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Original Article

Immediate implant placement with and without provisionalization: A comparison of a one-year longitudinal study

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Received 21 April 2023; Final revision received 30 April 2023

Available online 13 May 2023

KEYWORDS

Immediate implant placement (IIP);
 Immediate provisionalization (Ipro);
 Implant stability;
 Implant stability quotient (ISQ);
 Marginal bone loss (MBL)

Abstract *Background/purpose:* Immediate implant placement (IIP) with and without immediate provisionalization (Ipro) may yield satisfactory results in appropriate indications and treatment, especially in the esthetic zone. The aim of this study was to compare implant stability, marginal bone loss (MBL), survival rates, and patient satisfaction between IIP with Ipro and IIP without Ipro.

Materials and methods: Seventy patients, each with a failed maxillary anterior tooth, were randomly assigned to IIP with Ipro (Group A: n = 35) or IIP without Ipro (Group B: n = 35). Implant stability quotient (ISQ) and standardized periapical radiographs were performed at surgery and at 3, 6, 9, and 12 months postoperatively to investigate implant stability and MBL, respectively. Survival was assessed 1 year after surgery. Patient satisfaction was evaluated with a visual analogue scale (VAS).

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<https://doi.org/10.1016/j.jds.2023.04.029>

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Results: Primary ISQ and MBL were not significantly different between groups A and B immediately after surgery ($P > 0.05$). Implant survival was 100% in both groups, and only one mechanical complication was observed. Patient satisfaction was good at definitive crown delivery and postoperatively 1-year in both groups. However, the immediate postoperative VAS score in Group A was significantly higher than that in Group B ($P < 0.05$).

Conclusion: Group A revealed significantly higher secondary ISQ than Group B at postoperatively 3, 6, 9, and 12 months. There were no significant differences between groups A and B in terms of MBL and survival. Notably, patient satisfaction in Group A was significantly higher than in Group B immediately after surgery.

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Introduction

The current trend of implant dentistry is toward developing methods to enhance efficiency, comfort, function, and esthetics. Modern approaches such as immediate implant placement (IIP) and immediate provisionalization (Ipro) have been proposed to shorten treatment period. Studies investigating IIP and Ipro of single implants have demonstrated successful outcomes.^{1,2} However, implant replacement of failed or missing teeth in the esthetic zone remains a technically sensitive work that presents challenges to dentists and technicians. Therefore, properly surgical and prosthetic planning is crucial to achieve adequate implant stability and ideal three-dimensional implant position, thereby contributing to predictable and esthetic results.

The main advantages of IIP compared to delayed implant placement are fewer surgeries, shorter treatment times, and improved patient acceptance.^{3,4} Placement of a provisional restoration following implant surgery can create soft tissue contours that resemble normal gingival topography before placing the definitive prosthesis.^{5,6} In addition, implementing Ipro of implants provides patient comfort and psychological benefits.

Adequate implant stability facilitates osseointegration, especially in IIP. Kan et al.² describe in detail case selection, prerequisites, diagnosis, treatment planning, and treatment procedures for successful IIP and Ipro. Primary implant stability is essential for IIP and Ipro in the maxillary anterior zone and is usually attained by engaging the palatal wall and underlying bone beyond the apex of the extraction socket. One of the main prerequisites for Ipro is sufficient primary implant stability ($ISQ \geq 60$). Achieving sufficient implant stability and careful stability monitoring are essential for satisfactory treatment outcomes.

It is worth noting that marginal bone level is a significant index to evaluate the status and stability of peri-implant tissue. The exact cause of peri-implant marginal bone loss (MBL) remains unclear and several theories have been proposed to interpret this situation. Coli and Jemt⁷ concluded that normal physiological adaptations to the external environment and/or host responses may change bone levels. Foreign body reactions have been reported to induce chronic inflammation that can lead to peri-implant bone loss.⁸ Another hypothesis for MBL is related to the

existence of bacteria at the implant-abutment junction. Herekar and colleagues⁹ investigated the effect of platform switching on MBL and found that platform switching appeared to preserve peri-implant bone levels.

Implant dentistry has evolved towards faster, more reliable methods of replacing failing or restoring missing teeth. Slagter et al.⁴ claimed that IIP and Ipro of implants in the esthetic region yielded eminent short-term therapeutic outcomes regarding implant survival and minimization of MBL. However, in addition to implant survival, patient satisfaction is also a growing concern.

This study aimed to compare a one-year longitudinal study on implant stability and marginal bone loss between IIP with Ipro and IIP without Ipro. Implant survival and patient satisfaction were also analyzed for IIP with Ipro and IIP without Ipro.

Materials and methods

Subject selection

This study was approved by the ethical review committee of the institutional review board of Kaohsiung Medical University Hospital (KMUHIRB-F(II)-20160091) and performed at the Department of Dentistry, Kaohsiung Medical University Hospital, Kaohsiung, Taiwan. Each eligible patient must have a failed tooth in the maxillary esthetic zone (central incisor, lateral incisor, or canine) and request an implant-supported crown.

Seventy subjects were recruited based on the following criteria: 1) age over 20 years, 2) no serious system diseases known to alter bone metabolism, 3) non-smokers, 4) controlled periodontal diseases and good oral hygiene, 5) at least 2 mm of keratinized tissue at the scheduled implant site. The exclusion criteria were: 1) acute infection at the implant site, 2) bone metabolism disorders, 3) severe bruxism or parafunction, 4) uncontrolled periodontal diseases or poor oral hygiene, 5) obvious buccal bone dehiscence, and 6) pregnancy. Informed consent was obtained from each patient before conducting the study. The 70 subjects were randomly allocated to Group A (immediate implant placement with immediate provisionalization, $n = 35$) or Group B (immediate implant placement without immediate provisionalization, $n = 35$).

Preoperative radiographic examination

The preoperative examination included periapical radiographs and cone beam computed tomography (CBCT). CBCT was used to evaluate space, bone volume, and bone density for implant installation. Implametric software (NNT viewer®, NewTom, Verona, Italy) was utilized to plan and simulate implant positions based on CBCT data before treatment.

Surgical and prosthetic procedures

The failed teeth were removed with a Periotome® (Nobel Biocare, Yorba Linda, CA, USA) for minimally invasive extraction. Implants (Seven®, MIS, Shlomi, Israel) were placed into the fresh extraction sockets immediately after the standard drilling protocol. The gap between implant fixtures and sockets was filled with freeze-dried bone allograft (OraGraft®, LifeNet Health, Virginia Beach, VA, USA). Screw-retained provisional crowns were delivered for subjects in Group A within 24 h after implant installation (Fig. 1). Any occlusal contact on the provisional crowns was eliminated, allowing immediate but reduced functional loading of the implants. Subjects in Group B were provided with healing abutments after implant placement. All subjects were strongly advised to consume soft food for one month postoperatively. The definitive implant-supported crowns were delivered 4 months postoperatively. Screw-retained crowns were fabricated for easier retrieval and ISQ measurement.

Implant stability measurement

Osstell® Mentor (Integration Diagnostics AB, Göteborg, Sweden) was used to measure implant stability immediately after implant placement (primary ISQ) and 3, 6, 9, and 12 months postoperatively (secondary ISQ). Every implant was measured from four directions (buccal, palatal, mesial, and distal) each time, and the mean of the 4 ISQ values was calculated.

Marginal bone loss

Standardized digital periapical radiographs were taken after implant installation (baseline) and at 3, 6, 9, and 12 months postoperatively to assess marginal bone loss (MBL). Radiographic magnification was determined from the image/real length ratio of the installed implant fixture. The linear distances between the implant platform and the mesial and distal marginal bone were measured. Changes in mesial and distal peri-implant bone levels relative to baseline were calculated at various time points. The average of the mesial and distal values for each implant was considered as the MBL.

Survival rate

Implant survival in this study was defined as the percentage of implants still functional at 1 year after insertion according to the criteria of Smith and Zarb.¹⁰ Survival of the

definitive restorations was calculated as the percentage of functional initial restorations that remained. Any biological or mechanical complications during the study would be documented.

Patient satisfaction

Patient satisfaction was evaluated using the VAS on a scale from 0 (not at all satisfied) to 10 (totally satisfied) at postoperatively immediate, definitive crown delivery, and postoperatively 1-year.

Statistical analysis

Statistical software (JMP® 10.0.0, JMP Statistical Discovery LLC, Cary, NC, USA) was used for data analysis. T-test and analysis of variance (ANOVA) for pairwise comparisons were performed to determine statistically significant differences. A *P* value ≤ 0.05 was considered statistically significant.

Results

A total of 70 subjects were randomly assigned to two groups. Group A (17 males and 18 females, mean age 55.7 ± 15.3 years) included 35 (16 central incisors, 12 lateral incisors, and 7 canines) immediate implants placed in fresh extraction sockets with immediate provisionalization. Group B (16 males and 19 females, mean age 59.3 ± 12.8 years) consisted of 35 implants (18 central incisors, 13 lateral incisors, and 4 canines) placed immediately in fresh extraction sockets without immediate provisionalization. Implant distribution in Group A according to fixture size (diameter \times length) was as follows: 3.3×11.5 mm ($n = 7$), 3.3×13 mm ($n = 5$), 3.75×11.5 mm ($n = 10$), and 3.75×13 mm ($n = 13$). Implant distribution in Group B was as follows: 3.3×11.5 mm ($n = 6$), 3.3×13 mm ($n = 7$), 3.75×11.5 mm ($n = 12$), and 3.75×13 mm ($n = 10$).

The mean primary ISQ was 64.57 ± 5.19 (range, 54 to 75) in Group A and 65.83 ± 4.67 (range, 56 to 74) in Group B. There was no significant difference in primary ISQ between groups A and B immediately after surgery ($P = 0.291$). However, Group A showed significantly higher secondary ISQ than Group B at 3, 6, 9, and 12 months postoperatively ($P = 0.0005$, 0.0021 , 0.0001 , and 0.0004 , respectively) (Fig. 2).

MBL was evaluated at postoperative 3, 6, 9, and 12 months as shown in Fig. 3. The change in MBL was greatest in both groups from implant placement to 3 months postoperatively. During the study period, the MBL of Group A was slightly higher than that of Group B, but there was no significant difference in the MBL between groups A and B ($P > 0.05$).

There were no implant loss or severe complications such as abutment screw or fixture fracture during this study, resulting in a 100% implant survival rate in both groups. In Group A, only one abutment screw was loosened in the provisional crown postoperative 3 months. No prosthetic complications were found in Group B.

Table 1 shows patient satisfaction as indicated by VAS scores at postoperatively immediate, definitive crown



Figure 1 The postoperative one-year follow-up. (A) The failed left maxillary central incisor before treatment. (B and C) Pre-operative radiographic evaluation. (D, E, and F) Immediate implant placement with immediate provisionalization. A screw-retained provisional crown was delivered. (G, H, and I) The definitive implant-supported crown was delivered 4 months postoperatively. (J, K, and L) One-year follow-up.

delivery, and postoperatively 1-year. Overall, patient satisfaction was good except in Group B immediately after surgery. Group A had a significantly higher VAS score (8.3 ± 1.5) than Group B (5.7 ± 1.8) immediately after surgery ($P = 0.027$). However, there were no significant differences in VAS scores between groups A and B at definitive crown delivery and postoperatively 1-year.

Discussion

Adequate implant stability facilitates implant osseointegration. Objective monitoring of implant stability with quantitative device aids in determining the proper timing for loading.¹¹ Implant stability quotient (ISQ) ranges from 1 to 100. High ISQ values indicate high stability, while low values indicate low implant stability. After implant placement, primary (mechanical) stability is gradually replaced by secondary (biologic) stability during early wound

healing. In general, ISQ values decrease slightly within two to three weeks after implant installation and then increase over time during normal osseointegration.¹² Rowan et al.¹³ compared immediately placed implants with implants placed at healed sites and found that immediate implants had lower ISQ than delayed implants at implant placement and subsequent follow-up. However, during the 6-month follow-up period, the mean ISQ of immediate implants were above the successful ISQ threshold of 65. The mean primary ISQ values of both groups in this study were similar to those of Rowan et al.,¹³ implying that immediate placement of implants in extraction sockets is feasible under appropriate conditions. Daher and colleagues¹⁴ studied immediately loaded implants compared to conventionally loaded implants and claimed that all implants showed an increase in ISQ over time. There were no significant differences between the groups at any time point. This present study revealed an increase in the mean

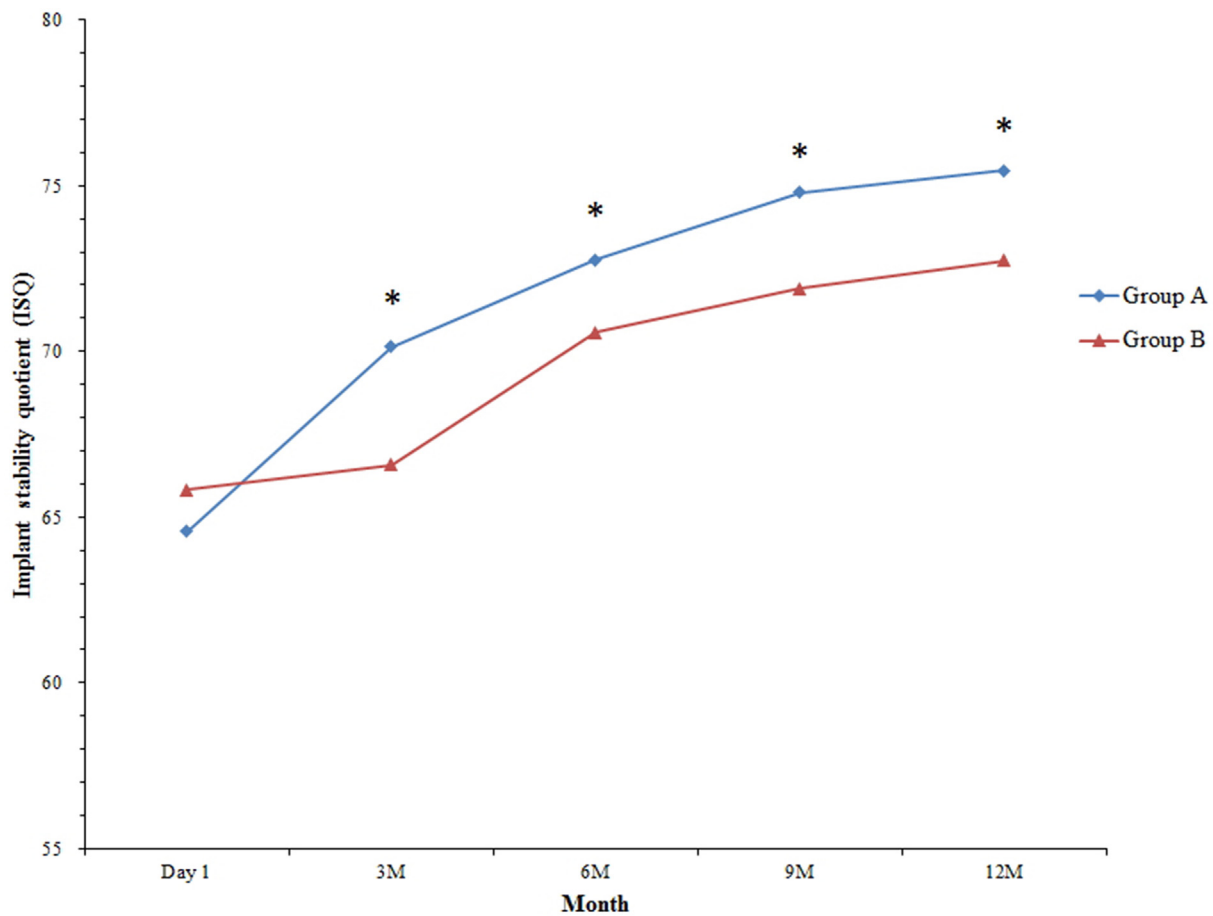


Figure 2 Implant stability quotient (ISQ) values over time. Group A: Immediate implant placement with immediate provisionalization, Group B: Immediate implant placement without immediate provisionalization, *: Statistical significance ($P < 0.05$).

ISQ over time for all implants, which is consistent with the study by Daher et al.¹⁴ However, secondary ISQ was significantly higher in Group A than in Group B at 3, 6, 9, and 12 months postoperatively.

Slagter et al.⁴ the MBL of immediate implants in the esthetic zone was 0.81 ± 0.48 mm at 1 year. In this study, the MBL at 1 year after surgery was 0.88 ± 0.18 mm and 0.80 ± 0.19 mm in groups A and B, respectively. This is consistent with the research by Slagter et al.⁴ Although the MBL of Group A was slightly larger than that of Group B in this study, no significant difference was detected.

There were different prosthetic options immediately after implant placement in groups A and B. The marginal bone level may be affected by tissue healing and maturation in combination with other factors such as prosthetic loading. In Group A, IIP with Ipro was somewhat similar to premature loading, even with the infraocclusion design. Impact on the implant during mastication was unavoidable and assumed to be one of the possible reasons of early MBL. Even though MBL was slightly greater in Group A than in Group B, secondary ISQ was significantly higher in Group A. This might be a load-induced bone training phenomenon, which increased bone density and, in turn, exhibited a higher ISQ.^{15,16}

Del Fabbro et al.¹⁷ conducted a review to assess the survival of immediate implants with immediate restoration. The overall 1-year implant survival rate was 97.62% (range, 78.6%–100%). Weigl and Strangio¹⁸ evaluated immediate implant placement and immediate provisionalization in the maxillary anterior region and found a survival rate of 98.25% at a mean follow-up of 31.2 months. The implant survival rate in this study was 100%, which might be attributed to strict subject selection and careful management.

Implant esthetics is as important as implant survival for successful treatment in the esthetic zone. Immediate implant placement and provisionalization are usually accompanied by a high level of satisfaction. In this study, patient satisfaction was high in immediate placement with provisionalization. This is consistent with the satisfaction reported by Kan et al.,² Hartlev et al.,¹⁹ Trimpou et al.,²⁰ and Raes et al.²¹

In this study, implant stability and MBL were favorable in both groups. IIP with and without Ipro are both predictable therapies under proper case selection and treatment. Furthermore, in conditions of adequate implant stability, proper occlusion, good oral hygiene and careful monitoring,

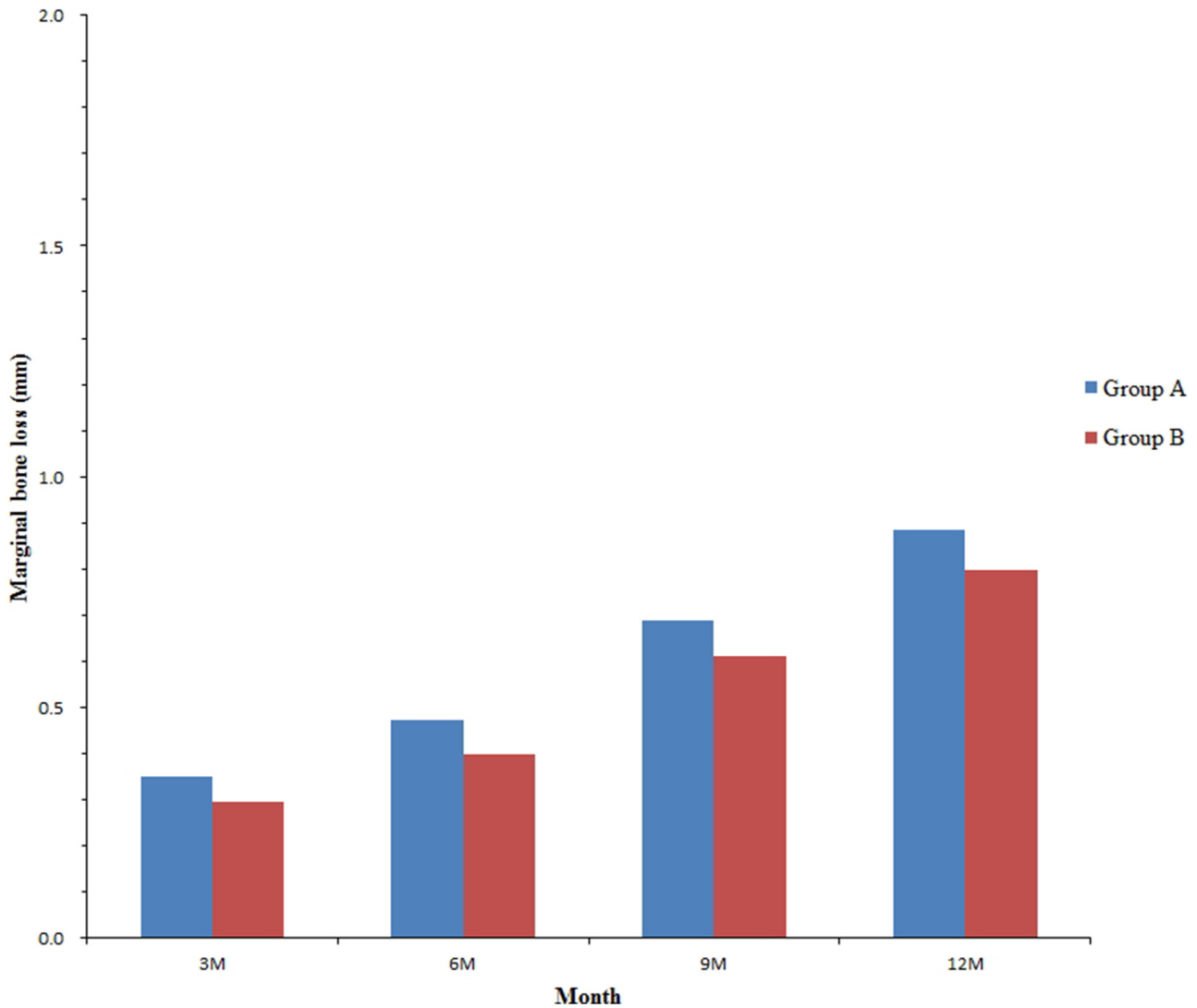


Figure 3 Changes in marginal bone level over time. Group A: Immediate implant placement with immediate provisionalization, Group B: Immediate implant placement without immediate provisionalization.

Table 1 Patient satisfaction was evaluated with a visual analogue scale (VAS, score 0–10) immediate postoperatively, after definitive crown delivery, and one-year postoperatively.

	Immediate postoperatively			After definitive crown delivery			One-year postoperatively		
	Group A (Mean ± SD)	Group B (Mean ± SD)	<i>P</i> value	Group A (Mean ± SD)	Group B (Mean ± SD)	<i>P</i> value	Group A (Mean ± SD)	Group B (Mean ± SD)	<i>P</i> value
VAS	8.3 ± 1.5	5.7 ± 1.8	0.027*	8.7 ± 1.2	8.2 ± 1.1	0.694	8.9 ± 0.9	8.7 ± 1.2	0.826

Group A, immediate implant placement with immediate provisionalization; Group B, immediate implant placement without immediate provisionalization; SD, standard deviation; *, statistical significance ($P < 0.05$).

the implementation of IIP with Ipro in the esthetic zone can immediately increase patient satisfaction, thereby improving the quality of life and social confidence of patients.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

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