

Immediate Loading of Maxillary and Mandibular Implant-Supported Fixed Complete Dentures: A 1- to 10-Year Retrospective Study

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This study evaluated the success rates of 50 full-arch maxillary and/or mandibular implant-supported fixed complete dentures. After a mean follow-up time of 42.1 months, 269 implants remained in function, which corresponded to cumulative implant success rates of 85.2% and an absolute success rate of 90.6% (269/297 implants). This study suggested that higher implant failure rates might be associated with a dental history of bruxism (29.3%) vs no history of bruxism (4.6%) and surgeons with limited experience (≤ 5 years; 12.2%) vs surgeons with experience (2.4%).

Key Words: *implant-supported fixed complete denture, marginal bone change, immediate loading, surgical experience, immediate implant placement, bruxism*

INTRODUCTION

Prosthetic rehabilitation with an implant-supported fixed complete denture (ISFCD) has been well documented and is a predictable treatment modality for edentulous patients.¹ Traditional guidelines for successful osseointegration have included a healing period of 3 to 6 months without functional loading.^{2,3} However, the use of an interim removable prosthesis during the course of treatment can be an inconvenience to patients.⁴ Recently, the immediate loading of ISFCDs was advocated, and comparable success rates have been reported.⁵⁻¹⁴ The placement of a provisional prosthesis immediately after implant placement can

provide immediate esthetics and function, decrease the number of patient visits, and reduce morbidity of a second surgical intervention.^{4,15}

This retrospective study evaluated the implant success rates of immediately loaded maxillary and/or mandibular ISFCD. Factors affecting implant success rates and prosthetic survival rates were also assessed.

MATERIALS AND METHODS

This study was approved by the institutional review board of Loma Linda University and was conducted in the Center for Implant Dentistry, Loma Linda University School of Dentistry, Loma Linda, California. Treatment records were reviewed for patients who received a full-arch maxillary and/or mandibular ISFCD between January 1998 and December 2008. Patients were included if periapical radiographs were available from the time of surgery (with the attached prosthesis; T0) and at the last follow-up (T1). Implant positions were represented

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by their corresponding tooth number. Patient demographics (age and gender), date of implant placement, and date of the final follow-up appointment were recorded.

Implant success was evaluated using a modification of criteria proposed by Spiekermann and Jansen¹⁶ where applicable:

- No implant loss.
- No mesial or distal vertical bone loss >4 mm as assessed on periapical radiograph.

Marginal bone level (MBL) was measured using periapical radiographs taken immediately after implant surgery (T0) and at the last follow-up examination (T1). The apical corner of the implant neck was used as the reference line (RL) (Figure). The marginal bone level was the distance between the RL and the implant-bone contact.¹⁷ The value was zero when the implant-bone contact point was at or more coronal to the RL, and negative when the implant-bone contact was more apical to the RL. Measurements were made on the mesial and distal aspects of each implant to the nearest 1 mm, and the MBL changes between T0 and T1 were calculated. A marginal bone loss greater than 4 mm at any individual implant site was indicative of a failure.

The intraexaminer reliability of the MBL measurements was determined by using double assessments of MBL measured 3 months apart by one examiner (T.J.) and expressed as the intraclass correlation coefficient. The number for marginal bone level measurements made in this study was 0.99.

Prosthesis failure included any provisional or definitive prostheses that were deemed nonfunctional and removed because of extensive implant loss. Implant failure rates were determined for the following categories:

- Type of prosthesis: provisional or definitive prosthesis
- Surgeons' surgical experience: >5 years or ≤5 years
- Surgical site: implant placement in previously grafted healed sites (socket preservation, sinus graft, socket preservation + sinus graft, guide bone regeneration (GBR) + sinus graft, iliac crest block + GBR + sinus graft or Ti-Mesh GBR + sinus

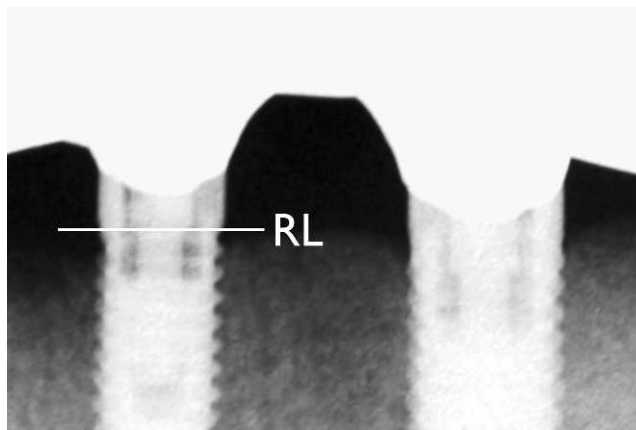


FIGURE. Measurement of marginal bone level (MBL). Reference line (RL) is at the apical corner of the implant neck. Zero and positive values were given when the MBLs were at or coronal and apical to the RL. Negative values were given when the MBLs were apical to the RL.

graft), implant placement in non-grafted healed sites, or immediate implant placement

- Smoking
- Diabetes
- Bruxism
- Implant locations: maxillary anterior (MxA), maxillary posterior (MxP), mandibular anterior (MdA), or mandibular posterior (MdP)
- Implant diameter: 3.0 mm to 3.5 mm, 3.6 mm to 4.5 mm, or 4.6 mm to 5.0 mm
- Implant length: 8.0 mm to 10.0 mm, 10.1 mm to 14.0 mm, or 14.1 mm to 16.0 mm
- Opposing dentition: natural dentition, implant-tissue-supported overdenture, implant-supported overdenture, ISFCD, complete denture, natural dentition with removable partial denture, or full-arch implant-supported fixed partial denture.

Prosthetic complications included any provisional or definitive prosthesis, such as acrylic resin base fracture, broken denture teeth, screw loosening, screw fracture, and/or framework misfit. Framework misfit was assessed at the time of prosthesis placement using a panoramic radiograph.

STATISTICAL ANALYSIS

Life table analysis was used to estimate the progress of implant success over time. The implant failure rates associated with each recorded parameter were represented using descriptive statistics.

TABLE 1
Life table analysis

| Time Interval (months) | Total No. of Implants | No. of Implant Successes | No. of Implant Failures | Absolute Implant Success Rate | Cumulative Implant Success Rate |
|------------------------|-----------------------|--------------------------|-------------------------|-------------------------------|---------------------------------|
| 0–12 | 284 | 284 | 13 | 0.956 | 0.956 |
| 13–24 | 241 | 241 | 0 | 1.000 | 0.956 |
| 25–36 | 204 | 194 | 10 | 0.951 | 0.909 |
| 37–48 | 111 | 109 | 2 | 0.982 | 0.892 |
| 49–60 | 67 | 64 | 3 | 0.955 | 0.852 |
| 61–72 | 40 | 40 | 0 | 1.000 | 0.852 |
| 73–84 | 18 | 18 | 0 | 1.000 | 0.852 |
| 85–96 | 6 | 6 | 0 | 1.000 | 0.852 |
| 97–108 | 6 | 6 | 0 | 1.000 | 0.852 |
| 109–126 | 6 | 6 | 0 | 1.000 | 0.852 |
| Overall (0–126) | 297 | 269 | 28 | 0.906 | 0.852 |

RESULTS

A total of 45 patients received 50 full-arch immediately loaded maxillary and/or mandibular ISFCDs. The subject population comprised 18 male and 27 female patients between the ages of 25 and 88 years (mean age = 61.5 years). Eight patients were smokers and one patient had diabetes. Five patients were treated with a maxillary and mandibular ISFCD, and the remaining 40 patients received a single-arch ISFCD. A total of 297 implants were placed in 50 jaws (147 implants in 21 maxillary arches, 150 implants in 29 mandibular arches). This included 233 TiUnite (168 NobelReplace Tapered Groovy; 38 Replace Select Tapered; 27 NobelSpeedy Replace, Nobel Biocare, Yorba Linda, Calif), 54 HA-coated (7 Steri-Oss Hex-Loc, Nobel Biocare; 47 Tapered Screw-Vent, Zimmer Dental, Carlsbad, Calif), and 10 grit-blasted, acid-etched threaded (10 Xive, Dentsply Friadent, Mannheim, Germany) implants.

After a mean follow-up time of 42.1 months (range = 1 to 125.5 months), 269 implants remained in function with <4 mm of MBL change corresponding to the cumulative implant success rates of 85.2% and absolute success rate of 90.6% (269/297) (Table 1).

Tables 1 through 10 display the number and percentage of failed implants in relation to the various recorded parameters.

DISCUSSION

Short- and long-term studies involving full-arch immediately loaded maxillary and/or mandibular ISFCDs have reported success/survival rates of 92.7% to 100.0%.^{5–14} Comparatively, a lower cumulative implant success rate of 85.2% and an absolute success rate of 90.6% (269 of 297) (Table 1) were observed after a mean follow-up time of 42.1 months (range = 1 to 125.5 months) in this study.

In this study, 15 of 81 implants (18.5%) supporting provisional prostheses and 13 of 216 implants (6.0%) supporting definitive prostheses failed (Table 2). It is interesting to note that similar implant failure rates were observed when comparing all resin (18.3%) and metal-resin (19.0%) provisional prostheses. Regardless of the incidence of implant failure, no prosthesis failure was observed in this study.

The experience of the surgeon and the complexity of the surgical procedure have a strong

TABLE 2
Implant failures during provisionalization vs after definitive prosthesis placement

| | No. of Implants | Implant Failures | | No. of Prostheses | Prostheses Failures | |
|------------------------|-----------------|------------------|------|-------------------|---------------------|---|
| | | No. | % | | No. | % |
| Provisional prosthesis | 81 | 15 | 18.5 | 11 | 0 | 0 |
| All resin prosthesis | 60 | 11 | 18.3 | 8 | 0 | 0 |
| Metal-resin prosthesis | 21 | 4 | 19.0 | 3 | 0 | 0 |
| Definitive prosthesis | 216 | 13 | 6.0 | 39 | 0 | 0 |

TABLE 3
Implant failures according to surgeons' experience

| Surgeons' Experience | No. of Implants | Implant Failures | |
|----------------------|-----------------|------------------|------|
| | | No. | % |
| >5 years | 85 | 2 | 2.4 |
| ≤5 years | 212 | 26 | 12.2 |

influence on future implant success.^{18,19} Lambert et al¹⁸ found that implants placed by surgeons with less experience (<50 implants) failed twice as often as those placed by surgeons with more experience (>50 implants). Similarly, in this study, the implant failure rate for 2 surgeons with >5 years of surgical experience was 2.4% (2 of 85 implants), whereas the remaining 18 surgeons, that is, those with ≤5 years of surgical experience, incurred an implant failure rate of 12.2% (26 of 212 implants) (Table 3).

It has been suggested that immediately loaded implants placed in fresh extraction sites pose a high risk for implant failure compared with those placed in healed sites.²⁰⁻²² This can result from reduced implant stability as extraction sites do not allow the implant to engage bone circumferentially throughout the length of the implant and/or the presence of residual infection from the failing tooth.²³⁻²⁷ De Bruyn and Collaert²⁷ reported significantly higher implant failure rates (39%) in extraction sites compared with healed sites (0.7%). Higher implant failure rates were observed in this study in the immediate implant placement groups (7/31 = 22.5%) compared with non-grafted healed-site

groups (14/180 = 7.8%) and the grafted-healed site groups (7/86 = 8.1%) (Table 4).

Various augmentation techniques and materials have been used to regenerate the alveolar process in preparation for implant placement.^{28,29} Furthermore, implants placed in augmented sites have been reported to have reasonable success and predictability.³⁰⁻³⁶ In this study, a high implant failure rate (3/6 = 50%) was observed in the iliac crest block + GBR + sinus graft group (Table 4). It could be speculated that bone maturation could be a contributing factor for high failure rates.²⁸

The effects of patient-related risk factors and their influence on implant success and failure have been evaluated.³⁷⁻⁴¹ Moy et al³⁸ reported that smoking, diabetes, head and neck radiation, and postmenopausal estrogen therapy were correlated with an increased rate of implant failure. Similarly, Goodacre et al³⁷ reported a high incidence of implant failure associated with patients with diabetes (9%) and smokers (11%). In this study, a higher implant failure rate was observed in patients with diabetes (28.6%) vs patients who did not have diabetes (8.5%), and comparable failure rates were observed in both smokers (9.7%) and nonsmokers (9.4%). These results differ from those of previous studies that reported significantly higher implant failure rates in smokers (11%) than in nonsmokers (5%) (Table 5).^{37,39}

It has been reported that bruxism may cause unfavorable occlusal forces to implants, ultimately leading to bone loss and implants failures.⁴² In a recent review of the literature, Lobbezoo et al⁴³

TABLE 4
Implant failures according to surgical procedure*

| Surgical Procedure | No. of Implants | Implant Failures | |
|--|-----------------|------------------|------|
| | | No. | % |
| Implant placement in previously grafted healed sites | 86 | 7 | 8.1 |
| Socket preservation only† | 7 | 0 | 0 |
| Sinus graft only† | 16 | 2 | 12.5 |
| GBR only† | 0 | 0 | 0 |
| Socket preservation + sinus graft† | 8 | 0 | 0 |
| GBR + sinus graft† | 42 | 2 | 4.8 |
| Iliac crest block + GBR + sinus graft† | 6 | 3 | 50.0 |
| Ti-Mesh GBR + Sinus graft† | 7 | 0 | 0 |
| Implant placement in non-grafted healed sites | 180 | 14 | 7.8 |
| Immediate implant placement | 31 | 7 | 22.5 |
| Total | 297 | 28 | 9.4 |

*GBR indicates guide bone regeneration; Ti, Titanium.
†Subset of implant placement in grafted healed site.

TABLE 5

Implant failures according to patient's habits and medical and dental status

| | | No. of Implants | Implant Failures | |
|----------------|-----|-----------------|------------------|------|
| | | | No. | % |
| Smoking status | Yes | 62 | 6 | 9.7 |
| | No | 235 | 22 | 9.4 |
| Diabetes | Yes | 14 | 4 | 28.6 |
| | No | 283 | 24 | 8.5 |
| Bruxism | Yes | 58 | 17 | 29.3 |
| | No | 239 | 11 | 4.6 |
| Total | | 297 | 28 | 9.4 |

stated that although there is insufficient evidence to support or refute the relationship between bruxism and implant failure, a careful approach is still recommended. Guidelines to minimize implant failures in patients with bruxism have included increasing the number of implants, improving the occlusion scheme, and incorporating an occlusal stabilization splint after treatment.⁴³ In this study, a higher implant failure rate was reported with patients with bruxism (29.3%) compared with patients without bruxism (4.6%) (Table 5). Because of the nature of this study, it was difficult to evaluate whether these guidelines had been applied during patient treatment. The results from this study suggested that patients with a history of bruxism might be contraindicated for immediately loaded ISFCDs.

With respect to bone quality, studies have shown that implant failure rates are higher in the maxilla than in the mandible, and the area of the lowest failure rate is in the anterior mandible and the highest failure rate is in the posterior maxilla.^{37,44-46} Although the implant failure rates in this study were highest in the MxP region (11.4%), the differences, compared with the failure rates at other regions (7.4%, 9.2%, and 9.5% for MxA, MdA, and MdP regions, respectively; Table 6), were not as great as previously reported in the literature.^{37,44,45} Furthermore, the higher implant failure rate in MxP reported in this study may be attributed to the fact that most of these implants were placed in grafted sites (7/9). These results suggest that the implant prognosis should not be made solely according to the implant location in relation to different sextant of the mouth.

The use of short implants (≤ 10 mm) has been controversial.⁴⁷⁻⁵⁵ Some studies have reported higher failure rates associated with short implants (≤ 10 mm),^{37,47-50} whereas others have reported

TABLE 6

Implant failures according to implant location*

| Implant Location | No. of Implants | Implant Failures | |
|------------------|-----------------|------------------|------|
| | | No. | % |
| MxA | 68 | 5 | 7.4 |
| MxP | 79 | 9 | 11.4 |
| MdA | 76 | 7 | 9.2 |
| MdP | 74 | 7 | 9.5 |
| Total | 297 | 28 | 9.4 |

*MxA indicates maxillary anterior; MxP, maxillary posterior; MdA, mandibular anterior; MdP, mandibular posterior.

good success.⁵¹⁻⁵⁴ Potential factors contributing to the failure of short implants include implant surface,⁵⁴ implant geometry,⁵⁵ bone quality,^{51,52} and biomechanical stress.⁵⁴ When these factors are appropriately selected and managed, a predictable outcome can be achieved with short implants.^{53,54} Therefore, implant length may not be a primary factor to distribute prosthetic loading to the bone-implant interface.⁵⁴ In this study, it is interesting to note that implants with a length of 14–16 mm had a higher failure rate (20.4%) than the shorter implants (Table 7). However, the failures in the group with implant lengths of 14–16 mm were all distributed among 4 patients with bruxism. Consequently, the implant failures appeared to be affected by patient-related risk factors (bruxism) rather than implant-related risk factors (implant length).

Finite-element analysis studies have suggested that implant diameter has a more significant impact on stress distribution than implant length.⁵⁶ Increasing implant diameter appears to reduce strain to the surrounding crestal bone, thereby preventing further bone remodeling.⁵⁷ The results of this study

TABLE 7

Implant failures according to the implant diameter and length

| Implant Size (mm) | No. of Implants | Implant Failures | |
|-------------------|-----------------|------------------|------|
| | | No. | % |
| Diameter | | | |
| 3.0–3.5 mm | 34 | 6 | 17.6 |
| 3.6–4.5 mm | 232 | 20 | 8.6 |
| 4.6–5.0 mm | 31 | 2 | 6.5 |
| Length | | | |
| 8.0–10.0 mm | 62 | 4 | 6.5 |
| 10.1–14.0 mm | 186 | 14 | 7.5 |
| 14.1–16.0 mm | 49 | 10 | 20.4 |

TABLE 8

Implant failures according to the opposing dentition

| Opposing Dentition | No. of Implants | Implant Failures | |
|---|-----------------|------------------|------|
| | | No. | % |
| Natural dentition | 133 | 18 | 13.5 |
| Implant-tissue-supported overdenture | 8 | 0 | 0 |
| Implant-supported overdenture | 5 | 0 | 0 |
| Implant-supported fixed complete denture | 108 | 7 | 6.5 |
| Implant-supported full-arch fixed partial denture | 8 | 2 | 25.0 |
| Complete denture | 19 | 1 | 5.3 |
| Natural dentition with removable partial denture | 16 | 0 | 0 |
| Total | 297 | 28 | 9.4 |

indicate that implant failures were inversely correlated to the implant diameter. (Table 7) Therefore, when it is possible, the use of implants with a diameter ≤ 3.5 mm should be avoided for immediate-loading situations.

It has been reported in the literature that the maximum bite force associated with natural teeth and/or an implant-supported prosthesis are higher than with a removable prosthesis.⁵⁸ The general agreement seems to indicate a correlation between high masticatory forces and increased rates of implant failure.⁵⁹ This concurs with the results of this study, where a higher implant failure rate (27/262 = 10.9%; Table 8) was observed when the ISFCD was opposing natural teeth and/or an implant-supported prosthesis rather than when it was opposing a removable prosthesis (1/35 = 2.1%; Table 8). It should be noted that proper management of the occlusal scheme and occlusal contacts of the prosthesis may influence treatment outcome; however, these factors were not accounted for in this study.

Prosthetic-related complications, such as acrylic resin fracture, screw loosening, screw fracture, and

prosthetic misfit, are common and have been reported in the literature.⁶⁰⁻⁶² In this study, similar incidence rates of prosthetic complications were observed in most categories for both provisional and definitive prostheses (Tables 9 and 10). The only exception was the incidence of prosthesis misfit, which occurred at the highest frequency among all complications during the provisional stage (24%; Table 9) and the lowest in definitive prosthesis (0%; Table 10). Of the 12 provisional prostheses that experienced misfit, 27% (9/33) of these implants failed. It is important to note that a small number of the prostheses placed immediately after implant placement were definitive. Therefore, special care should be taken when fabricating and fitting the prosthesis (provisional or definitive) when performing an immediately loaded ISFCD procedure.

CONCLUSIONS

After a mean follow-up period of 42.1 months, the cumulative implant success rate was 85.2%, with an

TABLE 9

Incidence of prosthetic complications with interim prosthesis

| Prosthetic Complication | No. of Prostheses (No. of Incidences)/ No. of Prostheses | | Incidence Rate (%) |
|-----------------------------|--|------------|--------------------|
| | Misfit | 12 (12)/50 | |
| Acrylic resin base fracture | 8 (20)/50 | 16.0 | |
| Broken denture teeth | 6 (15)/50 | 12.0 | |
| Screw loosening | 2 (2)/50 | 4.0 | |
| Screw fracture | 0 (0)/50 | 0 | |
| Total | 18* (49)/50 | 36.0 | |

*Indicates that more than one prosthetic complication occurred in one prosthesis.

TABLE 10

Incidence of prosthetic complications with definitive prosthesis

| Prosthetic Complication | No. of Prostheses (No. of Incidence)/ No. of Prostheses | | Incidence Rate (%) |
|-----------------------------|---|----------|--------------------|
| | Broken denture teeth | 5 (9)/35 | |
| Acrylic resin base fracture | 3 (5)/35 | 8.6 | |
| Screw fracture | 1 (1)/35 | 2.9 | |
| Screw loosening | 0 (0)/35 | 0 | |
| Misfit | 0 (0)/35 | 0 | |
| Total | 6* (15)/35 | 17.1 | |

*Indicates that more than one prosthetic complication occurred in one prosthesis.

absolute success rate of 90.6%. Within the confines of this retrospective study, the results of this study suggest that higher implant failure rates might be associated with patients reporting a history of bruxism (29.3%) vs those without bruxism (4.6%) and surgeons with limited experience (≤ 5 years; 12.2%) vs experienced surgeons (2.4%). However, further controlled studies are needed for more meaningful and definitive conclusions.

ABBREVIATIONS

GBR: guide bone regeneration
 ISFCD: implant-supported fixed complete denture
 MBL: marginal bone level
 MdA: mandibular anterior
 MdP: mandibular posterior
 MxA: maxillary anterior
 MxP: maxillary posterior
 RL: reference line

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