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A Comparative Study of the Functional Outcomes of Immediate vs. Delayed Dental Implant Placement Post-Mandibular Resection Surgery

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Abstract

Mandibular resection surgery, commonly performed due to oral cancer or trauma, leads to significant functional and aesthetic challenges. Dental implants are commonly used to restore function, but the optimal timing for implant placement (immediate vs. delayed) after mandibular resection remains unclear. This study aimed to compare the functional outcomes of immediate versus delayed dental implant placement in patients following mandibular resection surgery. The study aims to assess and compare the implant survival rates, masticatory function, speech function, oral health-related quality of life (OHRQoL), and patient satisfaction between immediate and delayed dental implant placement after mandibular resection. A prospective cohort study was conducted with 60 patients undergoing mandibular resection surgery. Participants were randomly assigned to either the immediate implant placement group (Group I) or the delayed implant placement group (Group II). Data were collected at baseline, 6 months, and 12 months' post-surgery. Implant survival, masticatory function, speech, OHRQoL, and patient satisfaction were measured using objective assessments and self-reported questionnaires. Statistical analyses included Kaplan-Meier survival analysis, multiple linear regression, Pearson's correlation, and ANCOVA. The immediate implant placement group exhibited higher initial implant success (90%) compared to the delayed placement group (85%). However, the delayed group showed superior long-term implant survival and fewer complications. Masticatory function and speech were significantly better in the delayed group after 12 months, as was OHRQoL, with patients reporting better outcomes in psychological well-being and social interaction. The delayed group also had higher patient satisfaction scores in all categories. Delayed implant placement yielded better long-term outcomes in terms of implant survival, masticatory function, speech, OHRQoL, and patient satisfaction compared to immediate placement. These findings suggest that delayed placement may be a more reliable approach for mandibular resection patients, though immediate placement can offer quicker restoration of function.

Keywords: Implant survival, Masticatory function, Oral health-related quality of life (OHRQoL), Patient satisfaction, Speech function

Introduction

Defects that are caused by surgery such as mandibular resection surgery, which is commonly carried out as a treatment of oral cancer and also during traumatic injuries, end up losing a large percentage of the mandible (1). Mandibular resection surgery, commonly performed due to oral cancer, trauma, or other pathologies, leads to significant functional and aesthetic challenges. This study focuses specifically on segmental mandibulectomy and marginal resection performed for oncologic and trauma-induced conditions, as these are the most prevalent in clinical practice. Such a loss can be very debilitating on the functional and aesthetic components of the oral and facial structure of a patient. Rehabilitation involves the key of restoring the functionality and outlook of such patients (2). Dental implants are a relatively old practice that has been identified as an efficient way of restoring the functionality of the mouth, as well as replacing lost teeth. The timing of the implant placement after mandibular resection surgery is however debatable (3). Various factors are relevant in making the decision to use immediate or delayed placement of dental implants, they include the amount of bone loss, the general health

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of the patient, the kind of surgery he or she is having and the aims of rehabilitation (4). The immediate dental implantation is the insertion of the implant into the fresh surgery or resected site, usually at the same operation. The given approach will have the benefits of diminishing the total treatment time, preserving the bone volume in the impacted region, and ensuring a quicker recovery (5). The psychological benefit of immediate placement can also be offered; this is because it can restore the appearance and functioning of the patient more immediately. Delayed dental implant placement, on the other hand, is a wait whereby one waits a few months or even a year before the surgical area has healed (6). This will enable a further evaluation of the healing process of the patient, whereby the bone would be fully healed before the placement of the implant. Delayed placement is commonly preferred in situations requiring bone grafting or the inner-parts of the surgical site are too unstable to be implanted immediately (7).

Whether to carry out immediate or delayed dental implant placement immediately after mandibular resection is not only a clinical decision but also the one that has a considerable impact on the further quality of life in the patient (8). The success of these procedures is mainly determined by the functional outcomes, such as masticatory efficiency, speech, and oral health. The advantages of immediate implant placement include faster functional recovery, whereas its disadvantages are that it may lead to implant failure or implant complications due to inappropriate bone integration (9). Although delayed placement will permit a more controlled healing process, it can increase the timeframe over which the patient will be experiencing functional deficits (10). Postoperative radiation therapy is a crucial factor influencing the success of dental implants, as it significantly impairs osseointegration and compromises bone healing. The timing of implant placement, whether immediate or delayed, may be particularly affected by radiation, as it can lead to complications such as bone necrosis and reduced implant stability.

The timing of dental implant placement following mandibular resection surgery remains debated due to various conflicting factors. These include differing implant survival rates, complication risks associated with immediate placement, the impact of postoperative radiotherapy on osseointegration, and a lack of sufficient comparative studies that assess both immediate and delayed placement outcomes across different patient groups. This ambiguity in the evidence makes it challenging for clinicians to establish the optimal treatment approach (11).

The purpose of the study is to compare the immediate and delayed dental implant placement in terms of functional results after the mandibular resection surgery. Through the critical analysis of the benefits and shortcomings of the two methods, the given research will offer a thorough investigation into the impact of these treatment methods on the rehabilitation of patients in general. The survival rates of the implants, patient satisfaction, quality of life, masticatory functions, and speech will be considered as the key factors. The study will as well examine the timing implication on post-operative complication, bone integration, and aesthetic outcome.

Finally, the results of the current research can be used in the creation of tailored treatment regimens that are able to assist the practitioner to make the most optimal choice towards their patients to achieve the most ideal outcome during the rehabilitation care in cases of mandibular resection surgery.

Methodology

The research design adopted in this study was comparative research design that aimed at assessing the functional outcome of immediate and delayed placement of dental implant after surgery to the mandibular resection. The main objective was to evaluate and compare the efficacy of the two treatment methods based on success of implantation, functional restoration (i.e. masticatory) and speech, patient satisfaction and quality of life. The methodology section provides the research design, sample selection, the description of the interventions, data collection, and data analysis.

Study Design

A prospective cohort study was conducted with 60 patients undergoing mandibular resection surgery. Participants were randomly assigned to either the immediate implant placement group (Group I) or the delayed implant placement group (Group II) based on their clinical condition and treatment protocol. While random assignment was

employed to allocate participants to the groups, this study remains a cohort study as it does not involve the level of blinding or controlled intervention typically associated with an RCT

Participants

The sample group of the study was the group of patients, who would undergo a mandibular resection surgery conducted due to oral cancer or a traumatic injury in a tertiary care dental/surgical facility.

Inclusion criteria were as follows:

a) Adult patients, who underwent surgery of mandibular resections (18 to 75 years old).
b) Patients who were in good general health and whose bones were good and had no contraindication to the placement of the implants (e.g. uncontrolled systemic diseases, active infection or poor bone volume).
c) Patients that gave informed consent to take part in the research.

Exclusion criteria included:

a) Patients that have severe systemic conditions (e.g., uncontrolled diabetes, immunosuppressed conditions) that may influence healing.
b) Patients that needed extensive bone grafting that would not allow them to implant immediately.
c) Patients with a history of poor oral health or those who failed to have implants before.

Participants were randomly assigned to one of two groups:

Immediate Implant Placement Group (Group I): These patients underwent implant placement immediately following the mandibular resection surgery.

Delayed Implant Placement Group (Group II): These patients underwent mandibular resection surgery followed by a waiting period of 4 to 6 months for healing, after which dental implants were placed.

Intervention Procedures

Group I (Immediate Implant Placement): Dental implants were inserted into the resected area immediately or soon after the resection of the mandibular area, based on the clinical case. The kind of implants and their sizes was made the same, depending on the quality of the bone and the space available to the patient.

Group II (Delayed Implant Placement): Group II consisted of patients undergoing some mandibular healing period after the mandibular resection which lasted between 4 and 6 months on average. The site was observed during this period and bone healing and the sufficient closure of the soft tissue. Dental implants were then inserted into the healed bone after this period. Other adjunctive procedures such as bone grafting were applied where necessary based on the response of the healing.

Data Collection

Data were collected at multiple time points: pre-surgery (baseline), immediately post-surgery, 6 months after surgery, and annually for up to two years. The following types of data were collected:

Demographic and Clinical Data: Age, gender, type of mandibular resection (partial or full), medical history, and smoking status were recorded.

Implant Success: The primary outcome measure was the success rate of implants in both groups, including implant survival (whether the implant remained functional) and the incidence of complications such as infection, implant failure, or bone loss.

Functional Outcomes: Functional outcomes included assessments of:

a) Masticatory Function**:** Evaluated using objective measures of chewing efficiency (e.g., number of chews per unit of food, bite force measurements) and subjective patient-reported outcomes using a validated questionnaire on chewing ability.
b) Speech: Speech quality was assessed using a speech evaluation scale, focusing on intelligibility and articulation of speech sounds that might be affected by the resection.

Oral Health-Related Quality of Life (OHRQoL): This was measured using the Oral Health Impact Profile (OHIP-14), a validated questionnaire assessing patients' perceptions of the impact of oral health on their well-being.

a) Patient Satisfaction: A self-reported questionnaire assessed overall satisfaction with the functional and aesthetic outcomes of the treatment. This included both general satisfaction and specific aspects such as appearance, speech, and chewing function.
b) Radiographic Analysis: Cone beam computed tomography (CBCT) scans were used pre- and post-surgery to assess bone volume, implant placement accuracy, and bone remodeling around the implant site over time.

c) Follow-up and Complications**:** Any complications, such as infection, implant mobility, or bone loss, were documented throughout the follow-up period.

Data Analysis

Statistical analysis was performed using SPSS software (version 25.0). Descriptive statistics (means, standard deviations, and percentages) were used to summarize demographic and clinical data. Comparative analysis between the two groups was conducted using:

a) Chi-square tests for categorical variables (e.g., implant failure rates, complication types).
b) Independent t-tests or Mann-Whitney U tests for continuous variables (e.g., masticatory function scores, speech scores).
c) Paired t-tests for comparing within-group changes over time (e.g., pre- and post-surgery functional assessments).

A p-value of <0.05 was considered statistically significant.

Ethical Considerations

This was done according to the ethical code of conduct of medical research and was done in compliance with the declaration of Helsinki. The institutional review board (IRB) of the hospital also agreed to its approval. All the participants gave informed consent and all the information was kept confidential during the study.

Results

The findings of this comparative study on the functional oucome of immediate versus delayed oral implant placement after surgery done on mandibular resection is described below. The variables of analysis include success of implants, masticatory, speech, oral health-related quality of life (OHRQoL) and patient satisfaction, and through the advanced statistical analysis the results have been able to be provided in a comprehensive manner.

Implant Success

The success was mainly measured by the survival of implants that is, lack of implant failures, infections and severe complications. This was done through a Kaplan-Meier survival analysis which used long term survival rates of implants on the immediate placement group as well as the delayed placement group.

While the immediate placement group exhibited a higher initial implant success rate [90%] compared to the delayed group [85%], the delayed group showed fewer complications in terms of long-term survival. The failure rate and infection rate for the delayed group were higher than the immediate placement group at the 12-month follow-up [10% vs. 5% and 10% vs. 5%, respectively], but the delayed group exhibited better long-term implant survival and fewer long-term complications after 12 months. Implant survival rates and complications after mandibular resection surgery are shown in Table 1.

Table 1: Implant survival rates and complications after mandibular resection surgery

Group	Implant Success (%)	Complications (%)	Failure Rate (%)	Infection Rate (%)
Immediate Placement (I)	90	10	5	5
Delayed Placement (II)	85	15	10	10

Masticatory Function

The masticatory performance was assessed using the objective (bite force and chewing efficiency) and subjective self-reported questionnaires. The bite force evaluation showed that the two groups showed a significant improvement after the implant placement. Immediate group had the improvement of bite force by 46 percent and the delayed group was by 58 percent. The chewing efficiency was also determined and the delayed group was found to be more efficient after 6 months as indicated by the number of fewer chews per unit quantity of food as shown in Table 2.

Table 2: Comparison of masticatory function between immediate and delayed implant placement groups

Group	Pre-test Bite Force (N)	Post-test Bite Force (N)	Chewing Efficiency (chews per item)
Immediate Placement (I)	75.4 ± 12.3	110.2 ± 14.7	18.5 ± 3.2
Delayed Placement (II)	72.6 ± 11.8	115.4 ± 13.5	16.8 ± 2.7

Speech Function

The speech functionality was measured through a speech intelligibility scale which was a measure taken to determine the level of articulation clarity and the capability of pronouncing certain sounds influenced by the resection. The two groups showed remarkable increment in the speech intelligibility scores following the placement of the implants. The delayed placement group however showed a greater improvement with an increase in the intelligibility scores of the group ranging between 60% and 85% as compared to the immediate group which increased between 60% and 78% as shown in Table 3.

Table 3: Speech intelligibility improvement after implant placement

Group	Pre-test Intelligibility (%)	Post-test Intelligibility (%)
Immediate Placement (I)	60	78
Delayed Placement (II)	58	85

Oral Health-Related Quality of Life (OHRQoL)

The OHIP-14 questionnaire was used to determine the effect of the implantation of dental implants on the oral health-related quality of life. The findings showed that both groups had been shown to have great improvements in OHRQoL, but more so the delayed placement group. The mean score of OHIP post-treatment dropped by 40 + 11 to 18 + 6 on the delayed group but dropped by 38 + 10 to 23 + 8 on the immediate group as shown in Table 4. The delayed placement group was better in terms of physical functioning, mental health, and social interaction.

Table 4: Oral health-related quality of life scores based on OHIP-14

Group	Pre-test OHIP Score	Post-test OHIP Score	Change in OHRQoL
Immediate Placement (I)	38 ± 10	23 ± 8	15
Delayed Placement (II)	40 ± 11	18 ± 6	22

Patient Satisfaction

Self-reported questionnaire was used to evaluate patient satisfaction which included things like appearance, chewing ability, speech and overall satisfaction. The level of satisfaction among the two groups was high, and the delayed placement group registered higher satisfaction levels across the board, especially on speech and aesthetics as shown in Table 5.

Table 5: Patient satisfaction ratings in both groups.

Group	Overall Satisfaction (%)	Aesthetic Satisfaction (%)	Speech Satisfaction (%)	Chewing Satisfaction (%)
Immediate Placement (I)	85	80	75	70
Delayed Placement (II)	90	85	80	75

Statistical Analysis

KaplanMeier Survival Analysis

The log-rank test established that the late implant group had much higher long-term survival rate ($p = 0.03$), which proved a more favorable result in delayed placement.

Regression Analysis

The results of the multiple linear regression analysis showed that the time of implant placement (immediate and delayed) had a significant effect on the post-treatment masticatory performance and speech [$p < 0.05$].

The late group had more chewing efficiency [B = 2.15, p = 0.01] and speech intelligibility [B = 3.45, p = 0.02] when the age, gender and initial functional scores were controlled.

Correlation Analysis

These are because Pearson correlation analysis showed a strong level of positive correlation between masticatory function and OHRQoL [r = 0.78, p < 0.01], in that as the chewing ability improved, the overall quality of life also improved.

ANCOVA

The results of ANCOVA indicated that the delayed placement group had better OHRQoL scores at post-treatment after the adjustment of the baseline differentiation [F = 7.32, p = 0.005]. This demonstrates the benefit of late placement in enhancing quality of life outcomes in the long term. The results of the present study which had indicated better long-term functional results in the delayed implant placement group than the immediate implant placement group after the mandibular resection surgery can be placed in perspective of the past studies. In spite of the fact that the majority of the literature available is devoted not to the placement of the implants following the tooth extraction but to the mandibular resection, the implant survival rates, the restoration of its functionality, and the complications in this case are generally similar.

Discussion

In this case, delayed implantation placement has a better long-term survival and reduced complications than an implantation placed immediately. In a paper it was found that the survival rates of delayed implants were significantly higher than immediate implants at 72 months, and the survival difference increased after 24 months [delayed: 81.1% vs. immediate: 53.2%, p < 0.0001] (11). Likewise, a meta-analysis in a research paper did not demonstrate a statistically significant difference in overall survival of the immediate and the delay placement groups, but delayed placement was more likely to result in a higher survival rate and a reduced failure rate in aggregated statistics (12). These major trends underpin our study results that postponement of implantation can provide more optimal results in terms of osseointegration and tissue remedy, particularly in complex surgery locations like post resection mandibles.

Conversely, A researcher noted no difference in the survival of immediate and delayed groups but that early complications were high with immediate (13). The survival rate was also not significantly different in immediate and delayed implants in 102 cases (14), which further supported the notion that both types of strategies could be considered when the surgical standards were carefully adhered to. These inconsistent results indicate that, although there may be no statistical difference in survival at intermediate time, delayed placement can be useful in both long-term stability and low early failure rates which are in agreement with our Kaplan Meier and regression outcomes.

More current studies however cast doubt on this advantage. As an illustration, in the meta-analysis, no clear superiority of immediate and delayed placement was reported using marginal bone changes as the outcome in early placement protocols. Delayed placement was found to have superior masticatory functionalities and quality of life in our study, which is probably due to more predictable bone remodelling and soft tissue stability following the initial healing period- a similar trend also exhibited (15), found no notable bone preservation and the quality of soft tissues in immediate and delayed groups when strict surgical procedures were implemented (16-19).

Satisfaction and quality of life are patient reported outcomes that are gaining popularity in the research of implants. A group of researchers have discovered that, although both immediate and delayed implants were rated highly on patient satisfaction levels, subjective comfort and pain levels might vary in regard to the methods used (20-23). In line with this, we observed that delayed placement had a superior overall OHRQoL and higher scores of satisfactions, especially of speech and aesthetics. This is an indication that the possibility of permitting full soft and hard tissue healing prior to the placement of implants can improve patient perceived functional outcomes- particularly in mandibular resection patients, whose impairments might be greater than in standard extraction sites.

Though indirectly related to immediate versus delayed timing, immediate placement protocols (2-4 weeks after extraction) have been suggested as a middle ground, and have in most cases been found to have the same implant survival and less bone loss than immediate placement (24,25). Such

results concur with our observation that initial healing is of benefit to peri implant tissue stability, although our study involved more complex resection cases than such and initial placement periods are not as viable.

Conclusion

The findings of this study suggest that delayed dental implant placement provides superior long-term outcomes compared to immediate placement in patients following mandibular resection surgery. This advantage was particularly evident in terms of implant survival, masticatory function, speech intelligibility, and overall quality of life. Delayed placement allows for a more stable healing environment and a lower risk of complications, particularly for patients undergoing postoperative radiation therapy. However, immediate placement can offer benefits in terms of a quicker return to function and may be appropriate for select patients. Future research should focus on refining patient selection criteria and investigating the long-term impact of postoperative radiation on implant success. Additionally, further studies are needed to assess the effectiveness of these approaches in more diverse patient populations, including those with different underlying health conditions and types of re-section.

Abbreviations

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Author Contributions

All authors contributed equally**.**

Conflict of Interest

The author declares no conflicts of interest related to this work**.**

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Ethics Approval

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