Implants as Surveyed Crowns for Implant-Assisted Removable Partial Dentures: A Long-Term Case Series Study

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Purpose: To evaluate the long-term outcomes and assess the risk factors associated with marginal bone loss (MBL) for implant-assisted removable partial denture surveyed crowns (IARPDSCs). ***Materials and Methods:*** A total of 51 implants were placed in 14 partially or fully edentulous patients and restored using IARPDSCs. Implant crowns or bridges served as abutments for removable partial dentures (RPDs) to enhance their esthetics, comfort, and function. All patients attended regular follow-up appointments every 3 to 6 months for up to 12.5 years, which included professional cleaning and oral hygiene reinforcement. The collected data included patient demographics, treatment modality, arch restoration, Kennedy classification, RPD connection and retention design, opposing dentition, implant characteristics (location, connection type, and diameter), and any complications. The clinical assessments included plaque score, bleeding on probing, probing depth, marginal tissue recession, and keratinized mucosa width. Univariate and multivariate analyses were performed to identify factors influencing the MBL of implants in IARPDSCs. ***Results:*** One implant failed during follow-up; thus, the implant survival rate was 98%. All patients were satisfied with their prostheses and reported only minor complications. Univariate analysis showed a significantly higher MBL in maxillary implants than in mandibular implants ($P = .045$). Multiple regression analysis revealed that bruxism ($P = .002$) and maxillary implants ($P = .013$) were significantly associated with a higher MBL. Female sex ($P = .051$) and anterior implants ($P = .058$) exhibited an association with higher MBL. ***Conclusions:*** Within the limitations of this retrospective clinical study, IARPDSCs demonstrated predictable long-term success in carefully selected and well-maintained patients. *Int J Oral Maxillofac Implants 2025;40:468–476. doi: 10.11607/jomi.11202*

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Discomfort, instability, and retention issues are prevalent drawbacks of distal extension removable partial dentures (RPD).[1–3] To address these limitations, implant-assisted removable partial denture (IARPDs) offer a viable and cost-effective solution for partially or fully edentulous patients who may not be suitable for immediate fixed implant-supported restorations.[4,5] By incorporating dental implants into RPDs, practitioners can enhance abutment support, retention, stability, and longevity. This approach also reduces costs and improves patient satisfaction. Consequently, implant placement during treatment planning for distal extension RPDs is recommended.[6,7] Strategic placement of a small number of implants on the opposite side of the remaining teeth can help mitigate the stress on these teeth and protect the underlying tissues. This approach provides additional support, stability, and retention to the RPD while altering the fulcrum line, potentially extending the lifespan of the remaining dentition.

When planning an IARPD, positioning posterior implants away from the fulcrum line can convert Kennedy class 1 and class 2 cases into more favorable Kennedy class 3 or class 4 situations, improving support, stability, and retention for distal extension RPDs.[8] In the past, options such as locator attachments, O-ring attachments, or bar-clip systems for overdentures were commonly employed, while the use of surveyed crowns as distal abutments for RPDs has received less attention.[9,10] The limited use of surveyed crowns in IARPDs has stemmed from concerns about lateral forces and high stress concentrations, which could potentially jeopardize implant stability, contribute to marginal bone resorption, and ultimately lead to implant failure.[11] Further, uncertainty persists regarding the extent to which a single posterior implant can support the vertical dimension while enduring the forces exerted by the RPD, especially considering the structural rotational movement of

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distal-extension RPDs because that can generate terminal torquing forces. These concerns have contributed to the belief that implant-assisted removable partial denture surveyed crowns (IARPDSCs) are not a viable therapeutic option. However, a significant implant loss rate (21%) was observed in maxillary overdentures with technical complications such as loosening of the overdenture retention mechanisms (33%), need for relining (19%), and clip or attachment fractures (16%).[1]

Jang et al[12] was the first to describe the successful use of IARPDSCs. Since that time, several case reports have confirmed that implementing IARPDSCs can enhance patient comfort and reduce costs and technical complications commonly associated with overdentures.[12–14] However, the literature on IARPDSCs remains limited, with only a few case reports[12–14] and retrospective studies.[15–21] Moreover, long-term data regarding the efficacy and associated risks of IARPDSCs are limited. Therefore, this study evaluated the long-term outcomes and risk factors associated with IARPDSCs.

MATERIALS AND METHODS

The study was conducted in accordance with the 1975 principles of the Declaration of Helsinki and its 2013 revision. Written informed consent was obtained from all patients for treatment planning and procedures. Ethical approval for this case series was granted by the Institutional Review Board of Taipei Tzu Chi Hospital (Protocol No.: 13-IRB036).

This retrospective study included 14 patients (5 men and 9 women) with a mean age of 69.08 years (range: 50–79 years) at the time of implant placement. Partially or fully edentulous patients were treated in the Periodontal Department at Taipei Tzu Chi Hospital between 2010 and 2018. Only medically healthy patients treated with IARPDs were included and no additional exclusion criteria were applied. All patients underwent comprehensive clinical and radiographic examinations before implant placement. A total of 51 dental implants (Replace or Nobel Direct system, Nobel Biocare AB) were placed to enhance esthetics, comfort, and function. The implant lengths and diameters ranged from 8 to 16 mm and 3.5 to 6 mm, respectively. Before implant placement, the patients received active periodontal therapy to establish stable periodontal health. The surveyed crowns or bridges were used as prosthetic abutments to support the RPDs, and all were internally connected cement-retained restorations with metal margins and occlusions. The prosthetic abutments used with the implants to support RPDs were surveyed crowns or bridges. Guiding planes and rest seat preparations were made after treatment planning and cast survey. Occlusal rest, proximal plate, and I-bar partial dentures were fabricated for each case, with implant crowns or bridges serving as opposing dentitions for all IARPDSCs. Figures 1 and 2 illustrate two examples of treatments following this protocol.

The patients attended recall visits for professional cleaning (supragingival and subgingival debridement) and oral hygiene reinforcement every 3 to 6 months for up to 12.5 years, depending on their periodontal disease history and individual risk factors. Details on treatment modality, implant location, Kennedy classification, implant connection type, implant diameter, distal free-end abutments, RPD connection and retention design, complications, opposing dentition, and implant risk factors were collected. The assessed clinical parameters included plaque score, bleeding on probing, probing depth, marginal tissue recession, and keratinized gingiva (KG) width. The number of implants or teeth lost during supportive periodontal therapy was also documented. Prosthetic complications such as loss of retention and prosthetic element fractures were also recorded. Implant survival was defined as the normal functioning of both the implant and its superstructure at the final observation.[17]

The peri-implant bone levels were evaluated radiographically using digital software (Infinitt Radiology PACS, INFNITT). The marginal bone levels were measured from the crown margin to the bone crest (Fig 3). Both mesial and distal implant bone levels were assessed at two key points: *(1)* crown delivery and *(2)* follow-up. The mean mesial and distal bone levels were calculated to determine the average bone level of each implant. The average total bone loss was quantified by the following:

$$([a+b]/2) - ([c+d]/2) = \textit{average total bone loss}$$

The potential patient- and implant-related risk factors affecting the marginal bone loss (MBL) of IARPDSCs were analyzed. Univariate analyses were conducted using the Wilcoxon rank-sum test for dichotomous variables and the Kruskal-Wallis test for categoric variables with more than two groups. Multiple regression analysis was used to predict MBL among the identified risk factors. All statistical analyses were performed using R software, (version 4.3.3). The level of significance used in the analyses was set to 5% ($\alpha = .05$).

RESULTS

Table 1 provides patient and implant information. A total of 51 implants were placed in 14 partially or fully edentulous patients, all restored with IARPDSCs and followed up for up to 12.5 years. Characteristics,

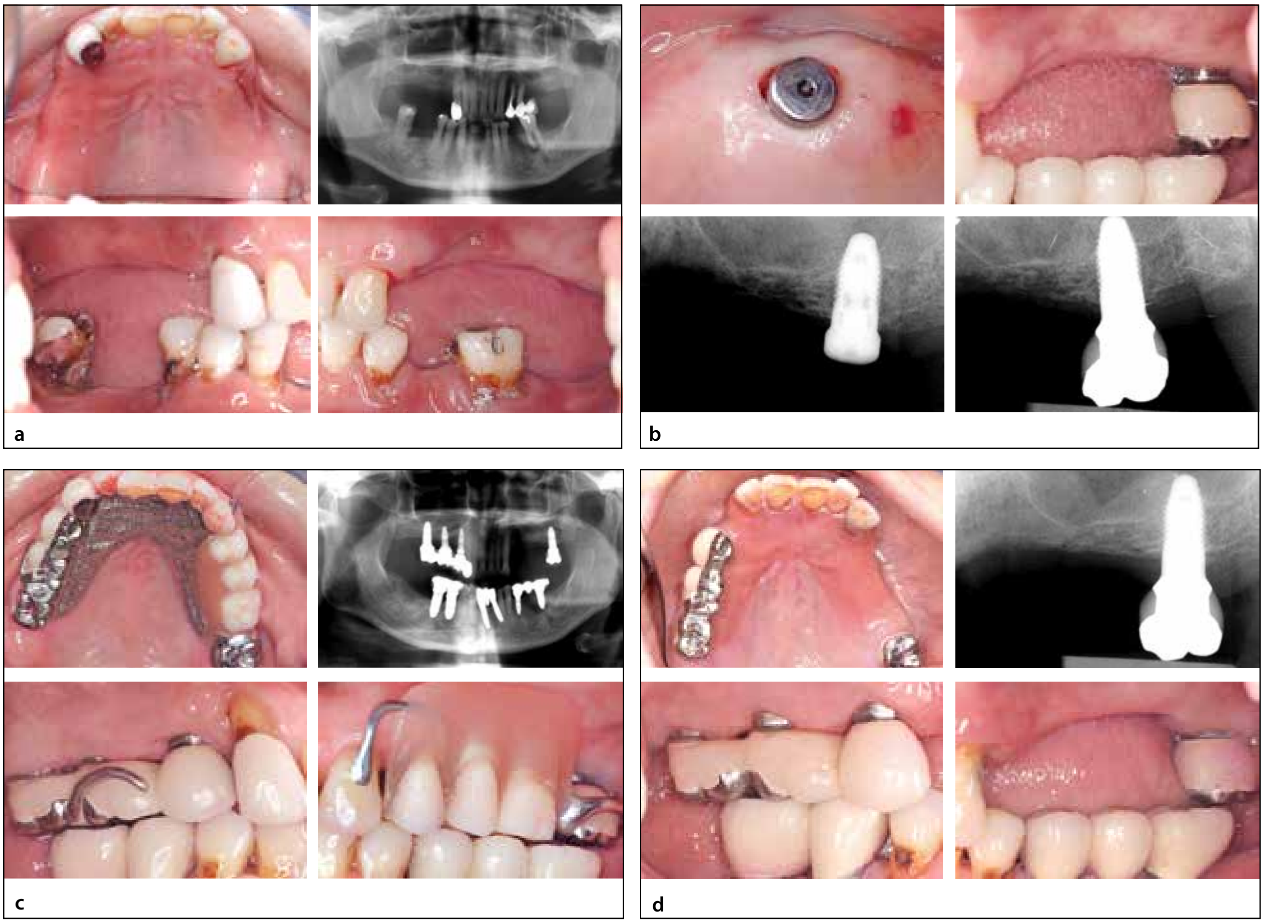

Fig 1 *(a)* Case 1 involves a 65-year-old patient with a Kennedy class 1 partially edentulous maxillary arch. *(b)* An IARPDSC was fabricated to address esthetic, functional, and financial concerns. The maxillary left first and second premolars were extracted due to hopeless prognosis. Implants were placed at the right first and second premolar, the right first molar, and the left second molar sites. *(c)* Implant bridges at the right first and second premolar and the right first molar sites as well as an implant crown at the left canine were restored 4 months after implant placement, aiming to transition the RPD from Kennedy class 1 to a more favorable Kennedy class 3. Two clasps at the maxillary right second premolar and left second molar were used to provide RPD retention. *(d)* Ten years after denture delivery, clinical and radiographic examinations were documented. Minimal MBL was detected for all implants, and no marginal tissue recession was noted at the left second molar. Over the 10-year follow-up period, no biologic or mechanical complications were observed at the left second molar and the IARPD. The right canine was lost due to deep caries and restored by denture repair.

treatment outcomes, and complications of IARPDSCs are listed in Table 2. Maxillary and mandibular prostheses were placed in nine and seven patients, respectively. Among these RPDs, 12 were classified as Kennedy class 3 and four as class 4. Forty implant abutments were surveyed crowns, and 11 were splinted as surveyed bridges. All implant prostheses featured internal connections and were cement-retained. Fifteen implant abutments were placed in the anterior region and 36 in the posterior region. Among the opposing dentitions for the IARPDs, nine were fixed prostheses and seven were removable. Regarding KG, 27 implant abutments had a width of < 2 mm, whereas 24 implant abutments had a width of > 2 mm. Only one implant failed during the follow-up period; thus, the implant survival rate was 98%. Prosthetic complications were minimal, with 9.8% of the implant prostheses experiencing porcelain fractures. In addition, clasp fractures and the loss of artificial teeth were observed in some RPDs. All patients reported satisfactory chewing function and prosthetic stability.

The MBL around the implants is listed in Table 3. Univariate analysis was performed for each variable to assess its association with MBL. None of the variables, except for restored arch (P = .045), was significantly associated with MBL. No significant effects were observed for sex, implant risk factors, KG < 2 mm, Kennedy classification, occlusion of the opposing dentition, implant location, posterior distal free-end abutments, or splinting on MBL (see Table 2).

Multiple regression analysis indicated that bruxism (P = .002) and maxillary implants (P = .013) were

Fig 2 *(a)* Case 2 involves a 58-year-old man with a Kennedy class 1 partially edentulous mandibular arch. *(b)* An IARPDSC was fabricated to address esthetic, functional, and financial concerns. Four implant crowns were placed aiming to transition the RPD from Kennedy class 1 to a more favorable Kennedy class 3. *(c)* Ten years following denture delivery, clinical examinations were documented. No additional periodontal bone loss was observed; tooth loss occurred due to tooth fractures. At the implant crowns, no MBL was detected, and a 1-mm buccal tissue recession was noted. *(d)* Over the 12-year follow-up period, no biologic or mechanical complications were observed with the implants.

significantly associated with a higher MBL (Table 4). Additionally, trends toward higher MBL in women (*P* = .051) and anterior implants (*P* = .058) were observed. MBL was not significantly associated with any other variables, including KG < 2 mm, Kennedy classification, opposing dentition, distal free-end abutments, splinting, history of periodontitis, and smoking.

DISCUSSION

The long-term stable bone level around the distal free-end implants in IARPD in this case series is an encouraging finding, likely attributable to the proper occlusal scheme, optimal denture design, and strict maintenance program provided for these patients. Most of the available literature employs ball or bar attachments to enhance the stability and function of implant-supported distal free-end RPDs.[3–5] In a photoelastic stress analysis, Ozel et al[22] compared a new design of implant-supported RPDs, which were retained with an anterior fixed prosthesis to a conventional locator- or bar-attached implant overdenture prostheses. They found that the novel design exhibited lower stress distributions in the

Fig 3 Measurement of marginal bone level. Both mesial and distal implant bone levels at crown delivery and follow-up date were measured. The mean mesial and distal bone level values were calculated as the average bone level of each implant. Average total bone loss was measured by deduction of the baseline mean bone level (a+b)/2 from the last follow-up bone level (c+d)/2.

Table 1 Patient and Implant Information

No.	Age/sex	Implant brand	Surgical date	Restore date	Last FU	Maxillary or mandibular	Follow-up (years)	Implant risk factor
1	59 / M	Replace	06.20.2011	12.16.2011	06.19.2024	Mandibular	12.5	Bruxer
2	51 / M	Replace	04.22.2013	07.23.2013	12.06.2023	Maxillary	10.5	Periodontitis
3	79 / F	Replace	12.24.2018	07.08.2019	03.22.2024	Mandibular	4.5	No
4	80 / F	Replace	11.18.2010	07.28.2011	03.27.2024	Maxillary	12.5	Bruxer
5	80 / F	Replace	10.08.2011	12.12.2012	02.05.2020	Maxillary	7	No
6	69 / F	Replace	05.20.2013	12.13.2013	04.03.2024	Maxillary	10.5	No
6	69 / F	Replace	06.03.2013	12.13.2013	04.03.2024	Mandibular	10.5	No
7	80 / F	Replace	09.03.2018	07.08.2019	01.22.2024	Mandibular	4.5	No
8	69 / F	Replace	12.02.2013	05.02.2014	04.17.2024	Mandibular	10	No
9	67 / F	Nobel Direct	03.10.2011	07.04.2011	11.21.2023	Mandibular	12.5	No
10	71 / F	Replace	07.07.2015	06.03.2016	06.07.2024	Maxillary	8	Periodontitis
11	58 / M	Replace	09.24.2011	08.11.2012	02.25.2017	Maxillary	4.5	Periodontitis
12	62 / M	Replace	03.27.2018	03.22.2019	01.17.2024	Maxillary	5	Periodontitis/smoker
13	62 / M	Replace	04.01.2013	09.12.2013	03.13.2024	Maxillary	10.5	Periodontitis
14	77 / F	Replace	07.09.2012	11.23.2012	06.29.2022	Maxillary	10	Periodontitis

crest region compared with bar-retained prostheses, suggesting that the new design generated less lateral force during functioning. Furthermore, the authors reported a higher stress distribution in the apical region for IARPD with fixed prostheses compared with those with locators, indicating that fixed prostheses absorb more bite force during function. This finding highlights the potential advantage of IARPDSCs in distributing occlusal forces more effectively, provided that the force remains within a patient's physiologic tolerance. This could be beneficial for the long-term support and stability of IARPDs, particularly when managing complex cases with varied demands.

To date, only a few short-term reports have used surveyed implant crowns or bridges as abutments for RPD.[12,13,15,16] Notably, none of these case reports employed distal free-end implant crowns as abutments for IARPD. Retrospective studies have compared IARPD with implant-supported fixed prostheses or overdentures.[15,17,19] In a retrospective study lasting up to 44 months, Bae et al[15] observed a higher rate of MBL and more frequent technical complications in RPDs with stud-type attachments compared with those with surveyed bridges. Kang et al[17] evaluated IARPDs for up to 185 months (mean, 48 months) and reported a higher survival rate for implants supporting the surveyed crowns than for those used in overdentures. In another retrospective study spanning 149 months (mean, 47 months), Yoo et al[18] reported that the most frequent prosthetic complication in patients with IARPDs with surveyed crowns was clasp loosening, whereas attachment dislodgement was more common in the implant overdenture group.

Studies on the impact of implant retainers in the free-end region of RPDs on the occlusal force and masticatory efficiency compared with conventional removable dentures have consistently demonstrated significantly more occlusal force and improved masticatory efficiency for implant-supported RPDs with distal abutments.[23–25] However, and importantly, implant-supported RPDs with ball or bar attachments—while providing improved functional outcomes—have been associated with reduced comfort, increased technical complications, and higher long-term denture maintenance and repair costs.[1,2,26–28]

IARPDSC may be a viable alternative to conventional RPDs and implant-supported fixed partial prostheses, particularly in cases where implant placement is restricted due to limitations in bone height, thickness, esthetic considerations, or financial constraints. In such scenarios, the strategic placement of a limited number of implants as distal abutments in the form of crowns or bridges can significantly stabilize the RPD while providing additional support. This approach offers benefits such as improved patient comfort, enhanced masticatory efficacy, and better esthetics.[20,21]

The results of the present case series confirmed another important benefit of the IARPDSC approach, which is the ability to use a major horseshoe connector in the maxilla. This design effectively prevents impingement on the palatal tori and prominent median palatal sutures while also alleviating the gagging

Table 2 Characteristics, Treatment Outcomes, and Complications of IARPDSCs

No.	Implant site	Implant size (mm)	MBL changes (mm)	RPD connection/ retention design	Kennedy classification	Complications	Opposing dentition
1	34	3.5 × 10	0.1	Embrasure clasp	Class 3	No	Implant crown
1	37*	5 × 10	0.25	I-bar	Class 3	No	Natural tooth
1	43	4.3 × 13	−0.25	Embrasure clasp	Class 3	Porcelain fracture	Implant crown
1	46*	5 × 10	−0.7	I-bar	Class 3	No	Natural tooth
2	24	4.3 × 10	-0.55	Embrasure clasp	Class 4	No	Natural tooth
3	32	3.5 × 10	0.25	I-bar	Class 3	No	Fixed bridge
3	35*	4.3 × 8	0.8	I-bar	Class 3	No	Fixed bridge
3	42	3.5 × 10	0.1	I-bar	Class 3	No	Fixed bridge
3	45*	4.3 × 8	−0.5	I-bar	Class 3	No	Fixed bridge
4	17*	5 × 13	1.9	Embrasure clasp	Class 3	No	Natural tooth
4	13	3.5 × 16	2.85	I-bar	Class 3	Porcelain fracture	Implant bridge
4	23	4.3 × 13	5	I-bar	Class 3	No	Implant bridge
5	15*	3.5 × 13	0.4	I-bar	Class 4	Porcelain fracture	Implant bridge
5	16*	5 × 13	−0.85	Embrasure clasp	Class 4	No	Implant bridge
5	17*	4.3 × 13	−0.3	No (rest)	Class 4	No	No
6	13	3.5 × 16	0.35	I-bar	Class 3	No	Implant crown
6	16*	6 × 10	0.9	Embrasure clasp	Class 3	No	Implant crown
6	23	3.5 × 16	−0.05	I-bar	Class 3	No	Implant crown
6	33	4.3 × 13	0.35	I-bar	Class 3	No	Implant crown
6	36*	5 × 8	0.25	Embrasure clasp	Class 3	Porcelain fracture	Natural tooth
6	43	3.5 × 13	0.2	I-bar	Class 3	No	Implant crown
6	46*	4.3 × 10	−0.4	Embrasure clasp	Class 3	Porcelain fracture	Implant crown
7	33	3.5 × 10	0.3	I-bar	Class 3	No	Tooth crown
7	36*	5 × 8	0.45	Embrasure clasp	Class 3	No	Tooth bridge
7	43	3.5 × 13	0.6	I-bar	Class 3	No	Tooth bridge
7	46*	5 × 8	−0.2	Embrasure clasp	Class 3	No	No
8	33	4.3 × 16	−0.9	I-bar	Class 3	No	Full denture
8	36*	4.3 × 10	−0.05	Embrasure clasp	Class 3	No	Full denture
8	43	4.3 × 13	−0.15	I-bar	Class 3	No	Full denture
8	46*	4.3 × 10	−0.8	Embrasure clasp	Class 3	No	Full denture
9	36*	4.3 × 10	0.35	Embrasure clasp	Class 3	No	Overdenture
9	46*	4.3 × 10	0.85	Embrasure clasp	Class 3	No	Overdenture
10	14*	4.3 × 16	0.1	I-bar	Class 4	No	Implant crown
10	15*	3.5 × 13	0.3	No (rest)	Class 4	No	Natural tooth
10	16*	3.5 × 10	0.25	Embrasure clasp	Class 4	No	Natural tooth
10	26*	3.5 × 10	0	Embrasure clasp	Class 4	No	Implant bridge
11	16*	5 × 10	0.4	Embrasure clasp	Class 3	No	Natural tooth
12	16*	5 × 13	−0.15	Embrasure clasp	Class 3	No	Implant crown
12	24	3.5 × 13	0.75	I-bar	Class 3	No	Implant crown
12	26*	5 × 13	0.4	Embrasure clasp	Class 3	No	Implant crown
12	33	3.5 × 13	0.2	I-bar	Class 3	No	Natural tooth
12	36*	3.5 × 13	−0.55	Embrasure clasp	Class 3	No	Implant crown
12	43	4.3 × 10	0.1	I-bar	Class 3	No	Natural tooth
12	46*	4.3 × 10	—	Embrasure clasp	Class 3	Implant loss	Implant crown
13	17*	6 × 10	0.3	Embrasure clasp	Class 4	No	Tooth crown
13	24*	3.5 × 13	0.8	No (rest)	Class 4	No	Tooth crown
13	26*	3.5 × 10	1.2	Embrasure clasp	Class 4	No	Implant crown
14	27*	5 × 10	0.5	Embrasure clasp	Class 3	No	Implant bridge
14	14	4.3 × 10	0.15	No (rest)	Class 3	No	Implant bridge
14	15	4.3 × 10	0.15	Embrasure clasp	Class 3	No	Implant bridge
14	16	5 × 10	0.4	No (rest)	Class 3	No	Implant bridge

*Distal free-end abutments of IARPDs.

Table 3 Factors Affecting MBL of IARPDSCs

Variable	N	MBL (mm)	Univariate analysis (*P* value)
KG < 2 mm	Yes (n = 24)	0.24 ± 1.11	.138
	No (n = 27)	0.37 ± 0.76	
Sex	Male (n = 7)	0.12 ± 0.48	.539
	Female (n = 7)	0.39 ± 1.06	
Restored arch	Maxillary (n = 9)	0.58 ± 1.17	.045
	Mandibular (n = 7)	0.04 ± 0.48	
Kennedy classification	III (n = 12)	0.37 ± 1.01	.614
	IV (n = 4)	0.10 ± 0.50	
Opposing dentition	Fixed (n = 9)	0.42 ± 1.15	.961
	Removable (n = 7)	0.18 ± 0.52	
Distal free-end abutments	Maxillary (n = 16)	0.35 ± 0.59	.135
	Mandibular (n = 14)	−0.01 ± 0.56	
Splinting (crown or bridge)	Surveyed crown (n = 40)	0.35 ± 1.02	.934
	Surveyed bridge (n = 11)	0.19 ± 0.45	
Implant location	Anterior (n = 15)	0.62 ± 1.44	.799
	Posterior (n = 36)	0.18 ± 0.57	
Implant risk factors	Bruxer (n = 4)	1.30 ± 2.05	.714
	Periodontitis (n = 4)	0.27 ± 0.33	
	Periodontitis/smoker (n = 1)	0.12 ± 0.47	
	No (n = 5)	0.09 ± 0.52	

Used Wilcoxon singed-rank test and Kruskal test for two categories and more than two categories, respectively.

Table 4 Multiple Regression for Prediction of MBL Among Risk Factors

Risk factor	Regression coefficient	95% confidence interval	*P* value
KG < 2 mm (yes)	0.258	(−0.335, 0.851)	.383
Sex (male)	−0.842	(−1.688, 0.004)	.051
Arch (maxillary)	1.095	(0.239, 1.951)	.013
Kennedy classification (4)	−0.305	(−1.275, 0.663)	.526
Opposing dentition (removable)	−0.178	(−0.410, 0.767)	.541
Distal free-end abutments (mandibular)	0.309	(−0.535, 1.154)	.462
Splinting (surveyed bridge)	−0.142	(−1.002, 0.717)	.738
Implant location (posterior)	−0.754	(−1.537, 0.027)	.058
Implant risk factors (bruxer)	1.585	(0.608, 2.561)	.002
Implant risk factors (periodontitis/ smoker)	0.720	(−0.431, 1.872)	.212
Implant risk factors (periodontitis)	0.398	(−0.451, 1.249)	.348

sensation often experienced by patients. However, despite the advantages of the horseshoe connector, the rigidity of the major connector is a critical factor for long-term RPD success. Hence, more rigid major connectors such as the anteroposterior (A-P) strap or palatal plate are strongly recommended to ensure stability and prevent mechanical failure in patients with high bite forces.

Effects of Implant Position on MBL

Implant-supported crowns positioned at different locations along the edentulous ridge experience varying masticatory forces, which may affect IARPD performance. In the present study, the results of the univariate analysis revealed a trend toward higher MBL in anterior implants (*P* = .058). However, no significant increases in MBL were observed for the maxillary or mandibular posterior distal free-end abutments in either the univariate (*P* = .135) or multiple regression (*P* = .261) analyses. These results align with findings from a retrospective study on the strategic positions of IARPDSCs in distal extension areas of Kennedy class 1 and class 2 arches, which observed higher failure rates for IARPDSCs on the anterior area apart from the abutment tooth.[20] The impact of implant position on MBL might be attributed to the fact that anterior IARPDSCs may experience more oblique forces during function, leading to increased MBL. These findings underscore the importance of carefully considering the implant location and achieving proper occlusal equilibration of IARPDs when assessing MBL in IARPDs. Moreover, anterior IARPDSCs may require closer monitoring because they may potentially show a higher rate of MBL.

The posterior implants maintained stable bone levels without significant adverse effects. This information is crucial for clinicians planning treatment strategies for partially edentulous patients, particularly those patients classified as Kennedy class 1 or class 2. Similar to our findings, Jung and Yi[21] evaluated the clinical outcomes of posterior implants with IARPDSC over a follow-up period of up to 155 months (mean: 61 months). Their study included 32 posterior implants restored with crowns surveyed for IARPDs in 16 patients (7 men and 9 women). Of these, 15 IARPDs were placed in the mandible and only 1 was placed in the maxilla. Before implant placement, 13 cases were classified as Kennedy class 1 and 3 were classified as class 2. Their results demonstrated high survival rates for implants used for IARPDSCs (96.9%) during short- to medium-term follow-ups. In the present study, posterior implants with the surveyed crowns also demonstrated reliability as a treatment option for patients with free-end RPD (see Fig 2). However, IARPDSC placed away from natural tooth abutments may increase the risk of IAPRD failure.[20]

Restored Arch on MBL

The results of the univariate and multiple regression analyses in this case series demonstrated significantly greater MBL for maxillary implants compared with mandibular implants. In contrast, previous retrospective clinical evaluations of IARPDSCs reported that the restored arch did not significantly influence the MBL ($P > .05$).[19,20] This disparity could be attributed to various factors including implant-related risk factors, implant position, bone density, and longer follow-up periods. The maxillary bone is typically less dense than the mandibular bone, which may contribute to greater MBL owing to its reduced capacity to withstand occlusal forces. In addition, implant placement in the anterior maxillary region is prone to greater oblique forces during mastication, further exacerbating MBL in these cases. Furthermore, implant placement in the maxilla may lead to complications related to surgical access, soft tissue thickness, and anatomical challenges. Collectively, these factors suggest that maxillary implants require cautious long-term monitoring to mitigate MBL in patients receiving IARPDs.

Surprisingly few long-term studies have documented the use of IARPDSCs as distal abutments in maxillary free-end cases.[14] The present study is the first to report favorable long-term results associated with the use of a maxillary distal free-end posterior implant for IARPDs in carefully selected partially edentulous patients. Moreover, the findings demonstrated no significant differences in MBL between maxillary and mandibular distal free-end posterior implants ($P = .135$). These results suggest that—when appropriately planned and executed—IARPD s can provide stable support for free-end removable prostheses in both arches and support their viability as a treatment option in complex cases.

Implant Risk Factors for MBL

To the best of our knowledge, this is the first long-term study to assess the effect of implant risk factors on MBL in IARPDSCs. The results of the multiple regression analysis revealed that bruxism was significantly associated with a higher MBL ($P = .002$), whereas a history of periodontitis or smoking was not (see Table 3). However, because of the limited sample size, these findings should be interpreted with caution when making broader generalizations. Additional randomized controlled clinical trials with larger sample sizes are required to confirm the significance of implant risk factors for MBL. Within the limitations of this study, please note that careful planning is essential before placing IARPDSCs in patients with bruxism.

IARPDs and Conventional RPDs

Compared to cases treated with conventional RPDs, IARPDSCs effectively enhance RPD quality by providing additional support and stability through strategically placed implants. This reduces the need for frequent denture adjustments, which are common with extension-based RPDs.[29] Extension-based RPDs often subject the alveolar bone to excessive pressure, leading to accelerated bone resorption. This resorption reduces denture stability and fit, thus initiating a vicious cycle of ongoing bone loss and necessitating frequent denture adjustments. Thus, IARPDSCs as distal abutments can not only provide support for RPDs but also can play a protective role against bone resorption.

However, the force transmitted to the implant abutments during function should be carefully considered. In the maxilla with poor-quality alveolar bone, two or more splinted implants are highly recommended.[15,16,19] Otherwise, long and wide-diameter implants may be considered, as illustrated in Fig 1, if a single implant is placed at the distal free end as a surveyed crown for IARPD. Moreover, given the force exerted by RPDs, the need for retentive clasps in IARPDSCs should be minimized. When placing clasps on IARPDSCs is unavoidable, the reciprocating component must be activated during retentive arm placement.

The use of IARPDSCs should be avoided for implants placed at the distal free end, where the crown-to-implant ratio may be unfavorable. In such cases, RPD rotation can induce a lever effect on the posterior implants, potentially resulting in excessive lateral forces.[13] Instead, using an overdenture abutment that provides a vertical stop and sufficient retention may be a preferable option. Regular biologic and prosthetic evaluations are required in such cases.[30]

In this study, one implant (mandibular first molar) failure was noted in a Class 3 case, in which the IARPDSC served as an abutment for an embrasure clasp (see Table 2). This finding aligns with previous research reporting a trend of higher failure rates in Class 3 cases.[17] The excessive force generated by the presence of an embrasure clasp is highly likely to play a significant role in implant failure. In addition, factors such as non-passive seating of the RPD and occlusal overload may contribute to failure. The prosthetic complications encountered in this study, including porcelain fractures, loss of resin teeth, and clasp fractures, were relatively minor. Although these events were not related to the implants but rather to general RPD complications, meticulous IARPD fabrication and maintenance are essential. To reduce the risk of implant failure and associated complications— with a thorough understanding of the underlying biomechanics— careful planning during the design phase and regular follow-up assessments can help identify potential issues early and ensure optimal prosthesis function and longevity. This proactive approach is crucial for enhancing patient satisfaction and achieving successful long-term clinical outcomes.

CONCLUSIONS

Within the limitations of this study, the results suggest that this treatment modality can be employed with high patient satisfaction in a carefully selected and well-maintained population. Patients should be informed about their role in maintenance, and a comprehensive recall system is imperative to achieve satisfactory long-term results.

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