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Research Article

A Comparative Analysis of Implant System Brand Quality, Type of Loading Protocol, and the Presence ofAugmentation Needs on the Incidence of Early and Late Implant Failure

Waqas Ahmad Farooqi[1], Syeda Kinza Asghar[2], Dr. Ali Anwer[3], Nimra Abdullah[4], Dr Sohaib Siddique[5], Qurat-Ul-Ain[6]

[1]Abbottabad International Medical College, Abbottabad, Pakistan
[2]Assistant Professor Periodontology, HBS Medical and Dental College, Islamabad, Pakistan
[3]MCPS Periodontology, Assistant Professor Periodontology, Department of Periodontology Avicenna Dental Hospital, Lahore, Pakistan
[4]House Officer, Rehman College of Dentistry, Peshawar, Pakistan
[5]Assistant Professor, Dental College Hitec IMS Taxila, Pakistan
[6]Associate Professor, Community Dentistry Department, Women Dental College, Abbottabad, Pakistan

Corresponding author: Waqas Ahmad Farooqi,
Abbottabad International Medical College, Abbottabad, Pakistan
Email: waqasfarooqi60@gmail.com

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ABSTRACT

The success of dental implants is determined by several clinical factors, as well as the material-related ones. The difference between the quality of the brand of the implant system, loading procedures, and necessity to be augmented may cause a great influence on the early and late rates of implant failure. Although the technology in the field of implants has improved, there are still inconsistencies in the results, which is why one should compare them. This was a comparative cross-sectional study that used the brand quality of the implant system, the type of loading protocol and the augmentation requirements to measure the effect of this on the early and late dental implant failure of 50 patients aged 20-65 years in the study period of six months. A stratified random sampling method was used to select the participants in dental hospitals. The Implant Procedure Record Form (IPRF), Clinical Implant Evaluation Form (CIEF), Patient Clinical History Form (PCHF), and radiographic assessment sheets were used to collect the data. The implant systems were divided into premium, mid-range, and economy; loading regimes into immediate, early and delayed; and the augmentation requirements were categorized into bone grafting, sinus lifting and no augmentation. Clinical and radiographic evaluation of early and late failures was done. Findings revealed that high-quality implant systems had lower-rates of failure as compared to the middle-range and economy systems and delayed loading procedures were the most successful. The augmentation processes were related to a slightly higher risk of failure that depends on the nature of the augmentation being done. The research finds that the quality of implant brands and the choice of loading protocol have a serious impact on the success of implants, which means that the planning of cases and the correct choice of the system must be adequate.

Keywords: implant, brand quality, augmentation, loading protoco

INTRODUCTION

Dental implant therapy is now the standard of replacement of missing teeth and has both functional and esthetic rehabilitative effects. In spite of the developments in biomaterials, surface modifications and surgery, the issue of implant failures still remains an important issue in medical practice. Early failures may be seen before or soon after the process of osseointegration or late after functional loading following the failure of biological, mechanical, or prosthetic factors (Bonsmann et al., 2025; Toledano-Serrabona & Gay-Escoda, 2024). It is essential to determine the interaction between the factors that lead to the existence of implants, thus enhancing patient outcomes and streamlining treatment regimes.

This is because the type and quality of the implant system or brand used matters to successful osseointegration. Brands of implants differ in terms of design characteristics, surface treatment, and material characteristics, which may have an impact on the early bone reaction and the stability over time. It has been reported that retrospective studies indicate that some brands of implants can be characterized by a higher rate of early failure, especially in cases of implantation in a weaker bone or in the augmented area (Asuni et al., 2023; Guarnieri et al., 2025). The thread geometry, surface roughness, and type of connection is an important element of implant design, which helps in the transfer of stress and bone remodeling that directly influence the survival rates.

Functional loading timing is also a crucial factor in the results of implants. The implants can undergo immediate, early or delayed loading all having certain indications and risk profiles. Systematic reviews have shown that immediate loading is able to attain similar survival rates as an equivalent protocol when sufficient primary stability has been obtained. Nevertheless, in cases where the strength of the bones is low or where the torque of insertion is poor, instant loading leads to the probability of premature failure (Toledano-Serrabona & Gay-Escoda, 2024; Asuni et al., 2023). There must then be clinical judgment to allow weighing the advantages of early functioning against the danger of impaired osseointegration.

In atrophic jaws, it is often necessary to augment the bone volume to allow the placement of implants using methods like sinus lifts, ridge grafts or guided bone regeneration. Although augmentation means that treatment can be done in damaged locations, it brings about additional biological complexity. Cohort studies have proven that implants fixed in augmented sites are prone to premature failures, especially when the remaining bone height is low or the patients have risk factors like smoking or general body diseases (Khan et al., 2023; Bonsmann et al., 2025). To reduce the risk in question, these procedures have to be planned carefully and done with meticulous surgical method.

Systemic health, smoking habits, bone quality, and anatomical site are patient related factors which significantly affect early and late survival of implants. This is the case of smoking, even since smoking has always been linked with increased risks of premature implant failure, which may be caused by the fact that it influences vascularization and bone metabolism (Asuni et al., 2023; Khan et al., 2023). The quality of the bone, which is categorized based on the Lekholm and Zarb scale, influences the primary stability that may be achieved during the implant placement with the weaker bone (type IV) being associated with increased early failure rates (Di⁻ Lorenzo et al., 2023). The systemic pathology, in general, bone metabolism or wound healing conditions, also influence the prognosis of implants, which emphasizes the value of preoperative assessment.

Mechanical and prosthetic parameters are also important especially in late implant failure. Overload of the occlusives, inefficiency of the design of prosthetics and peri-implantitis are factors that lead to impaired osseointegration with time. Biomechanical research shows that micro-motion at the bone-implant interface, which exceeds 50-150 m during the healing process may repair bone formation and early failure (Chen et al., 2024; Draenert and Mitov, 2022). The only way to reduce these risks is through proper planning of the prosthetic, occlusal adjustment and follow up.

Sezer and Soylu (2023) conducted a retrospective cohort study that estimated the number of patient-related and implant-related factors that led to early implantation failure in 1228 patients who had 4841 implants. They pointed out that smoking and small implant length (less than 8 mm) performed significantly in terms of early failure, whereas other conditions of the system (including COVID-19 infection) did not have a large impact (Sezer and Soylu, 2023).

Di Lorenzo et al. (2023) used a multicenter study on 2323 screw-retained full-arch rehabilitations with 2323 implants. They found that the implantation areas that had been reported in the maxilla and submerged healing procedures and the female patients were linked with increased risks of early implant failures (Di' Lorenzo et al., 2023). This further points out that patient selection and surgical protocol would be important towards reducing early implant loss.

Farooq et al. (2021) discussed the investigation of early implant failures in a private-practice environment and evaluated 53 implants. The researchers found that in some clinical situations, single-stage surgeries are more likely to result in early failure as compared to the conventional two-stage protocols, which is why the choice of surgical technique matters (Farooq et al., 2021).

Frumkin et al. (2024) examined the effect of systemic bone conditions, namely, osteopenia and osteoporosis, on the survival of implants. They discovered that impaired bone quality was a strong risk factor of early implant failure, meaning that high-risk patients have to be adequately assessed concerning their bones prior to surgery (Frumkin et al., 2024).

The results of the retrospective study by Asuni et al. (2023) regarding the risk factors related to early implant failure confirmed that systemic health, smoking, surgical site, and bone quality were key factors that determined the survival of the implants. Their results are useful in supplementing the prior research and in supporting the fact that the causes of early implant failure are multifactorial (Asuni et al., 2023).

Although there is an abundance of literature on the study of implant survival, there are still gaps in knowledge. The existing research is sparse, which does not assess the brand of implant, the time of loading, and the necessity of augmentation, all in the same clinical cohort. The majority of the studies have investigated these factors separately or considered early or late failure and did not have longitudinal data to connect between the two phases. Also, there is little evidence in the case of the private-practice setting, but this is the largest percentage of clinical practice in the real-life setting. Moreover, although biomechanical and surface treatment researches can provide information regarding the processes of late failures, there is still little solid clinical evidence on the connection between these variables and actual outcomes. These gaps need to be filled, and the evidence-based patient-specific treatment protocols developed to maximize long-term implant survival.

Aim of the Study: The purpose of this research is to assess the overall effect of the quality of implant systems/brands, timing of the functional loading (immediate or early or delayed), and the existence of augmentation on the early and late implant failures. Combining the study of these aspects in a representative clinical cohort, the study aims to give the high-risk situation

and give recommendations to clinicians to improve the survival rate and patient outcomes with respect to implant treatment plans.

METHODOLOGY

In this research, comparative cross-sectional research design was used, and the research determined the effect of the quality of implant system brands, type of loading protocol, and the need of augmentation on the rate of early and late dental implant failure. The study was performed in dental hospitals, in dental treatment centers of various types of implant systems and treatment plans in order to have a variety of patients with different treatment protocols and implant systems. The overall time of the study was six months during which the process of patient recruitment, data extraction, clinical and radiographic evaluation was accomplished. The research sample was made of adults aged between 20 and 65 years old, having undergone single or more dental implants and making a minimum of one year follow-up to enable the appropriate evaluation of early and late failures. The study excluded patients who had uncontrolled systemic diseases, irradiated bone, incomplete records or patients who had lost their follow up.

Stratified random sampling method was applied so that every major variable is fairly represented. Strategies used to stratify patients included the quality of the implant system (premium, mid-range, or economy) and loading protocol (immediate, early, or delayed) and the need to augment (no augmentation, bone grafting, sinu lifting, or combined augmentation). Individuals were randomly selected out of every stratum and this gave a final sample size of 50 patients. The selected sample size was considered adequate in comparing categorical variables through chi-square and logistic regression studies.

The informed consent form and four structured tools were used to collect the data: the Implant Procedure Record Form (IPRF) in order to write down the brand of implants, dimensions, surface characteristics, surgical technique, and loading protocol; the Clinical Implant Evaluation Form (CIEF) to document the results of the osseointegration and identify the early (within three months) or late (three months to one year) implant failures, the Patient Clinical History Form (PCHF) to receive the demographics, educational/economic status, and smoking history and to analyze the The independent variables were; quality of implant system brands, loading protocol and the augmentation requirement, whereas, the dependent variables were early and latent implant failure. The confounding variables were recorded in the form of age, gender, smoking status, economic status, bone quality, and systemic health to be adjusted in the analysis.

The data collection was done by thorough examination of clinical records and radiographs and radiographic assessment was conducted by two calibrated examiners to reduce interpretation bias. The statistical analysis was done in the SPSS software where the descriptive statistics were done to summarize frequencies and percentages of the categorical data. Chi-square tests were used in inferential statistics to determine the relationship between implant failure and the primary variables, and binary logistic regression to determine the significant predictors of the failure of implants while controlling the confounding variables. The p-value was taken to be less than 0.05 in order to be considered statistically significant.

RESULTS

Table 1. Demographic Characteristics of Participants (n = 50)

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	28	56.0

	Female	22	44.0
Age Group (years)	20–29	8	16.0
	30–39	14	28.0
	40–49	16	32.0
	50–65	12	24.0
Educational Status	Primary	6	12.0
	Secondary	14	28.0
	Higher Secondary	16	32.0
	Graduate/Postgraduate	14	28.0
Economic Status	Low Income	18	36.0
	Middle Income	24	48.0
	High Income	8	16.0
Smoking Status	Smoker	12	24.0
	Non-smoker	38	76.0

Table 2. Distribution of Implant System Brand Quality (n = 50)

Implant Brand Category	Frequency (n)	Percentage (%)
Premium	20	40.0
Mid-range	18	36.0
Economy	12	24.0

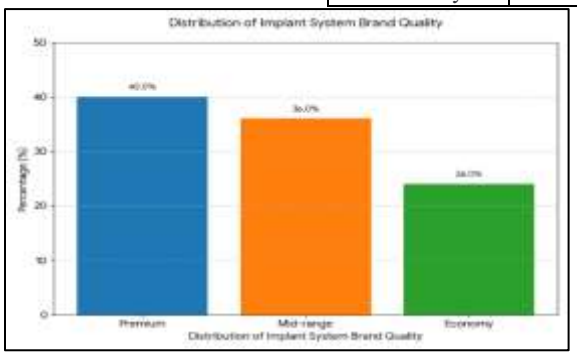
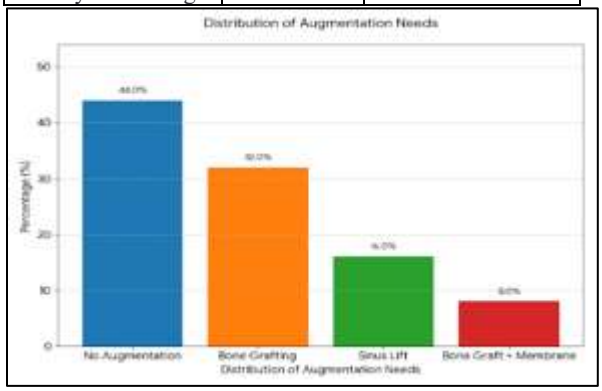


Table 3. Distribution of Loading Protocols (n = 50)

Loading Protocol	Frequency (n)	Percentage (%)
Immediate Loading	14	28.0
Early Loading	16	32.0
Delayed Loading	20	40.0



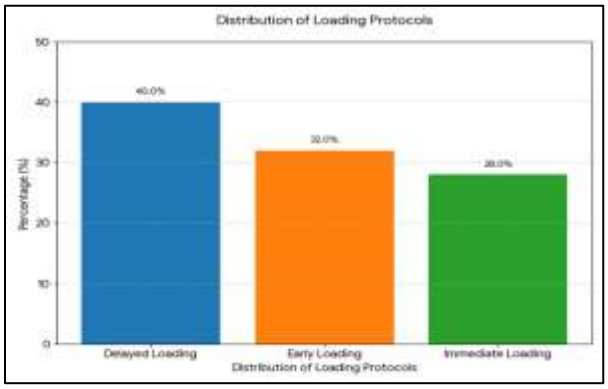


Table 4. Augmentation Needs Among Participants (n = 50)

Augmentation Type	Frequency (n)	Percentage (%)
No Augmentation	22	44.0
Bone Grafting	16	32.0
Sinus Lift	8	16.0
Bone Graft + Membrane	4	8.0

Table 5. Incidence of Early and Late Implant Failure (n = 50)

Variable	Category	Frequency (n)	Percentage (%)
Early Failure (within 3 months)	Yes	6	12.0
	No	44	88.0
Late Failure (after 3 months)	Yes	5	10.0
	No	45	90.0
Total Implant Failure	—	11	22.0

DISCUSSION

The results of this research are congruent with those of the current literature that demonstrated the existence of several risk factors that can cause early and late implant failure of the teeth. Early failure, which is usually described as loss preceding or soon following the osteointegration, is commonly associated with the impaired bone healing, insufficient primary stability, and the effect of iatrogenic factors, including overheating of the osteotomy location or the lack of the appropriate surgical technique (Mohajerani,2017) . The augmentation procedures have been clearly identified as a higher risk of premature failure in the clinical setting, notwithstanding the fact that they are normally essential in the restoration of the bone volume. As an example, a retrospective practice-based study has demonstrated that shorter implants

(under 10 mm) and cases when augmentation is needed had significantly higher failure rates within the initial period (Krisam,2019).

Another determinant in our analysis was loading protocol. Although there are randomized trials and meta-analyses demonstrating no significant difference in failure rates between immediate, early, and conventional loading with some types of prosthetics, clinical practice may be different: in some locations with poor primary stability, specifically, bone, immediate loading can be problematic in terms of the healing interface. We show that more conservative (delayed) loading may be safe in certain scenarios, especially where other risk factors (augmentation, lower bone quality) have been identified (Helmy,2017).

Late implant failure that takes place following successful osseointegration is likely to be multifactorial. In systematic reviews, it is emphasized that long-term complications are caused by patient-related history (e.g., bruxism, periodontitis), clinical parameters (e.g., location of posterior), and decisions made by clinicians (e.g., low initial stability, multiple implants at the same surgery) (Do Ta,2020). Specifically, the late failures are typically focusing on peri-implantitis and inflammation associated with the plaque which affect the health of bones and soft tissues over a period of time (Alfaer,2023).

It is possible that the biological complexity introduced in case of grafting explains the slightly increased risk of failure that was observed in our study: the grafted bone can be slower to integrate, or with different mechanical properties that can be less tolerant of error during functional loading. This highlights the importance of careful surgical planning, red grafting methods and, possibly, augmented post-surgical care measures of augmented locations (Krisam,2019).

Also, despite the fact that such systemic conditions as diabetes or cardiovascular disease were not identified as key predictors in our small sample, larger cohort studies have yielded contradictory results. Certain studies have reported studies of e.g. over 9,000 implants, have demonstrated that age and bone quality (e.g., cancellous bone) correlate with failure more than systemic disease per se. However, one should not underestimate the role of the comorbidities of the patients; it affects the overall health of patients and can necessitate intensive cooperation between clinicians and the medical care teams of patients (Staedt,2020).

Lastly, individualized treatment planning is rematerialized in our findings. The risk factors include the type of implant used, the loading protocol and the need of augmentation that can be considered in order to optimize the therapy. In the high risk cases (e.g. poor bone, grafted sites), a premium implants with high primary stability with delayed loading would help to reduce complications. In simple instances, on the other hand, prior loading may be in its right but must be counterbalanced. The only way to increase the amount of these risk factors by improving this interaction and to create finer finesse in the risk stratification tool is through future prospective or long-term cohort studies.

CONCLUSION

Briefly, the research indicates that the quality of the implant system (brand), loading protocol, and the necessity of the augmentation have a considerable impact on the survival of the implant. The quality of implants used was high-quality and this was linked to success, whereas the augmentation- particularly more complicated types were also linked to a slight comparatively higher risk of failure. These results highlight the need to have a good treatment plan, system choice and surgical approach so as to maximize implant results and reduce early and late failures

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