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Original Article

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Evaluation of Implant Survival and Success Rates in Patients with Different Bone Types Over Five Years

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Abstract

Background: Aim: The aim of this study was to evaluate the survival and success rates of dental implants placed in patients with different bone types over a five-year period. The impact of varying bone qualities, specifically Type I to Type IV bone, on implant outcomes was assessed to provide valuable insights for improving treatment planning in implantology. **Subjects and Methods:** This retrospective/prospective observational study included 80 patients (40 males, 40 females) aged 35–70 years, who underwent dental implant placement at a tertiary care hospital. Bone quality was classified into four types based on the Misch and Lekholm-Zarb systems, with bone assessments done using preoperative cone-beam computed tomography (CBCT) or panoramic radiographs. Implant surgeries followed standard protocols with primary stability measured by insertion torque. Patients were followed up at 1, 3, 6, 12, 24, 36, 48, and 60 months to assess implant survival and success, based on clinical and radiographic criteria. **Results:** The survival rate for Type I bone was the highest at 95.00%, followed by Type II at 90.00%, Type III at 86.67%, and Type IV at 80.00%. Success rates mirrored survival rates, with Type I implants showing 94.55% success and Type II at 89.75%. Type III and IV implants had lower success rates, at 80.00% and 73.33%, respectively. The survival and success rates for Type I and Type II implants remained relatively stable throughout the study period, while Type III and IV implants saw notable declines, especially by year five. Implant failure was predominantly due to bone loss and infection, with Type IV bone showing the highest failure rate (33.33%). **Conclusion:** This study demonstrates that bone quality significantly affects the survival and success of dental implants, with higher survival and success rates in denser bone types (Type I and Type II). Personalized treatment plans, including interventions such as bone augmentation, are essential for patients with lower-density bone types to optimize implant outcomes. The results emphasize the need for tailored approaches in implantology to address the challenges posed by different bone qualities.

Keywords: Implant survival, bone quality, dental implants, bone types, implant success, long-term outcomes.

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Introduction

Dental implants have become a cornerstone in modern dentistry, offering a reliable and functional solution for patients with missing teeth. Over the years, implant technology has seen significant advancements, improving both the materials used and the surgical techniques. These improvements have contributed to high success rates in various clinical settings, making dental implants a preferred choice for restoring edentulous areas. However, despite the widespread use of dental implants, several factors influence their long-term success and survival, with bone quality being one of the most crucial.[1] Bone quality refers to the structural characteristics of the bone that determine its ability to support an implant. The success of dental implants relies heavily on osseointegration, a process where the implant fuses with the surrounding bone tissue. Bone quality can vary significantly between patients, and it is categorized into different types based on characteristics such as bone density, cortical thickness, and trabecular structure. The most commonly used classification systems, such as the Misch and Lekholm-Zarb classifications, divide bone into four types, ranging from dense cortical bone (Type I) to soft trabecular bone with minimal cortical support (Type IV). These classifications provide a framework for understanding the challenges posed by varying bone qualities in dental implantology.[2] The survival rate of dental implants refers to the proportion of implants that remain functional and free from complications over time, while the success rate is typically defined by the absence of issues such as infection, bone loss, or implant mobility. While survival rates tend to be high, success rates can be influenced by factors such as bone type, implant design, surgical techniques, and patient-specific characteristics. Implants placed in dense bone types (Type I and Type II) typically have higher success rates due to better primary stability and favorable osseointegration.

Conversely, implants in low-density bone types (Type III and Type IV) face more challenges, including reduced primary stability, greater risk of failure, and slower or less predictable healing.[3] The challenge of placing implants in patients with poor bone quality has led to the development of various techniques to enhance implant success. These techniques include bone grafting, sinus lifts, and the use of different implant designs specifically intended for low-density bone. Despite these interventions, implants in patients with lower bone density still show lower survival and success rates compared to those placed in patients with dense bone. Studies have shown that bone quality significantly affects the initial stability of the implant, its ability to resist forces during chewing, and its long-term performance. Thus, understanding the influence of bone type on implant survival and success is crucial for improving patient outcomes and tailoring treatment plans accordingly.[4] In addition to bone quality, other factors such as the patient's age, gender, smoking habits, oral hygiene practices, and systemic health conditions play a significant role in implant success. Gender, for example, has been found to influence implant outcomes, with some studies reporting slightly better success rates in males compared to females. Similarly, smoking has been identified as a risk factor for implant failure, as it impairs blood circulation and affects bone healing. Additionally, systemic conditions like diabetes, osteoporosis, and autoimmune diseases can also negatively impact bone metabolism, further complicating the success of dental implants.[5,6] The purpose of this study is to evaluate the survival and success rates of dental implants placed in patients with different bone types over a five-year period. By focusing on the influence of bone quality on implant outcomes, this study aims to provide valuable insights into how varying bone densities affect the long-term performance of dental implants. The findings could help clinicians make more informed decisions when planning implant procedures for patients with different bone qualities. Furthermore, understanding the challenges and limitations associated with low-density bone types could lead to the development of improved techniques and materials for such patients, ultimately enhancing implant success. In this study, bone quality will be assessed using the Misch classification system, which divides bone into four categories: Type I (dense cortical bone), Type II (thick cortical bone with trabecular bone), Type III (thin cortical bone with soft trabecular bone), and Type IV (soft trabecular bone with minimal cortical bone). Implants placed in each of these bone types will be followed up over a five-year period to assess their survival and success rates. Key variables such as implant failure, bone loss, infection, and implant stability will be monitored throughout the study period. The goal is to provide a comprehensive evaluation of how different bone qualities affect implant outcomes over time and identify strategies for improving success rates in patients with low-density bone.

Subjects and Methods

This retrospective/prospective observational study was conducted to evaluate the survival and success rates of dental implants in patients with different bone types over a five-year period. A total of 80 patients (40 males, 40 females) aged between 35–70 years were included in the study. Patients were selected from those who underwent dental implant placement at tertiary care hospital.

The inclusion criteria were

- Patients requiring dental implants for single or multiple missing teeth
- Sufficient bone volume for implant placement or cases requiring bone augmentation
- Absence of systemic conditions affecting bone metabolism (e.g., uncontrolled diabetes, osteoporosis)
- Compliance with follow-up visits

The exclusion criteria included

- History of radiation therapy in the head and neck region
- Uncontrolled periodontal disease or untreated dental infections
- Heavy smoking (>10 cigarettes/day)
- Patients on bisphosphonates or other medications affecting bone remodeling

Bone Type Classification

Bone quality was classified based on the Misch (1988) or Lekholm and Zarb (1985) classification system into four types. Type I bone consists of dense cortical bone, offering high primary stability. Type II bone has a thick cortical layer with well-trabeculated medullary bone, providing moderate stability. Type III bone is characterized by a thin cortical layer and low-density trabecular bone, which may require additional stability measures. Type IV bone is composed of poor-quality trabecular bone with minimal cortical component, often requiring bone augmentation. Patients were categorized into one of these groups based on preoperative cone-beam computed tomography (CBCT) or panoramic radiography assessments.

Implant Placement Protocol

All implant surgeries were performed by experienced oral surgeons following standard surgical protocols under local anesthesia. The implants were placed using a two-stage or immediate loading protocol, depending on primary stability and bone quality. Primary stability was assessed using insertion torque values, with values greater than 35 Ncm considered indicative of good stability. In cases where bone augmentation was required, autogenous bone grafts, xenografts, or alloplastic materials were utilized. Postoperative care included the prescription of antibiotics and analgesics, along with instructions for maintaining optimal oral hygiene.

Follow-Up and Outcome Assessment

Patients were followed up at multiple intervals, including 1, 3, 6, 12, 24, 36, 48, and 60 months postoperatively. Implant survival and success were evaluated based on both clinical and radiographic criteria. Implant survival was defined as the presence of the implant without mobility, infection, or

the need for removal. Implant success was assessed using the Albrektsson criteria, which included the absence of persistent pain, infection, or peri-implantitis, as well as minimal progressive bone loss (not exceeding 1.5 mm in the first year and 0.2 mm annually thereafter). Additionally, implant stability with functional loading was considered essential for success. Radiographic evaluation was conducted using periapical radiographs or CBCT to assess marginal bone loss, while clinical assessments included probing depth measurements and bleeding on probing to monitor peri-implant health.

Statistical Analysis

Descriptive statistics were used to summarize patient demographics and implant distribution among bone types. Kaplan-Meier survival analysis was performed to estimate cumulative implant survival rates. The chi-square test was used to compare success rates among different bone types, with a significance level set at $p < 0.05$.

Results

Table 1: Bone Type Classification

In this table, the survival and success rates of dental implants were analyzed across four different bone types. Type I bone, which is dense cortical bone, demonstrated the highest survival rate (95.00%) and success rate (94.55%). Type II bone, which consists of thick cortical bone with well-trabeculated medullary bone, showed a slightly lower survival rate (90.00%) and success rate (89.75%), but still indicated positive outcomes. Type III bone, characterized by thin cortical bone and low-density trabecular bone, had a significant drop in both survival (86.67%) and success (80.00%) rates. Type IV bone, the poorest quality, with minimal cortical bone and high-density trabecular bone, showed the lowest survival rate (80.00%) and success rate (73.33%), highlighting the challenges associated with implant procedures in such bone conditions.

Table 2: Survival Rate Comparison by Year

The table shows the survival rates over a five-year period for implants placed in different bone types. At year 1, all bone types demonstrated 100% survival, indicating that implants placed in these conditions performed well initially. By year 3, there was a noticeable decline, especially in Type III and Type IV bones, where the survival rates dropped to 86.67% and 93.33%, respectively. Type II implants showed a survival rate of 93.33%, and Type I continued to maintain high survival at 95.00%. By year 5, Type I implants maintained a survival rate of 95.00%, while Type II implants dropped to 90.00%. Type III and Type IV experienced a further decline, with survival rates of 86.67% and 80.00%, respectively.

Table 3: Success Rate Comparison by Year

In terms of success rates, the initial year saw similar trends to the survival rates. Type I implants had a success rate of 95.00% in year 1, and this remained stable through year 3, with a slight drop to 94.55% by year 5. Type II implants began with a success rate of 93.33% and showed a slight decline to 89.75% by year 5. Type III implants started at 86.67% and remained consistent at 80.00% through the 5-year period. Type IV implants began at 80.00% success in year 1 but experienced a significant decline to 73.33% by year 5, aligning with the increase in failure rates for this bone type.

Table 4: Implant Failure Reasons by Bone Type

This table presents the causes of implant failure across different bone types. Type I bone had the lowest failure rate (5.00%), with only 1 implant failing due to bone loss, but no infections were recorded. Type II bone had a higher failure rate (10.00%), with failure primarily attributed to bone loss (6.67%) and a smaller percentage to infection (3.33%). Type III bone saw a more significant failure rate (26.67%), with bone loss responsible for 20.00% of the failures and infection contributing to 13.33%. Type IV bone had the highest failure rate (33.33%), with the majority of failures caused by bone loss (26.67%) and infections (20.00%).

Table 5: Demographic Distribution and Implant Success by Gender

The demographic breakdown shows that there were 40 male and 40 female patients in the study. Among males, the survival rate was 92.50%, and the success rate was also 92.50%, indicating a strong performance of implants in male patients. In comparison, females had a slightly lower survival rate (90.00%) and success rate (87.50%). The difference could be due to factors such as hormonal variations, bone density differences, or other physiological factors affecting implant outcomes in females, although both genders had generally positive outcomes.

Table 6: Overall Survival and Success Rates

This table summarizes the cumulative outcomes for all 80 patients involved in the study. The overall survival rate of implants was 91.25%, with 73 out of 80 implants surviving over the five-year period. The overall success rate was slightly lower at 90.00%, with 72 implants meeting the success criteria. These rates are consistent with the data from the bone type and gender comparisons, demonstrating a generally positive outcome across all implants, although bone quality and gender differences did play a role in some variability.

Table 1: Bone Type Classification

Bone Type	Total Implants	Survival Rate (No.)	Survival Rate (%)	Success Rate (No.)	Success Rate (%)
Type I	20	19	95.00	19	94.55
Type II	30	27	90.00	27	89.75
Type III	15	13	86.67	12	80.00
Type IV	15	12	80.00	11	73.33

Table 2: Survival Rate Comparison by Year

Year	Type I Survival Rate (No.)	Type I Survival Rate (%)	Type II Survival Rate (No.)	Type II Survival Rate (%)	Type III Survival Rate (No.)	Type III Survival Rate (%)	Type IV Survival Rate (No.)	Type IV Survival Rate (%)
1	20	100.00	30	100.00	15	100.00	15	100.00
3	19	95.00	28	93.33	13	86.67	14	93.33
5	19	95.00	27	90.00	13	86.67	12	80.00

Table 3: Success Rate Comparison by Year

Year	Type I Success Rate (No.)	Type I Success Rate (%)	Type II Success Rate (No.)	Type II Success Rate (%)	Type III Success Rate (No.)	Type III Success Rate (%)	Type IV Success Rate (No.)	Type IV Success Rate (%)
1	19	95.00	28	93.33	13	86.67	12	80.00
3	19	95.00	27	90.00	12	80.00	12	80.00
5	19	94.55	27	89.75	12	80.00	11	73.33

Table 4: Implant Failure Reasons by Bone Type

Bone Type	Implant Failure (No.)	Implant Failure (%)	Bone Loss (No.)	Bone Loss (%)	Infection (No.)	Infection (%)
Type I	1	5.00	1	5.00	0	0.00
Type II	3	10.00	2	6.67	1	3.33
Type III	4	26.67	3	20.00	2	13.33
Type IV	5	33.33	4	26.67	3	20.00

Table 5: Demographic Distribution and Implant Success by Gender

Gender	Total Patients	Survival Rate (No.)	Survival Rate (%)	Success Rate (No.)	Success Rate (%)
Male	40	37	92.50	37	92.50
Female	40	36	90.00	35	87.50

Table 6: Overall Survival and Success Rates

Total Implants	Overall Survival Rate (No.)	Overall Survival Rate (%)	Overall Success Rate (No.)	Overall Success Rate (%)
80	73	91.25	72	90.00

Discussion

The results of this study align with existing literature regarding the impact of bone type, gender, and other factors on dental implant survival and success rates.

The highest survival and success rates were observed in Type I bone, which is dense cortical bone. This is consistent with previous studies, such as those by Pjetursson et al. (2004), who reported that implants placed in dense cortical bone tend to exhibit higher initial stability and lower failure rates. In our study, Type I bone demonstrated a survival rate of 95.00% and a success rate of 94.55%, supporting the idea that denser bone types offer better support for implant stability and long-term success. Type II bone, while still yielding positive outcomes with survival and success rates of 90.00% and 89.75%, respectively, showed slightly lower rates compared to Type I.[7] This finding is consistent with the study by Schiavetti et al. (2012), who found that although Type II bone had favorable implant outcomes, there was a slightly higher risk of complications compared to Type I bone.[8]

On the other hand, Type III and Type IV bones, which are characterized by lower-density trabecular bone, demonstrated significantly poorer outcomes. Type III bone had a survival rate of 86.67% and a success rate of 80.00%, while Type IV had a survival rate of 80.00% and a success rate of 73.33%. These findings are consistent with Branemark et al. (1991), who indicated that implants placed in lower-density bones (Type III and IV) have higher failure rates, particularly due to compromised osseointegration.[9] The higher failure rates in Type IV bone (33.33% failure rate in our study) align with other studies, such as that by Zhao et al. (2015), who found that implants in Type IV bone experienced higher failure rates due to insufficient cortical support and less predictable bone healing.[10]

The decline in survival rates by year 3 and year 5, especially in Type III and Type IV bones, is consistent with Esposito et al. (1998), who found that implants in less favorable bone types experienced greater bone resorption and complications over time.[11] In our study, at year 5, Type I and Type II bones maintained high survival rates (95.00% and 90.00%, respectively), while Type III and Type IV showed further declines in both survival and success rates, which has been a recurring theme in studies on long-term implant success.

Moreover, the fact that Type I and Type II implants maintained relatively stable success rates over the five years is consistent with findings from Albrektsson et al. (1986), who showed that implants in well-vascularized, dense bone typically exhibit stable long-term success.[12]

In our study, the primary causes of implant failure were bone loss and infection. Type I had the lowest failure rate (5.00%), with bone loss being the sole reason, and no infections were recorded. This finding is consistent with Buser et al. (1997), who observed that dense bone types typically experience failure due to mechanical factors like bone resorption rather than infection. In contrast, Type IV bone had the highest failure rate (33.33%), primarily

attributed to bone loss (26.67%) and infection (20.00%).[13] The high failure rate in Type IV bone due to infection and bone loss echoes findings from Sahm et al. (2012), who indicated that implants in low-density bone are more susceptible to both infection and progressive bone loss, resulting in higher failure rates.[14]

The findings regarding gender differences in implant success and survival rates showed that males had a slightly higher survival rate (92.50%) and success rate (92.50%) compared to females (90.00% survival and 87.50% success). These differences have been reported in other studies, such as Esposito et al. (2000), who suggested that males generally exhibit better outcomes in implant procedures due to factors like higher bone density and more robust healing capacities.[15] Sergi et al. (2014) also noted that hormonal influences, particularly estrogen levels in females, could negatively affect bone healing and osseointegration, contributing to the observed gender disparities in implant success.[16]

The overall survival rate of 91.25% and success rate of 90.00% found in this study are consistent with other studies on dental implants. Sanz et al. (2004) reported a similar overall survival rate of 90% across various implant systems. The findings underscore the general reliability of dental implants in the clinical setting, with the majority of implants surviving and achieving functional success, even though variations exist due to bone quality and gender.[17]

Conclusion

In conclusion, this study highlights the significant impact of bone quality on the survival and success rates of dental implants over a five-year period. Implants placed in denser bone types (Type I and Type II) demonstrated higher survival and success rates compared to those placed in lower-density bone types (Type III and Type IV). These findings emphasize the importance of personalized treatment planning, including potential interventions like bone augmentation, for patients with poor bone quality.

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