치의과학박사 학위논문

Survival rate and clinical evaluation of the implants in implant assisted removable partial dentures: clasp retained and overdenture abutment

임플란트 융합 국소의치에 적용된 임플란트의 생존율과 임상적 평가: 클래스프 유지와 피개의치 지대치

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강 수 현

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지도교수 김 성 균

이 논문을 강수현 박사학위논문으로 제출함

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-Abstract-

Survival rate and clinical evaluation of the implants in implant assisted removable partial dentures: clasp retained and overdenture abutment

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Purpose: The purpose of this study was to investigate survival rates and periodontal indices of the implants used in implant assisted removable partial dentures (IARPDs). This study also aimed to analyze the factors that influence the survival rate and periodontal indices. In addition, complications related to IARPDs were investigated clinically.

Materials and methods: A retrospective clinical study was carried out for 21 patients (9 men, 12 women), mean age of 66.6, who were treated with IARPDs. The 58 implants used in the IARPDs were applied to two modalities; 41 implants were for clasp retained abutments, and 17 were for overdenture abutments. Survival rates and periodontal indices (plaque index, calculus index, mucositis index, bleeding index, probing depth, marginal bone loss) of total 58 implants were investigated clinically and radiographically. They were analyzed statistically with regard to the factors: treatment modality, implant's location, Kennedy classification, opposing dentition, implant connection type, and implant's diameter. Lastly, complications associated with the IARPDs were investigated and summarized.

Results: The average follow-up period of the 58 implants was 47.9 months (minimum 12 to maximum 185 months). The survival rate of total 58 implants was 93.1%; of these, the survival rate of 41 clasp retained implant abutments was 95.1%, while that of 17 overdenture implant abutments was 88.2%. Among the clasp retained implant abutments, the significant difference ($p<.05$) of the survival rate was observed when regular diameter implants (survival rate 100%) were used compared to when narrow (survival rate 88.9%) or wide (survival rate 87.5%) were used. Regarding the periodontal index, there were higher mucositis and bleeding indices of the overdenture implant abutments compared to clasp retained implant abutments ($p<.05$). Plaque index was higher for mandibular implants compared to maxillary implants ($p<.05$). The Kennedy class IV implants had higher plaque index compared to the implants in class I or II ($p<.05$). Plaque index was also higher for implants with opposing removable denture (complete denture or RPD) compared to natural teeth or fixed prosthesis as opposing teeth ($p<.05$). The marginal bone loss was severe for Kennedy class I implants than class III ($p<.05$). The most frequent complication was dislodgement of clasp retained crown due to cementation failure, while attachment replacement due to wear was most common for overdenture abutment.

Conclusion: The survival rate of the implants used in IARPDs was 93.1% (clasp retained implant: 95.1%, overdenture implant: 88.2%). IARPDs and their implants functioned without critical complications throughout the period.

Keywords : Dental implant; Removable partial denture; Implant assisted removable partial denture; Clasp retained implant abutment; Overdenture abutment
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Ⅰ. INTRODUCTION

In recent decades, prosthetic treatment using implants for fully or partially edentulous patients had made progressive improvement in various modalities.[1]

For fully edentulous patients, one may first install six to nine implants and make full fixed prosthesis, or install two to four implants and make removable overdentures similar to complete dentures using attachments.[2] Implant supported fixed detachable denture, a hybrid form between implant fixed prosthesis, and removable denture, supported by four to six implants are also possible.[3] Currently, for the lower arch, overdenture using two implants suggested by 2002 McGill consensus is being used as the standard form of edentulous treatment.[4,5]

For partial edentulous patients, while performing restoration with implant fixed prosthesis or making removable partial dentures without implants had been served as general methods of treatment, recently, much interest is being gathered around implant assisted removable partial dentures (IARPD) as an optional treatment method that allows for additional support and retention from a few implants.[6,7,8,9,10,11,12,13,14]

While many terminologies had been used in place of IARPD in clinical research publications depending on the method for retention and support.[14,15] Implant supported removable partial denture (ISRPD) was termed when only support was gained, while implant retained removable partial denture (IRRPD) was used for when retention was gained. Schneid et al. introduced the term IARPD, allowing for IARPD to recently be universally used as a concept that incorporates both ISRPD and IRRPD.[16]

Methods for IARPD implication can be divided into two modalities. The first modality is an ‘clasp retained implant abutment’ that makes the suprastructures, supported by implants, in the form of a surveyed crown to be used as the abutment to make the removable partial denture on top.[17]

The second modality is an 'overdenture implant abutment' that places the implants and their abutments beneath RPD base.

Both modalities allow additional support and retention compared to unfavorable conventional removable partial dentures. These allow the patients to feel more comfortable while chewing or pronouncing.[11,18,19] Depending on the circumstances, omission of clasps can also bring advancements in aesthetics.[20,21]

However, clinical evidences for treatments with IARPD is currently lacking in frequency compared to overdenture.[22] As in the case for overdenture implant abutment, clinical result over varying follow-up periods were published; Grossmann et al.[11] for average of 35 months, Mijiritsky et al. [13] for two to seven years, Mitrani et al.[18] for maximum four years, Bortolini et al.[19] for maximum eight years, Ohkubo et al.[14] for under three weeks, Payne et al.[23] for a year, and Kaufmann et al.[8] for maximum eight years. While these previous studies reported that the survival rate for the implants was 93-100% with few prosthetic complications, they did not further explain the conditions of the implants or their related complications.

Moreover, clasp retained implant abutment also had not been studied as a topic of research so far, its introduction limited to case reports and short term result evaluations.[24,25,26,27] These previous studies also were not equipped with guide or advice that must be considered in a clinical situations.

This present study investigated the survival rate and periodontal indices of the implants used in IARPD.[28] This study also examined the effects of various factors such as treatment modality, implant location, Kennedy classification, opposing dentition, conjunction of implants, and implants' diameter. In addition, all biologic and technical complications arose during the entire observed time were examined and analyzed.

Ⅱ. MATERIALS AND METHODS

Subjects and implants

A retrospective clinical study was carried out for the patients who received IARPD from 2000 to 2015 at the Department of Prosthodontics, Seoul National University Dental Hospital. All the investigated patients have visited for periodical recall check, and were free from severe systemic disease that might have an effect on the prognosis of implant prosthesis.

Total 22 IARPDs of 21 patients (9 males, 12 females) were evaluated clinically and radiographically (One patients was treated with 2 IARPDs in the upper and lower arches.). (Table 1)

Table 1. Total number of the patients, IARPDs, and implants

Modalities	Clasp retained abutment	Overdenture abutment	Total
Patients	11 (Males: 7, Females: 4)	10 (Males: 2, Females: 8)	21
IARPDs	12 (Upper: 8, Lower: 4)	10 (Upper: 3, Lower: 7)	22
Implants	41 (Maxilla: 22, Mandible: 19)	17 (Maxilla: 6, Mandible: 11)	58

Among total 22 IARPDs, there were 12 IARPDs (Upper: 8, Lower: 4) using clasp retained abutment and 10 IARPDs (Upper: 3, Lower: 7) using overdenture abutment. The numbers of implants placed in IARPDs were 41 for clasp retained abutments and 17 for overdenture abutments.

Total 58 implants were examined clinically and radiographically, and their information such as treatment modality, location, the Kennedy classification, implant connection type, implant diameter, and opposing dentition type were compiled.

This study was conducted after obtaining approval from Seoul National University Dental Hospital's Institutional Review Board (IRB 074/03-16).

Implant survival

To determine the implant was survival, the implants were analyzed according to Pisa consensus statement of the ICOI Conference 2007.[29] The implant was considered survival if the implant and its superstructure remained at the point of the final observation and functioned normally. If any symptoms (e.g., pain on function, mobility, severe radiographic bone loss, uncontrolled exudate, or extraction) were present, the implant was classified as failure.

Periodontal evaluation

Periodontal indices (plaque index, calculus index, mucositis index, sulcus bleeding index, probing depth) were measured. Each criteria index of periodontal parameter was as follows.

- Plaque index[30]

  0: No plaque

  1: Separate flecks of plaque at the cervical margin

  2: Plaque can be seen by naked eye

  3: Abundance of soft matter

- Calculus index[31]

  0: Absence of supra and/or subgingival calculus by visual or tactile examination

  1: Presence of supra and/or subgingival calculus by visual or tactile examination

- Mucositis index[31]

  0: Absence of inflammation

  1: Mild inflammation ~ slight change in color and little change in texture

  2: Moderate inflammation ~ moderate glazing, redness, edema & hypertrophy

  3: Severe inflammation ~ marked redness and hypertrophy tendency for spontaneous bleeding

- Modified sulcus bleeding index[30]

  0: No bleeding when periodontal probe is passed along the gingival margin

  1: Isolated bleeding spots visible

  2: Blood forms a confluent red line on the gingival margin

  3: Heavy or profuse bleeding

- Probing depth was defined as a mean value of measurements of 6 sites (Mesiobuccal, Midbuccal, Distobuccal, Mesiolingual, Midlingual, Distolingual) using a periodontal probe (*Premier periowise*) from free gingival margin to the most apical part of the sulcus.[30]

Radiographic evaluation

Digitized panoramic and periapical radiographs were taken for all patients after the delivery of IARPD and at the time of recall visits. Then the bone resorption was observed in the mesial and distal area from the top of the implant to the level of the adjacent osseous crest. Based on the actual length of the implants, actual bone resorption was determined by proportion.[32] (Fig. 1) The average of mesial and distal resorption between the both measurements at the delivery of IARPDs and the final recall visit was defined 'Bone loss' in this study.

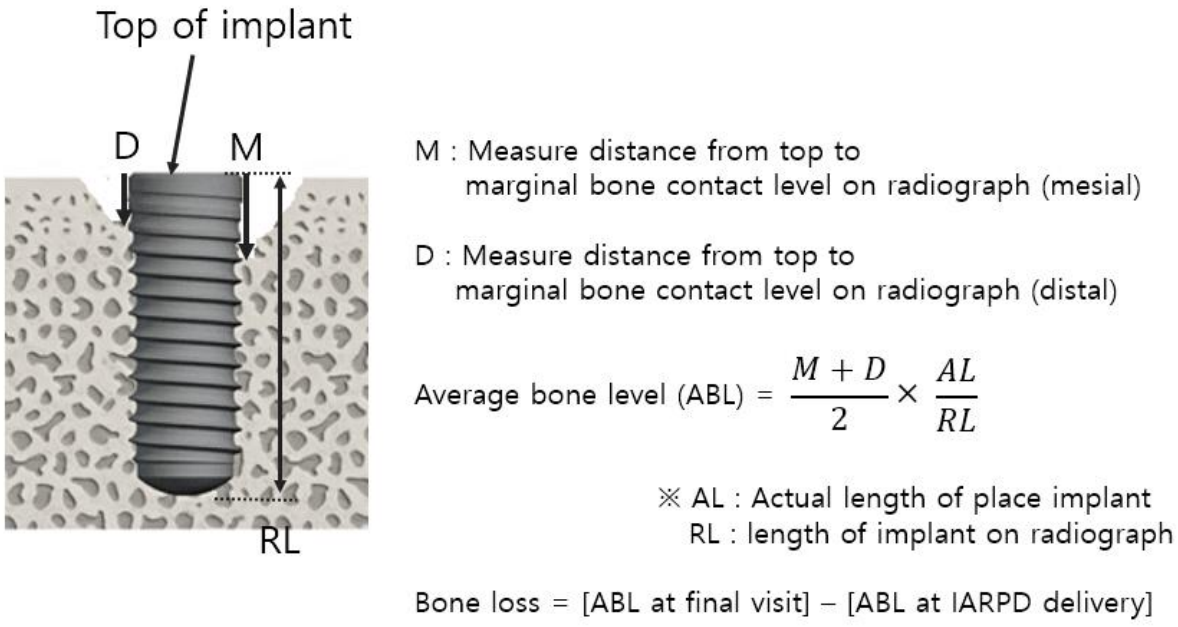

Figure 1. The definition of 'Bone Loss'

IARPD complication evaluation

All biologic and technical complications were recorded in the patients' charts throughout the entire observation time. All the records of the chart were reviewed what complications related to IARPDs arose.

The complications were classified into five categories.

- Denture: fractures or deformations of the RPD components followed by repair of the denture or fabrication of new denture.
- Implant: screw loosening or fractures, fracture of implant fixture.
- Crown: veneer porcelain fracture, dislodgement of prostheses.
- Tissue: sore spots, peri-implantitis, bleeding on probe, marginal bone resorption, caries crown fracture, loss of tooth. need of restoration,
- Others: opposing tooth fracture or mobility, occlusal adjustment, discomfort.

Statistical analyses

All the measurements of 58 implants were recorded and compared with regard to the factors which affect the prognosis of the implants in IARPDs.

- Treatment modality (clasp retained abutment vs. overdenture abutment)
- Restored Arch (maxilla vs. mandible)
- Implant location (anterior vs. posterior)
- Kennedy classification (I ~ IV)
- Implant connection type (internal vs. external)
- Diameter: narrow($< 3.75mm$) vs. regular($\geq 3.75mm, < 5.0mm$) vs. wide($\geq 5.0mm$)

All the data were entered into a database system and evaluated by means of the statistical package SPSS version 23 (SPSS Inc., Chicago, IL, USA).

Kaplan & Meier survival analysis was used for survival curve, and log rank (Mantel-Cox) test was used for the comparison of implant's survival rate. The criterion for the time interval up to implant failure was the time difference between the respective delivery date of IARPD and the date of occurrence (implant failure) or the end of observation (censored data).

Because of small sample size, to compare the periodontal indices of implant, nonparametric statistical analyses were used in this study. In cases of the analyses for two group comparison, Mann-Whitney U test were used. For the analyses for more than three group comparison, the Kruskal-Wallis test was performed to evaluate. When a significant result was obtained by the Kruskal-Wallis test, the pairwise comparisons were carried out using Mann-Whitney U test under the type one error rate adjusted by Bonferroni correction.

Ⅲ. RESULTS

As shown in Table. 1, total 21 patients (9 males, 12 females, average age of 66.6 years) were evaluated in this study, along with one patient with two IARPDs in the upper and lower arches; the total number of IARPD was 22 (12: for clasp retained abutment, 10: for overdenture abutment). Total implants' number in this study was 58 and of these, 41 were clasp retained implant abutments, while 17 were overdenture implant abutments. The follow-up period of IARPDs was average 47.9 months (minimum 12 months, maximum 185 months) and its distribution is shown Fig. 2.

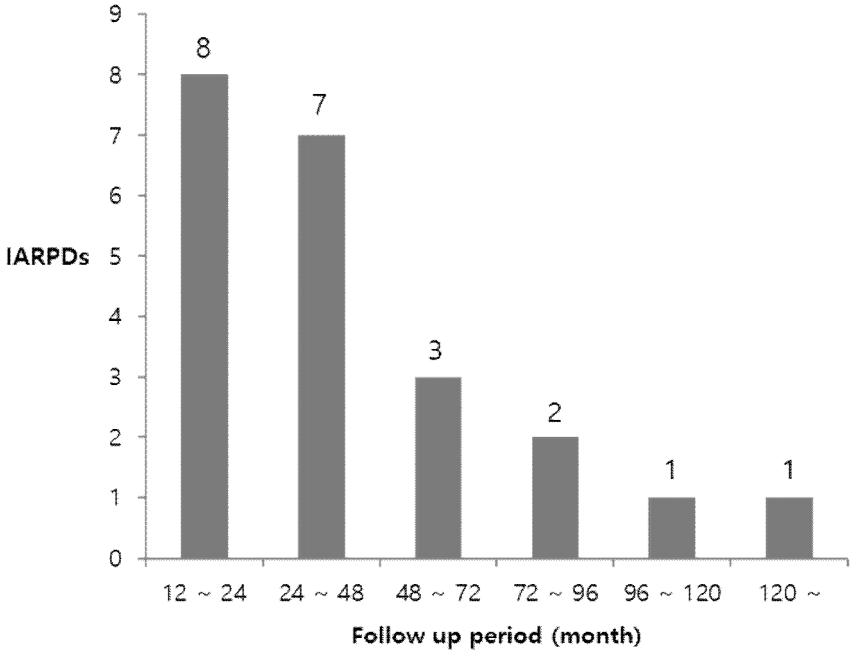

Figure 2. The follow-up period distribution of IARPDs (Total 22 IARPDs)

Implant survival rate

Of the 58 implants, four implants failed, the details of which were given in table 2. The total survival rate was 93.1%. Survival rates categorized by conditions are shown in Table 3. If the p-value was less than or equal to 0.05, the null hypothesis that there is no difference between the groups was rejected.

Table 2. The information of four failed implants

	Failed implants			
	A	B	C	D
Patients Age* / Gender	45 / Female	91 / Male	54 / Female	60 / Female
Treatment modality	Clasp retained abutment		Overdenture abutment	
Retention type	Embrasure clasp	Embrasure clasp	Hader bar	Hader bar
Location of implant placed	#37	#37	#14	#22
Diameter / length of implant (mm)	3.3 / 18	6.0 / 11.5	4.0 / 11.5	4.0 / 11.5
Connection type	External	External	External	External
Survival periods (months)	134	22	17	85
Opposing dentition	Natural tooth	Implant FPD	Natural tooth	Natural tooth

*The age of patient when the implant was removed

Table 3. Implant survival rates in total IARPDs (n=58)

Condition		No. of implants	Failed implants	Survival rate (%)	p-value
Treatment modalities	Clasp retained abutment	41	2	95.1	0.415
	Overdenture abutment	17	2	88.2	
Restored Arch	Maxilla	28	2	92.9	0.761
	Mandible	30	2	93.3	
Kennedy class	I	21	2	90.5	0.184
	II	19	1	94.7	
	III	8	1	87.5	
	IV	10	0	100	
Type of Opposing teeth	Natural teeth or FPD	44	4	90.9	0.402
	RPD or CD	14	0	100	

p-values were obtained from log rank (Mantel-Cox) test.

When the survival rate is categorized by two treatment modalities, two clasp retained implant abutments failed, while the other were two overdenture implant abutments. The survival rates were 95.1% and 88.2% respectively. The difference in survival rate was not significant. Kaplan–Meier survival curve depending on the treatment modality is illustrated in Fig. 3.

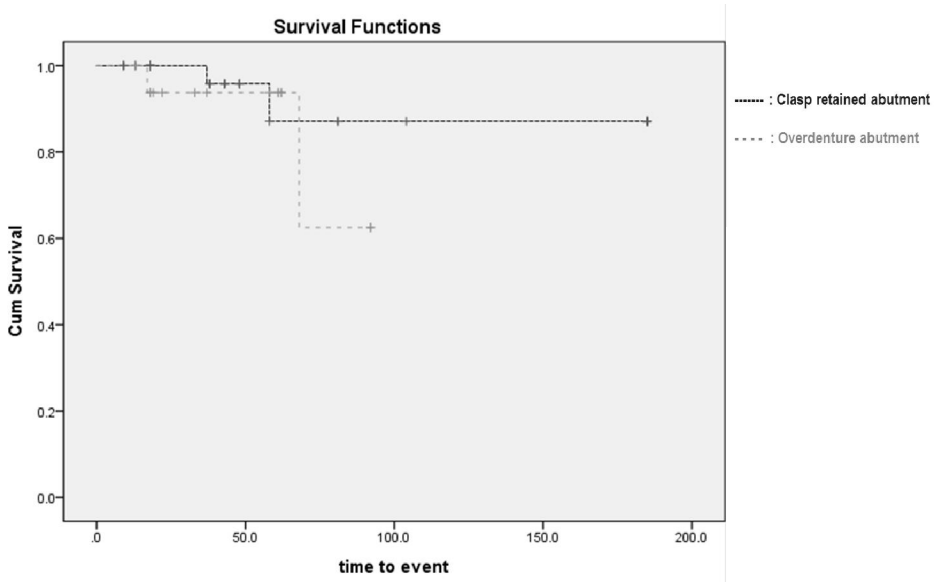

Figure 3. Kaplan-Meier survival curves depending on treatment modality

Two implants failed in maxilla and mandible each, resulting in 92.9%, 93.3 survival rates for maxilla and mandible respectively. There was no significant difference of the survival rates between maxilla and mandible.

According to the implants' Kennedy classifications, Classes I, II, III and IV showed 90.5%, 94.7%, 87.5%, and 100% survival rates respectively. There was no significant difference regarding Kennedy classifications.

There were 44 implant abutments with opposing natural teeth or fixed prostheses, and of these, four implants failed to result in 90.9% survival rate. When the opposing teeth were RPD or complete denture (CD), there was no implant failure out of 14 implants, which resulted in a 100% survival rate. However, there was no significant difference regarding opposing dentitions.

Out of the implants used in the entire IARPDs, only the 41 clasp retained implant abutments were ramified to show results for Table 4. The other 17 overdenture implant abutments were shown in Table 5.

Table 4. Survival rates of the implants for clasp retained abutment (n=41)

Condition		No. of implants	Failed implants	Survival rate (%)	p-value
Implant diameter	Narrow	9	1	88.9	0.027[1)]
	Regular	24	0	100	
	Wide	8	1	87.5	
Location of implant placed	Anterior	13	0	100	0.058
	Posterior	28	2	92.9	
Restored Arch	Maxilla	22	0	100	0.761
	Mandible	19	2	89.5	
Splinting	Splinting	38	2	94.7	0.576
	Non-splinting	3	0	100	
Kennedy class	I	10	0	100	0.057
	II	18	1	94.4	
	III	3	1	66.7	
	IV	10	0	100	
Implant connection type	Internal	15	0	100	0.451
	External	26	2	92.3	

p-values were obtained from log rank (Mantel-Cox) test.

[1)] Significant difference according to Implant diameter: Regular > Narrow, Regular > Wide

With regard to the implants' diameter, one, none, and one failed for each narrow (*<3.75mm*), regular (*≥ 3.75mm, < 5.0mm)*, and wide (*≥ 5.0mm)* diameter implants with 88.9%, 100%, and 87.5% survival rate respectively. The significant difference ($p = 0.027$) of the survival rate was observed when regular diameter implants were used compared to when narrow or wide diameter implants were used.

According to the implant location, the survival rates of the anterior and posterior implants were 100%, 92.9% respectively. The survival rates of the maxillary and mandibular implants were 100%, 89.5%. There was no significant difference in the survival rate regarding the implant location.

With regard to the implant splinting, 38 implant prostheses were splinted, two of them were failed (survival rate 94.7%). Three non-splinted implants were all survived (survival rate 100%). No significant difference of survival rates was found.

According to the Kennedy classifications, the survival rates were 100%, 94.4%, 66.7%, 100% for each classes I, II, III, and IV respectively. No significant difference of survival rates was found.

When categorized by the implant connection type, the survival rates of the implants were 100% (internal connection) and 92.3% (External connection). No significant difference was found regarding the connection type.

The survival rates of the overdenture implant abutments were shown in Table 5.

Table 5. Survival rates of the overdenture implant abutments (n=17)

Condition		No. of implants	Failed implants	Survival rate (%)	p-value
Implant diameter	Narrow	2	0	100	0.846
	Regular	13	2	84.6	
	Wide	2	0	100	
Location of implant placed	Anterior	6	2	66.7	0.197
	Posterior	11	0	100	
Restored Arch	Maxilla	6	2	66.7	0.138
	Mandible	11	0	100	
Implant connection type	Internal	3	0	100	0.705
	External	14	2	85.7	

p-values were obtained from log rank (Mantel-Cox) test.

Among total 17 overdenture implant abutments, two implants failed from one patient, who had no specific disease. When observed according to the implants' diameter, the survival rates were 100%, 84.6%, 100% for each narrow, regular, and wide diameter respectively. No significant difference of survival rates was found.

According to the implant location, the survival rates of the anterior and posterior implants were 66.7%, 100% respectively. The survival rates of the maxillary and mandibular implants were also 66.7%, 100% respectively. No significant difference in the survival rate regarding the locations was found.

When categorized by the implant connection type, the survival rates were 100%

(internal connection), 85.7% (External connection). No significant difference in the survival rate regarding the connection type was found.

Result of periodontal index

Table 6 below shows plaque index, calculus index, mucositis index, bleeding index, probing depth, and bone loss of total 54 implants, excluding the four aforementioned failed implants.

Table 6. Periodontal parameters of total 54 implants (4 failed implants excluded)

Condition		No. of implant	Plaque index		Calculus index		Mucositis index		Bleeding index		Probing depth		Bone loss	
			pts	p-value	pts	p-value	pts	p-value	pts	p-value	mm	p-value	mm	p-value
Treatment modalities	Clasp retained abutment	39	0.38	1	0	1	0.03	.033 [1)]	0.13	.024 [2)]	2.9	.417	1.2	.790
	Overdenture abutment	15	0.47		0		0.2		0.47		3.5		1.4	
Restored Arch	Maxilla	26	0.23	.033 [3)]	0	1	0.08	.939	0.12	.116	3.1	.193	1.4	.584
	Mandible	28	0.57		0		0.07		0.32		3.0		1.2	
Kennedy class	I	19	0.32	<0.001 [4)]	0	1	0.11	.582	0.32	.371	3.1	.860	1.5	.015 [5)]
	II	18	0.17		0		0.11		0.22		3.0		1.2	
	III	7	0.43		0		0.10		0.33		3.2		0.2	
	IV	9	1.0		0		0		0.20		2.9		1.8	
Type of Opposing teeth	Natural teeth or FPD	40	0.20	<0.001 [6)]	0	1	0.10	.220	0.20	.41	3.1	.69	1.2	.22
	RPD or CD	14	1.0		0		0		0.29		2.7		1.6	

P-values were obtained from Mann-Whitney U test (for 2 groups) and Kruskal-Wallis test (for ≥3 groups).
Significance differences were found in

[1,2)] Mucositis and bleeding index : overdenture abutment > clasp retained abutment

[3)] Plaque index : mandible > maxilla

[4)] Plaque index : class IV > class I; p-value = .002 < .0125 (Mann-Whitney U test as post hoc test),
class IV > class II; p-value = .001 < .0125 (Mann-Whitney U test as post hoc test),
(0.0125 significance level under Bonferroni correction)

[5)] Bone loss : class I > class III; p-value = .004 < .0125 (Mann-Whitney U test as post hoc test)
(0.0125 significance level under Bonferroni correction)

[6)] Plaque index : opposing RPD+CD > opposing natural teeth+FPD

Any calculus around the total 54 implants was not found, thus the corresponding p-values were all equal to one.

Depending on the treatment modalities, overdenture implant abutments had higher scores for mucositis and bleeding index compared to clasp retained implant abutments.

According to the arch of implant placement, plaque index for the mandibular implants was higher than that in the maxilla.

When categorized by the Kennedy classification, the plaque index for the class IV implants was higher than those of class I and class II, while bone loss of the class I implants was greater than those in class III.

Regarding the type of opposing teeth, implants opposing RPD or CD had higher plaque index score than natural teeth or FPD as opposing dentition.

Upon closer inspection for bone loss, the average bone loss of the total 54 implants was 1.3 ± 1.6mm; the distribution of bone loss is shown in the figure 4 below. The 70% of the total implants were below 1.5mm bone loss.

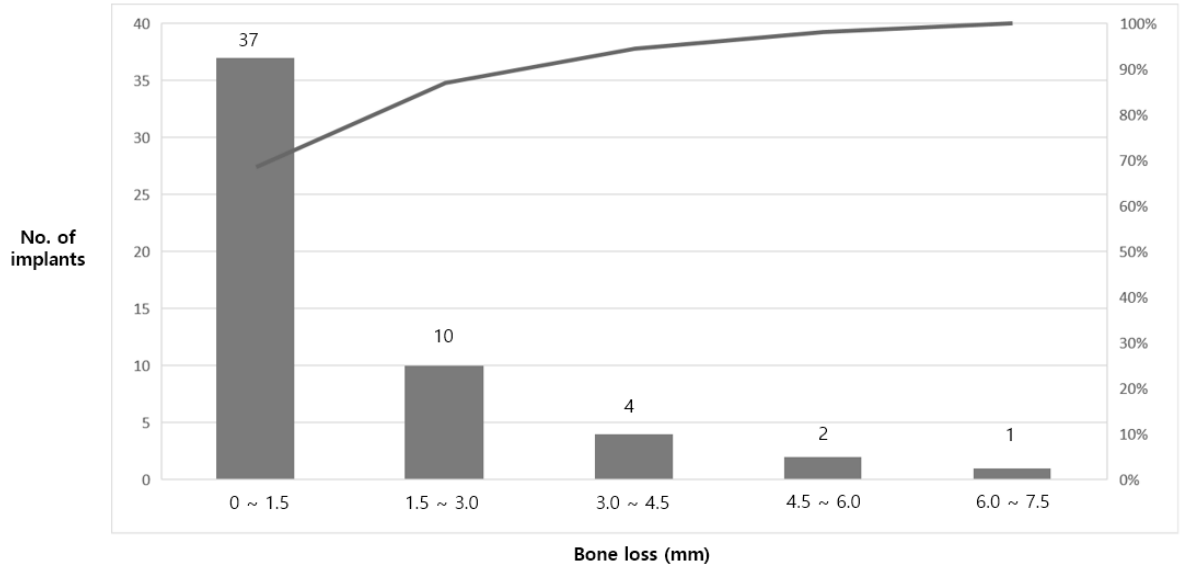

Figure 4. The distribution of Bone loss

Detailed periodontal measurements of 39 clasp retained implant abutments, excluding the two failed implants, are given in Table 7.

Table 7. Periodontal parameters (39 clasp retained implant abutments)

Condition		No. of implant	Plaque index		Calculus index		Mucositis index		Bleeding index		Probing depth		Bone loss	
			pts	p-value	pts	p-value	pts	p-value	pts	p-value	mm	p-value	mm	p-value
Location of implant placed	Anterior	13	0.23	.26	0	1	0.08	.71	.23	.45	3.2	.49	1.3	.67
	Posterior	26	0.46		0		0		0.08		2.7		1.5	
Restored Arch	Maxilla	22	0.27	.18	0	1	0	.77	0.05	.32	3.1	.14	1.4	.55
	Mandible	17	0.53		0		0.06		0.24		2.6		1.2	
Splinting	Splinting	36	0.42	.38	0	1	0.03	.94	0.08	.10	2.9	.90	1.3	1.0
	Non-splinting	3	0		0		0		0.67		2.8		1.0	
Kennedy class	I	10	0.20	.001 [1)]	0	1	0	.73	0.10	.84	3.0	.23	1.3	.40
	II	17	0.18		0		0.06		0.12		2.9		1.2	
	III	2	0		0		0		0		2.0		0.6	
	IV	10	1.0		0		0		0.20		2.7		1.8	
Implant connection type	Internal	15	0.47	.50	0	1	0	.83	0.13	.97	2.5	.18	1.0	.37
	External	24	0.33		0		0.04		0.13		3.1		1.4	
Implant diameter	Narrow	8	0.05	.32	0	1	0	.73	0	.48	2.7	.19	1.5	.29
	Regular	24	0.29		0		0.04		0.17		3.1		1.3	
	Wide	7	0.57		0		0		0.14		2.3		0.7	

p-values were obtained from Mann-Whitney U test (for 2 groups) and Kruskal-Wallis test (for ≥3 groups).

[1)] Significant difference found in Plaque index: class IV > class II; p-value = .001 < .0125 (Mann-Whitney U test as post hoc test, 0.0125 significance level under Bonferroni correction)

According to the Kennedy classification, the plaque index of the class IV implants was significantly higher compared to class II. Though the plaque indices in class I and III were also lower than class IV, statistical difference was not found.

Except for plaque index of the implants, calculus index, mucositis index, bleeding index, probing depth, and bone loss of the implants were difficult to discriminate between the conditions.

A detailed description of 15 overdenture implant abutments, excluding the two failed implants, is shown in this Table 8.

Table 8. Periodontal parameters (15 overdenture implant abutments)

Condition		No. of implant	Plaque index		Calculus index		Mucositis index		Bleeding index		Probing depth		Bone loss	
			pts	p-value	pts	p-value	pts	p-value	pts	p-value	mm	p-value	mm	p-value
Location of implant placed	Anterior	4	0	.23	0	1.0	.5	.28	.5	.85	2.5	.23	2.3	.28
	Posterior	11	0.64		0		0.09		0.45		3.8		1.2	
Restored Arch	Maxilla	4	0	.23	0	1.0	.5	.28	.5	.85	3.5	.66	2.0	.95
	Mandible	11	0.64		0		0.09		0.45		3.5		1.3	
Implant connection type	Internal	3	0	.30	0	1.0	0	.54	0	.23	1.8	.07	0.5	.54
	External	12	0.58		0		0.25		0.58		3.9		1.7	
Implant diameter	Narrow	2	0	.59	0	1.0	0	.53	0	.20	1.5	.11	0.5	.18
	Regular	11	0.55		0		0.27		0.64		3.7		1.9	
	Wide	2	0.50		0		0		0		4.0		0	

p-values were obtained from Mann-Whitney U test (for 2 groups) and Kruskal-Wallis test (for ≥3 groups).

Though plaque indices in posterior region, mandible, or external connection type were higher than the other conditions, the differences were not significant. Regarding the mucositis indices of the implants, higher scores were found in anterior area, maxilla, external connection type, or regular diameter implants, but the significant differences were also not found either.

Likewise, bleeding index were higher for the external connection or regular diameter implants. Probing depth were higher in posterior area, external type, or wide diameter implants. Bone loss were higher in anterior region, maxilla, external type, or regular diameter implants. However, all these parameters had no significant difference between the conditions.

IARPD related complications

The complications of IARPDs have been investigated: In case of the clasp retained abutment, the complications' incidences and remarks are shown in table 9.

Table 9. Complications in IARPDs using clasp retained abutment

Complication	Incidences / patients	Remarks
Dislodgement of surveyed implant crown	4 / 2	Temporary cement loss
Loss of osseointegration	2 / 2	Implant removal
Loss of opposing tooth	2 / 1	One natural tooth fracture One implant removal
Fracture of screw	2 / 1	External, single implant, Wrought wire clasp retained
Screw loosening	1 / 1	Anterior region
Clasp loosening	1 / 1	Embrasure clasp
Porcelain veneer fracture	1 / 1	Anterior region
Marginal bone resorption	1 / 1	2 thread exposed
Fracture of RPD artificial tooth	1 / 1	Anterior region
Fracture of RPD rest	1 / 1	Akers clasp

The most common complication was dislodgement of surveyed implant crown due to washout of temporary cement.

In case of overdenture abutment, loss of retention of attachment was the most frequent complication. Their incidences and remarks are shown in table 10. All the complications were resolved by repairing or changing the components.

Table 10. Complications in IARPDs using overdenture abutment

Complication	Incidences / patients	Remarks
Need of changing attachments	6 / 4	Attachment change and/or denture relining
Loss of natural tooth abutment of IARPD	3 / 3	Crown fracture and extraction, RPD repair
Loss of natural tooth	2 / 2	Fistula, abscess
Need of restoration on tooth	3 / 3	Caries, chipping
Fracture of IARPD framework	2 / 2	Re-fabrication
Clasp loosening	1 / 1	Clasp tightening
Marginal bone resorption	1 / 1	Relining
Loss of osseointegration	2 / 1	Maxilla, anterior region, bar-type attachment
Loss of opposing tooth	2 / 2	Extraction, denture repair
Fracture of opposing denture	2 / 2	Repair, re-fab

The complications in the both treatment modalities were divided into aforementioned five categories and shown in table 11.

Table 11. Comparison of complications in IARPDs (clasp retained abutment vs. overdenture abutment)

	Clasp retained abutment (12 IARPDs)			Overdenture abutment (10 IARPDs)		
	Complications	Incidences	Sum (proportion)	Complications	Incidences	Sum (Proportion)
Denture	Clasp loosening	1	3 (18.8%)	Clasp loosening	1	9 (37.5%)
	Fracture of RPD artificial tooth	1		Need of changing attachments	6	
	Fracture of RPD rest	1		Fracture of RPD framework	2	
Implant	Fracture of screw	2	3 (18.8%)			0 (0%)
	Screw loosening	1				
Crown	Dislodgement of surveyed implant crown	4	5 (31.2%)			0 (0%)
	Porcelain veneer fracture	1				
Tissue	Loss of osseointegration	2	3 (18.8%)	Loss of osseointegration	2	11 (45.8%)
	Marginal bone resorption	1		Loss of natural tooth abutment of IARPD	3	
				Loss of natural tooth	2	
				Need of restoration on tooth	3	
				Marginal bone resorption	1	
Others	Loss of opposing tooth	2	2 (12.4%)	Loss of opposing tooth	2	4 (16.7%)
				Fracture of opposing denture	2	
Total		16	16 (100%)		24	24 (100%)

Total incidences of overdenture IARPD were more than 1.8 folds relative to the clasp retained IARPD. In clasp retained IARPD, 31.2% of the complications were related to crowns. In overdenture IARPD, 45.8% were related to tissue, and 37.5% to denture. Mechanical complications related to implant were not involved in overdenture IARPD. Contrarily, problems of remaining natural tooth or abutment arose more in overdenture IARPD.

Ⅳ. DISCUSSION

There are many considerations for IARPD treatment; treatment modality, location of placement, diameter and connection type of implant, and other factors such as Kennedy classification, type of opposing teeth, etc.

As previously mentioned, it is unfortunate that sufficient evidences and theories of IARPD were not complied. The present study examined the survival rate and periodontal parameters of the implants used in IARPD from clinical and radiographic approach, and also observed the influential factors.

Survival rates of the clasp retained and overdenture implant abutments were 95.1% and 88.2% respectively, both of which were outstanding figures. Either modality did not show significant difference in survival rate compared to the other. This was explained by many factors having mixed effects on the survival rate or the limitation in sample size to observe significant differences.

In the comparisons among the clasp retained implant abutment, the survival rates of the implants were significantly different according to the implant's diameter; the significance was observed when regular diameter implants (100%) were used compared to when narrow (88.9%) or wide (87.5%) diameter implants were used.

Prosthodontists contemplating IARPD mostly have difficulty in placing implants due to inadequate residual alveolar bone. If the regular diameter implants were to be placed, the bone width must have been not inadequate for surgery. Verri[33] et al., using the finite element analysis, stated that even if the diameter of the implant increase, it will not influence the implant displacement when vertical height is administered. It means an additional advantage can't be attained from wider diameter. Considering this aspect, implants with appropriate size - not necessarily above 5.0mm but at least over 3.75mm - would promise a sufficient survival.

Some reports indicate a higher failure rate of wide diameter implants than that of regular diameter. Ivanoff et al.[34] stated that the higher failure rate of wide diameter implants may be caused as it is used as a rescue implant when the standard

diameter did not reach stability or failed. Handelsman et al.[35] stated that a wide bodied implant may be closer than 1.5 mm to the adjacent tooth or bone. As a result, the bone loss around the platform from an "implant biologic width," may also accelerate bone loss on the adjacent tooth or facial bone loss and gingival recession. Anner[36] stated that stress and bone implant contact influence the stability and survival of implants. A biological impediment for the use of wide diameter implants can lower blood supply because of minimum existing cancellous bone. Grossmann[11] presented the clinical guideline for ISRPD and stated 'use short or narrow body implants if necessary'. If 88.9% survival rate of narrow diameter implant obtained from this study are considered, usage of narrow implants can be thought suitable for IARPD.

Details of the four failed implants is shown in table 2. The two failed implants A and B, both on the location of lower left second molar (#37), all previously functioned as fixed prosthesis but were no longer available for fixed prosthesis after other tooth or implant were removed. They were then used as abutment for IARPD and retained by the embrasure clasp.

Of these, implant A was installed after iliac bone graft but later removed 37 months after IARPD delivery. However, considering the period it served as fixed prosthesis, it functioned for a total of 171 months.

The other implant B was functioned for 22 months after IARPD delivery, but accounting for 58 months as a fixed prosthesis, it functioned for a total of 80 months. Considering the period of functioning as fixed prosthesis, both implants were thought to have sufficient period before removed. There may have been periodontal problems regarding these implants since both implants were second molars on the lower arch; these being the most posterior region where hygiene maintenance was most difficult.

While the two implant C and D were for overdenture abutment and installed in a single patient. With only one remaining tooth in maxilla, four implants were placed

in the anterior of the upper arch, and a hader bar was fabricated to use them for support. The two implants C and D each went under removal 17 and 85 months later respectively. Opposing dentition were natural teeth, while the artificial tooth of IARPD was fractured twice before implant failure. Wear of hader clips was also observed two times. The reason may be due to parafunctional activity or imbalanced occlusion. After the two implants were removed, the patient has been so far using the remaining two implants and IARPD supported by healing abutment without problem (follow-up period of 92 months).

The mucositis and bleeding indices of the implants were higher for overdenture abutment than clasp retained abutment. This may be due to poor hygiene maintenance as the implant was covered by IARPD. Thus, it is necessary to educate patients of the importance of hygiene care when delivering IARPD.

The reasons for higher plaque index in mandible can be considered in the similar vein as of those mentioned above, in that there was higher chance for the accumulation of food residue in the lower arch. When fabricating dentures, the flange area of denture in the lower arch must be made with precision and must be examined for the need of relining periodically. Instruction is necessary for periodic cleansing of the dentures. Difference in plaque index was found depending on the type of the opposing dentition, and this generally are associated with the level of oral hygiene the patient had kept throughout his or her life.[37]

As for bone loss in this study, the average bone loss was 1.3±1.6mm for the entire 54 implants. Mitrani et al.[18] evaluated bone loss of the overdenture implant abutments in distal extension RPD during the average of 2.5 years. It was reported that when used only as the vertical stop, posterior implant's bone resorption was mesially 0.32±0.47mm and distally 0.44±0.45mm. While when retentive element such as hader bar or ERA attachments was used, the resorption was mesially 0.93±0.64mm and distally 0.88±0.34 mm. Compared to Mitrani's study, the bone loss in our study was 1.4 folds larger.

Significant difference of bone loss was observed between Kennedy class I (1.5mm±1.2 mm) and class III (0.2mm±0.4mm). Its cause may be due to the existence of the most posterior molars, which prevent the rotational movement of the dentures. Class I RPD have a larger rotation than class III RPD[38, 39]. These distinctive characteristic between class I bilateral distal extension RPD and class III tooth supported RPD may effect on the bone loss of the implants.[40] Based on such evidence, it can be assumed that Kennedy class III RPD has smaller denture rotating movements and distributes the masticatory load to the most posterior molars, which serves to be more favorable to the prognosis of the implant compared to bilateral distal extension RPD of Kennedy class I. However, Jacobs et al.[41] reported that the when masticatory functions enhance and the overdenture rotates further tissue-ward, the load on the posterior alveolar bone increases, resulting in the increase of alveolar bone loss. This underlies how we must put effort in the designing to lessen the rotation of dentures as much as possible and also in functional enhancements to decrease the burden on the implants and gain support from the underlying tissue.

Plotnick et al.[42] and Fisher[43] evaluated the effect, various types of opposing dentition have on the mobility of the natural teeth in the lower arch in patients with RPD due to partial edentulism. Compared to having natural teeth as opposing dentition, cases with opposing denture made the stability of lower RPD poor. According to the results of this study (Table 6), when opposing dentition was removable denture, bone loss was more severe (1.6mm>1.2mm) though the difference was not statistically significant. However, the implant survival rate was higher for removable denture as opposing dentition than that of fixed dentition group (100%>90.9%). It is likely that the survival rate and bone loss were complexly effected by fixed dentition, which comparatively has stronger biting force[44] and non-mobility. With regards to the opposing dentition, survival rate and bone loss may have been influenced not only by the stability of opposing denture

but also by the biting force.

There were different opinions from various scholars regarding the location of implant for IARPD. Grossmann[11] stated that the implant should be installed in the region where the strongest force is received thus supporting IARPD as much as possible, while Cunha et al.[45], using finite element analysis, presented results that there was least amount of denture displacement when the implant was placed in the first molar region, while there was least stress when the implant was placed in the second premolar region. In the present study, there was no significant difference in survival rate and bone loss wherever the implant was installed in the anterior, posterior, upper, or lower region. It seems that implant location must be considered peculiarly depending on each patient's circumstance. A multidimensional perspective is required to consider for numerous clinical variables, including the possibility of changing to fixed prosthesis in the future, the state and durability of keratinization of gingiva, and the location that minimizes the denture's rotational movement.

As for the mechanical complications, specific complication does not frequently emerge and complications observed in either implant prosthesis or RPD can also be found in IARPD. Goodacre et al. [46] looked into the incidence rates of implant prosthesis complications. Complications in IARPDs show a similar feature with implant complications in Goodacre's study. It cannot be said that its frequency is higher compared to when only implant prosthesis exists.[47,48] Dislodgements of crown were most commonly observed for clasp retained abutment. The cement loss of crown are unavoidable in temporary cement retained prosthesis; it is thought to occur frequently when the crown's cementation weakens during the repeated removal process of IARPD. Attachment changes were most frequently observed for overdenture abutment and occurred four times especially in the IARPD using locator attachment; periodic replacement is inevitable due to its intrinsic wear.[49] Its replacement/repair is a relatively simple process. Thus it is

difficult to regard this as a critical complication.

However, refabrication due to component fracture of IARPD must be further investigated for its cause. two refabrications of IARPD were observed; fracture occurred after 36 months of usage for the first case. The reason behind the fracture was concentration of occlusion in the implant's location. IARPD had been used with the placement of implant at lower left second premolar to sustain the crossed occlusion, which opposed the upper remaining teeth. All biting force concentrated in the location of the implant placed and made the IARPD framework broken. What is important is that the crown fracture of upper left second premolar, upper left first molar, and the subsequent fracture of the upper RPD had also occurred before the fracture in the lower IARPD. A 5mm bone loss of the implant was also observed. In another case, the reason for the refabrication was not due to the facture but due to the refabrication of the opposing denture, making the lower IARPD to go under refabrication after 66 months of use. Both cases commonly showed crown fracture ahead in the opposing dentition where implants opposed to and the occlusal force was concentrated

Precise comparisons of the survival rate, periodontal parameter, and complication occurrence were impossible because of individuals' difference in oral status, bite force, follow-up period, and practitioner who made IARPD. With the limitation of the study being retrospective with limited number of patients involved, the study may result in weakness in confirming statistical significance. However, future prospective research plans with larger number of patients and longer observation lengths will allow for more meaningful results to be drawn.

RPD and implant seem to be incompatible and impossible to coincide, because of RPD's rotational motion and the implants' vulnerability to the lateral forces. However, both can cooperate if plans for treatment are meticulously laid and essential considerations are taken in to account. Implant assisted removable partial denture can be considered as an adequate treatment modality.

Ⅴ. CONCLUSIONS

Total 58 implants in 22 IARPDs were included in the analyses. Within the limitation of current retrospective clinical study, the following results were obtained.

Total average survival rate of the implants used in IARPDs was 93.1%; of these, the survival rate of clasp retained implant abutments was 95.1%, while that of overdenture implant abutments was 88.2%.

Among clasp retained implant abutments, the significant difference of the survival rate was observed when regular diameter implants (100%) were used compared to when narrow (88.9%) or wide (87.5%) diameter.

Higher mucositis and bleeding indices of the overdenture implant abutments compared to the clasp retained implant abutments were found.

Plaque index of the mandibular implants was higher compared to maxilla, and plaque index of Kennedy class IV implants was also higher compared to Kennedy class I or II. Plaque index of the implants opposing removable denture was also higher than opposing natural teeth or FPD.

Bone loss of the Kennedy class I implants was greater compared to Kennedy class III.

In IARPDs, most common complications were dislodgements of implant crown and changes of the worn attachment.

Most implants used in IARPDs were functioned successfully throughout the follow-up periods. However, further clinical studies are necessary because the clinical evidences are still not enough to guarantee the satisfactory prognosis of IARPD for long term result.

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-국문초록-

임플란트 융합 국소의치에 적용된 임플란트의 생존율과 임상적 평가: 클래스프 유지와 피개의치 지대치

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강 수 현

목 적 : 본 연구의 목적은 임플란트 융합 국소의치에 적용된 임플란트의 생존율과 치주 지수를 조사하고자 하였다. 또한 생존율과 치주지수에 영향을 미치는 요인들을 분석하고자 하였다. 추가로 임플란트 융합 국소의치와 관련한 합병증들을 임상적으로 조사하였다.

재료 및 방법 : 임플란트 융합 국소의치 치료를 받은 21 명의 환자 (남자 9 명, 여자 12 명, 평균 나이 66.6 세) 대상으로 후향적 임상연구를 시행하였다. 임플란트 융합 국소의치에 적용된 총 58 개 임플란트는 두 가지 치료방법으로 적용이 되었다. 41 개의 임플란트는 클래스프 유지 지대치로 사용되었고, 17 개 임플란트는 피개의치 지대치로서 사용되었다. 총 58 개의 임플란트의 생존율과 치주지수 (치태 지수, 치석 지수, 점막염 지수, 출혈 지수, 치주낭 깊이, 변연 골 소실)를 임상적, 방사선학적으로 확인하였다. 이 임플란트들은 치료 방법, 임플란트의 위치, 케네디 분류, 대합 치열의 종류, 임플란트 연결 방식, 임플란트의 직경에 따라 통계적으로 분석하였다. 마지막으로 임플란트 융합 국소의치와 관련한 합병증을 조사하여 정리하였다.

결 과 : 58 개의 임플란트의 추시 기간은 평균 47.9 개월 (최소 12 개월, 최대 185 개월)이었다. 총 58 개의 임플란트 생존율은 93.1 % 였다. 이중 41 개의 클래스프 유지 임플란트 지대치 생존율은 95.1%, 17 개 피개의치 임플란트 지대치 생존율은 88.2% 였다. 클래스프 유지 임플란트 지대치 중에서는 작은 직경 (생존율 88.9%) 또는 큰 직경 (생존율 87.5%) 임플란트를 사용한 것과 비교해 보통 직경의 임플란트가 사용되었을 때 (생존율 100%) 생존율의 유의한 차이를 확인했다.

치주 지수를 살펴보면 피개의치 임플란트 지대치의 점막염 지수, 출혈 지수가 클래스프 유지 임플란트 지대치보다 높게 나타났다 ($p<.05$). 치태지수는 상악 임플란트에 비해 하악 임플란트에서 높게 나타났다 ($p<.05$). 케네디 분류 4 급 임플란트의 치태지수가 케네디 분류 1 급과 2 급의 임플란트보다 더 높게 나타났다 ($p<.05$). 또 대합치로 자연치 또는 고정성 보철물인 임플란트 보다 가철성 의치 (총의치 또는 국소의치) 대합 임플란트가 치태지수가 더 높게 나타났다 ($p<.05$). 변연 골 소실은 케네디 분류 3 급 임플란트 보다 케네디 분류 1 급에서 더 크게 나타났다 ($p<.05$). 가장 흔하게 나타난 합병증은 접착 실패로 인한 클래스프 유지 금관의 탈락이었으며, 피개의치 지대치에서는 부착 장치의 마모로 인한 교체가 가장 많이 발생하였다.

결 론 : 임플란트 융합 국소의치에 적용된 임플란트의 생존율 93.1% 였다. (클래스프 유지 임플란트 : 95.1%, 피개의치 임플란트 : 88.2%). 임플란트 융합 국소의치와 그 임플란트들은 총 추시 기간동안 심각한 합병증 없이 기능하였다.

주요어 : 치과용 임플란트, 가철성 국소의치, 임플란트 융합 국소의치, 클래스프 유지 임플란트 지대치, 피개의치 지대치

학 번 : 2014-31299

감사의 글

박사과정을 무사히 마치고 이 논문을 시작하여 마무리하기까지 많은 도움을 주신 여러 스승님과 동료, 가족에게 감사의 말씀을 전합니다.

치과보철과 수련 및 대학원 생활에 있어 따뜻한 충고와 조언으로 진료와 연구에 귀중한 가르침을 주신 김성균 교수님께 깊은 감사를 드립니다. 병원 진료와 업무로 바쁘신 와중에도 본 논문을 위하여 많은 지도 편달을 해주셨습니다.

국소의치학이라는 학문의 깊이와 열정을 일깨워주시고, 이번 논문 심사에도 열과 성을 다해주신 허성주 교수님과 곽재영 교수님께도 깊은 감사를 드립니다.

바쁘신 와중에도 본 논문 심사를 위해서 꼼꼼히 살펴주신 구강내과학교실의 정진우 교수님과 경희대학교 치과대학 치과보철과 권긍록 교수님께도 감사드립니다.

항상 격려와 조언을 아끼지 않으신 치과보철학교실의 이재봉 명예교수님, 한중석 교수님, 임영준 교수님, 김성훈 교수님, 김명주 교수님, 권호범 교수님, 여인성 교수님과 치과보철학교실원 여러분께 이 자리를 빌어 감사의 말씀을 전합니다.

치과보철과 수련기간부터 지금까지 항상 동고동락하며 서로를 격려해 준 이학주, 박선아, 정기원, 이경중 선생과 의국 선후배님들에게도 감사의 말씀을 전합니다.

오늘의 제가 있기까지 많은 사랑과 정성으로 보살펴주시고 지원해주신 부모님께 깊은 감사를 드리며, 제가 하는 모든 일을 응원 해주시는 장인, 장모님께도 깊은 감사를 드립니다.

마지막으로, 치과대학과 수련 생활을 지금까지 묵묵히 함께해 준 영원한 친구이자 인생의 반려자인 사랑하는 아내와 제 인생에 있어 크나큰 선물인 두 딸 이현이와 이진이에게 고마움을 전합니다.

2016년 12월

강 수 현