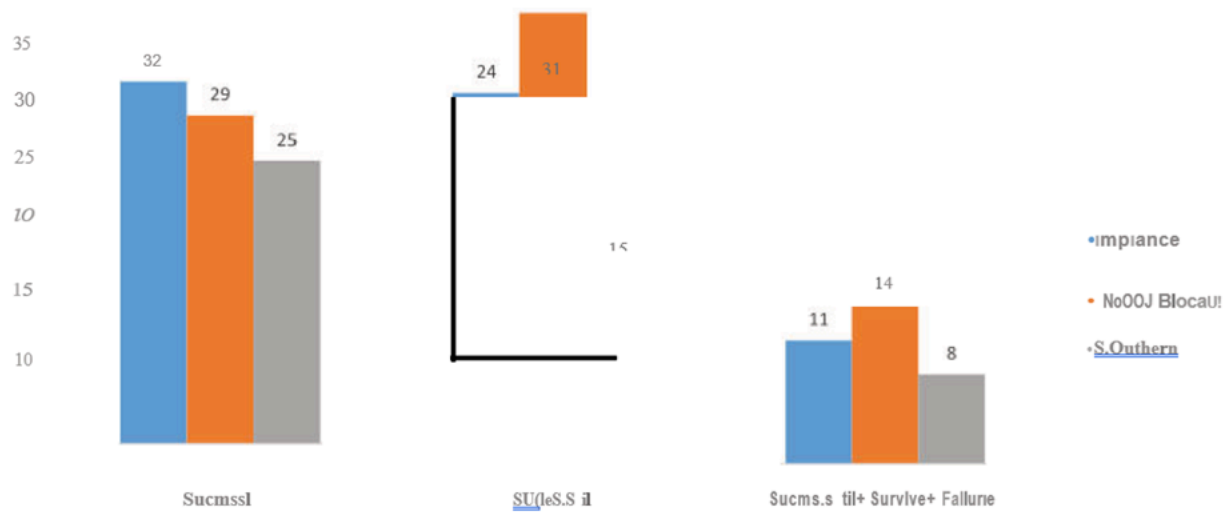


Figure 5

Cumulative Success Levels According to Implant Brands

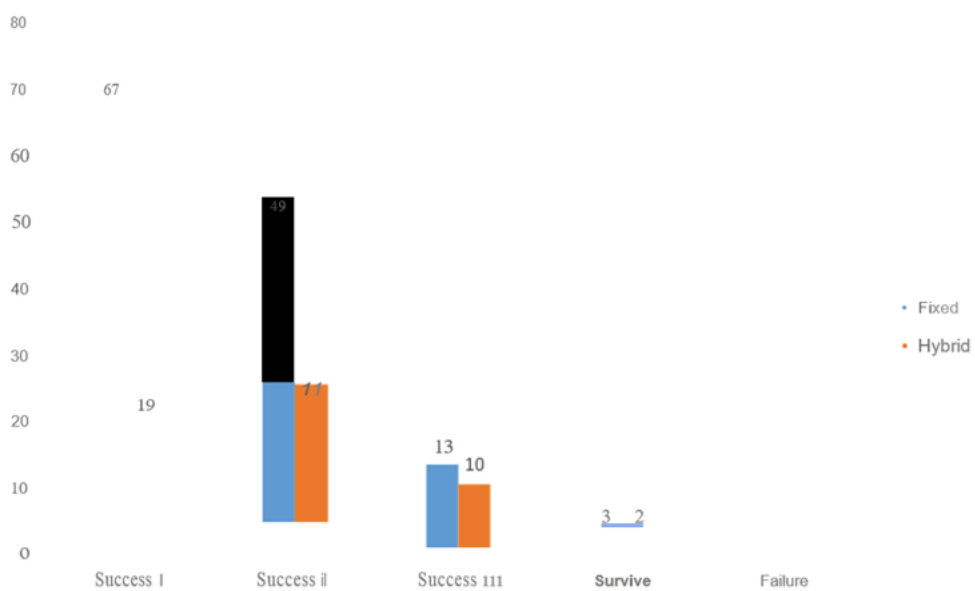


Figure 6

Implant Success Levels According to Prosthesis Type

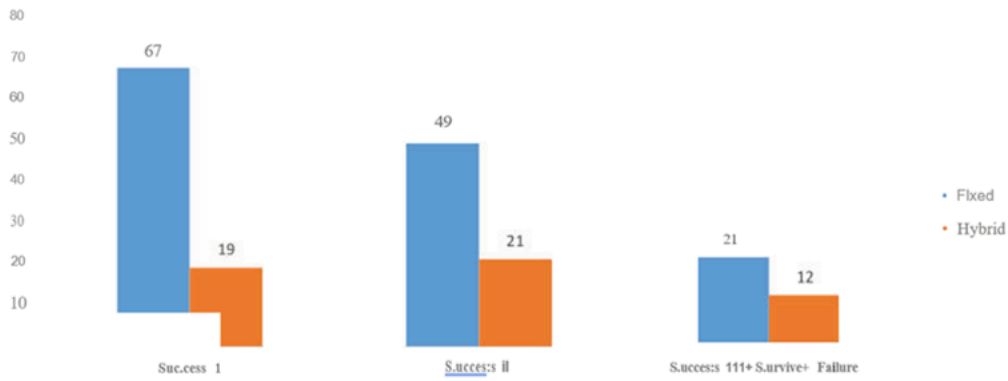


Figure 7

Cumulative Success Levels According to Prosthesis Type

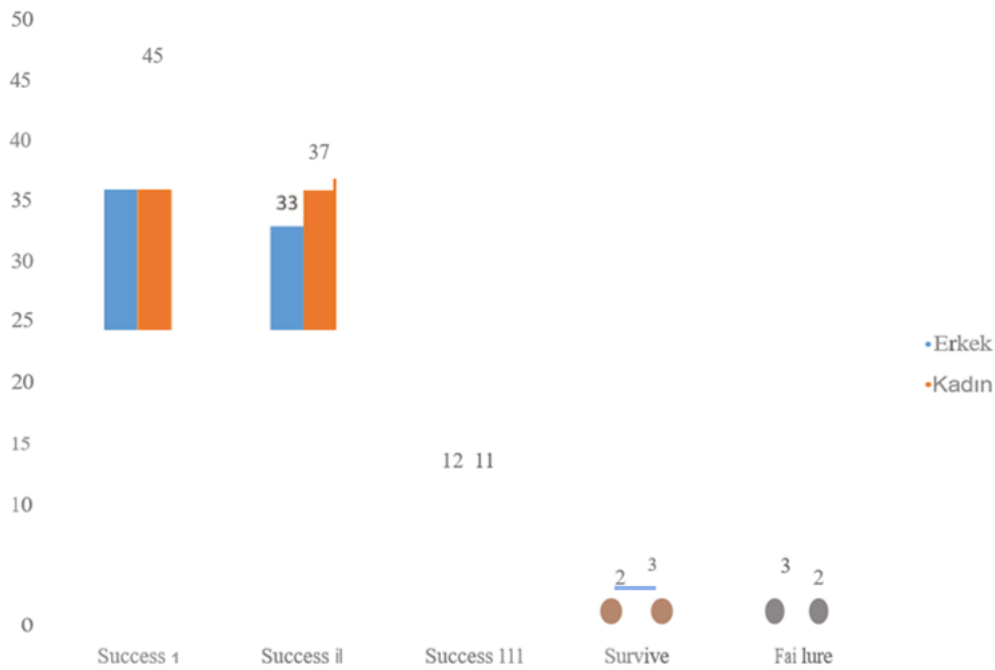


Figure 8

Implant Success Levels According to Patient Sex

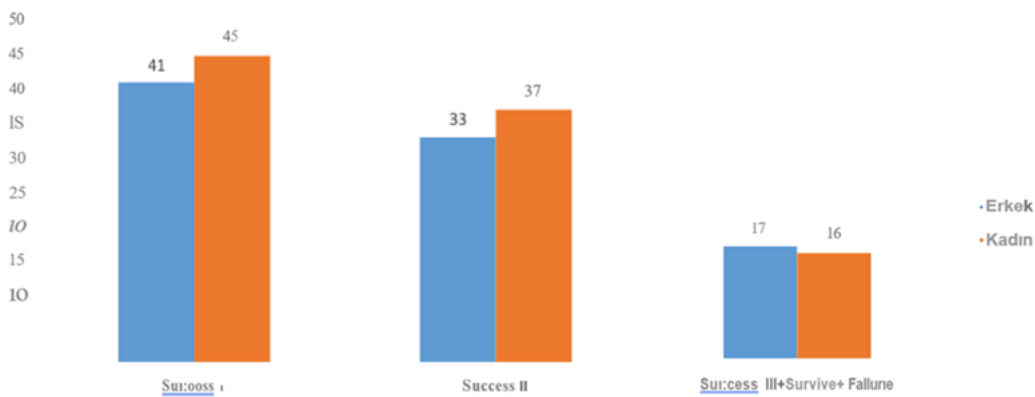


Figure 9

Cumulative Success Levels According to Patient Sex

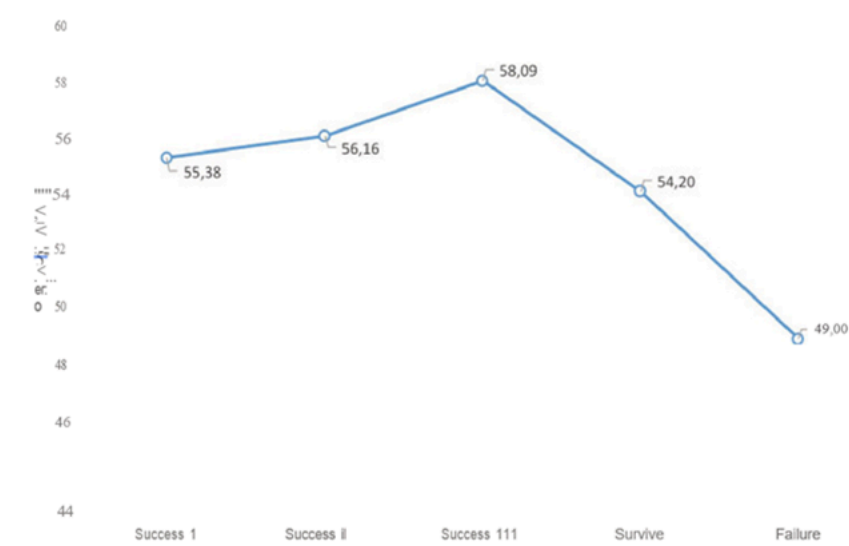


Figure 10

Distribution of Implant Success Levels According to Patient Age