博 士 論 文

Comparison of prognosis of the remaining teeth between implant-supported fixed prostheses and removable partial dentures in partially edentulous patients: A retrospective study

（部分歯列欠損患者におけるインプラント支持固定性補綴装置と可撤性部分床義歯の残存歯の予後の比較）

令和３年３月申請

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1. Introduction

The purpose of treatment for partially edentulous spaces is restoration of oral function, aesthetics and phonetics, protection of remaining tissues, and prevention of disease which is caused by loss of teeth ［1］. Prosthetic treatment methods to achieve these objectives include fixed partial dentures (FPDs), removable partial denture (RPDs), implant supported fixed prostheses (ISFPs) and implant supported removable partial dentures (ISRPD). In particular, RPDs and ISFPs are frequently used in cases where multiple teeth are missing.

RPD can be applied to various partial edentulism, and its application range is wide. It also requires minimal invasion to the abutment teeth. On the other hand, discomfort is strong due to its components such as retainers, major connectors, and bases. In addition, the aesthetics is inferior due to its components. Furthermore, it was reported that abutment teeth of RPD had a high risk of teeth loss. It is well known that the survival rates of abutment teeth of RPD were lower due to the mechanical and hygienic factors. Because the occlusal load on the edentulous space was distributed to the abutment retainer, the miner connecter and retainer worsen oral hygiene around the abutment tooth. ［2-4］.

The ISFP would give some surgical invasion to the patient but less invasive for adjacent teeth to dental implant. In addition, it is reported that the patients with ISFP were highly satisfied with the masticatory function and aesthetics, and had high oral-related quality of life (QoL)［5-10］.

Previous study reported that the 5-year survival rate of the direct abutment teeth with RPD was 86.6%

［11］. Aquilino et. al showed that survival rate of adjacent teeth with one tooth loss with FPD or RPD was 97% and 77% in 5 years and 92% and 56% in 10 years respectively［12］. Also, it was reported that survival rates of adjacent teeth of ISFP for one tooth loss have 100% in 5 years and 99% even in 10 years［13］. For each of ISFP and RPD, there are many reports on the prognosis of teeth adjacent to edentulous space［12,14-16］. However, there are a few reports about the prognosis of teeth adjacent to partial edentulous space and that of the other remaining teeth compared ISFP with RPD［17］.

Therefore, the aim of this retrospective study was to assess and compare prognosis of remaining teeth with ISFP or RPD in partially edentulous patients from viewpoints of survival and complication-free rates. The null hypothesis is that there is no difference on the prognosis of remaining teeth between ISFP and RPD.

2. Material and Methods

2. 1. Study population

The subjects were partially edentulous patients who inserted ISFP or RPD at the Clinic of Removable Prosthodontics in Hokkaido University Hospital from 2003 to 2016. The patients had been checked at least twice per year were selected. RPDs using with the metal framework were included. Patients who had complete dentures, resin dentures, or an observation period of less than one year were excluded.

2. 2. Study design

We obtained the patient's age, gender, the number of remaining teeth, Eichner classification, the type of prostheses, and the states of remaining teeth at date of prostheses insertion from clinical data.

The investigated teeth were those adjacent to edentulous spaces (A-teeth), those except for teeth adjacent to edentulous spaces (R-teeth), and those opposing to edentulous space (O-teeth). Each tooth was also assessed in terms of the type of tooth, endodontic therapy performed, type of prostheses, type of tooth restorations, splinting of teeth and presence of opposing teeth. The restorations were subdivided into crowns, partial restorations, and without restoration.

The date of prostheses insertion was defined as the start of observation period. Follow-up was checked to see until any technical or biological complications had occurred. The endpoint for survival was defined as tooth extraction. The endpoint for complications was defined as loss of cementation or fracture of crown restoration, fracture of teeth, caries, periapical disease, and periodontal disease. The

periodontal disease as endpoints was defined as tooth mobility or alveolar bone loss that lead to extraction or replacement to root coping.

If no complication was found, the end of the observation period was defined as the date of the last visit to the hospital before December 2017.

2. 3. Statistical analysis

Kaplan–Meier analysis was used to evaluate survival rates and complication-free rates for three types teeth respectively. The log-rank test was used to compare the survival curves between the ISFP group and RPD group. A multivariate stepwise Cox regression model was used to estimate the risk factors on the survival and complications of the investigated teeth.

Statistical analyses were performed using JMP 14.0 (SAS Institute Inc., Cary, NC, USA) with a significance level of 0.05.

The protocol of this study was approved by the Ethics Committee of Hokkaido University Hospital (017-0213).

3. Result

3. 1 Study population

From the 366 patients who inserted ISFP or RPD at the Clinic of Removable Prosthodontics in Hokkaido University Hospital from 2003 to 2016, 177 patients were excluded based on the exclusion criteria. There was no one in C group in ISFP, and A group in RPD had only four patients on the Eichner classification. Therefore, in the statistical analysis, A and C groups in the Eichner classification were excluded. As a result, 233 patients were evaluated. ISFP were 89 patients (male: 24, female: 65). RPD were 144 patients (male: 37, female: 107). The mean observation period was 55.6±35.3 months (Table 1).

The number of the evaluated teeth in ISFP consisted of 192 A-teeth, 988 R-teeth, and 210 O-teeth. These in RPD consisted of 512 A-teeth, 1147 R-teeth, and 698 O-teeth (Table 2).

3.2. Survival rates

In ISFP, the survival rates of A-teeth were 92.8% in 5-year and 92.8% in 10-year, those of R-teeth were 98.4% and 98.1%, and those of O-teeth were 97.5% and 97.5% respectively. In RPD, the survival rates of A-teeth were 93.0% in 5-year and 89.7% in 10-year, those of R-teeth were 96.1% and 91.6%, and those of O-teeth were 96.9% and 93.9% respectively (Figs. 1-3). There was no statistically significant difference between survival curves of ISFP and those of RPD at A-teeth ($p=0.5278$) and O-teeth ($p=0.1892$). In R-teeth, statistically significant difference between those of ISFP and RPD was

found (p=0.0003). There was no significant difference in the prognosis of A-teeth, R-teeth, and O-teeth in RPD, but there was a significant difference in ISFP (p=0.0673). (Figs. 4, 5)

The most causes of extraction of A-teeth, R-teeth and O-teeth in ISFP were teeth fracture. The number of tooth extraction due to fracture in ISFP were six of the seven at A-teeth, six of the 11 at R-teeth and two of the three at O-teeth. Sixteen of the 25 A-teeth of RPD were extracted due to tooth fracture. Thirteen of the 40 R-teeth of RPD were extracted due to fracture and periapical disease respectively. Seven of the 22 O-teeth of RPD were extracted due to caries (Table 3).

3. 3. Complication-free rates

In ISFP, the complication-free rates of A-teeth were 74.2% in 5-year and 61.9% in 10-year, those of R-teeth were 84.0% and 78.9%, and those of O-teeth were 78.3% and 68.9%, respectively. In RPD, the complication-free rates of A-teeth were 74.9% in 5-year and 56.8% in 10-year, those of R-teeth were 79.7% and 65.2%, and that of O-teeth were 82.6% and 65.7% respectively. There was no statistically significant difference between ISFP and RPD in A-teeth (p=0.9082) and O-teeth (p=0.3919). In R-teeth, there was statistically significant difference (p=0.0049) (Figs. 6-8). There was a significant difference in the prognosis of A-teeth, R-teeth, and O-teeth in both ISFP (p=0.0024) and RPD (p=0.0282). (Figs. 9, 10)

Table 4 shows the distribution of complications for each tooth. In ISFP, caries were observed at 10 teeth for A-teeth and at 51 teeth for R-teeth, and at 13 teeth for O-teeth. In RPD, loss of retention was

recognized at 30 for A-teeth and caries were observed at 80 for R-teeth and at 46 for O-teeth. In both groups, caries was most frequently found, except for A-teeth in RPD. Loss of retention was most frequently observed in A-teeth of RPD.

3.4. Multivariate analysis

Since there were strong correlations between the number of remaining teeth, the number of occlusal support and Eichner classification, we selected Eichner classification, which has been reported to be one of the risk factors of tooth loss as the representative of these variables［11］.

Therefore, age, sex, Eichner classification, type of protheses, type of tooth, endodontic therapy performed, type of restorations, presence of opposing teeth, and splint of teeth were used as covariates of the survival and complication-free function in the Cox regression model.

Risk factors for teeth survival are shown in Table 5. Cox proportional hazard analysis indicated that endodontic therapy and jaw performed were significant prognostic factors in the survival of the A-teeth. In R-teeth, Eichner classification, type of protheses, endodontic performed, splint of teeth, and type of teeth were indicated as significant prognostic factors in the survival. In O-teeth, Eichner classification was indicated as significant prognostic factors in the survival. The jaw was shown to be a statistically significant difference in the complications of A teeth. Risk factors for teeth complication are shown in Table 6. Eichner classifications, opposing teeth, type of teeth, and jaw were significant prognostic factors in the complications of the R-teeth. Eichner classifications and jaw were significant

prognostic factors in the complications of the O-teeth.

4. Discussion

4-1. Study Design

In this study, we examined the survival rate and complication-free rate of remaining teeth of ISFP and RPD. Inclusion criteria were set to adjust as much as possible the factors that influence survival and complication-free rate. Subjects were limited to patients who visited at least twice a year, as it has been reported that there is a significant difference in survival rate of teeth between patients who visit regularly and those who do not [18-21]. Since the design of the denture affects the prognosis of the remaining teeth, a rigid denture using a metal framework was selected excluding the acrylic resin denture and the treatment denture [22].

4-1. Prognosis of abutment teeth

Priest et al. reported that10-year survival rate of A-teeth in ISFP was 98.7% [13]. Krenmair et al. reported that the tooth adjacent to edentulous spaces in implant more than 3 years had a 100% survival rate and a 97.2% complication-free rate [14]. Misch et al. reported a 100% survival rate and a 94.7% complication-free rate over 10 years [15]. In this study, the 10-year survival rate for A-teeth of ISFP was 92.8%, slightly lower than previous study. However, the complication-free rate for 10 years is 61.9%, which is considerably lower than in the previous reports. In all of the previous reports, the

subjects were included the teeth adjacent to edentulous spaces of a single implant, and it is considered that the number of remaining teeth is more than that of this study. With a single missing tooth, the prognosis is good because a strong occlusal force is not applied to the adjacent tooth, and it is considered that the prognosis of the remaining teeth is affected as the number of defects increases [11]. In addition, the study included multiple missing teeth, which may have caused adjacent teeth to be overloaded during the treatment period.

Vanzeveren et al. reported that abutment tooth survival rate of RPD was 90.2% [23]. Tada et al. reported abutment teeth survival rate of RPD was 86.6% in 5 years [11]. In this study, the 10-year survival rate for tooth A in RPD was 89.7%. This was similar to the results of the study by Vanzeveren et al. and higher than that of Tada et al. The RPD reported by Vanzeveren et al. was a RPD with a metal framework, but Tada et al. also included a RPD covered by Japanese medical social insurance, so it is considered that there is a difference on the rigidity of RPD.

Tada et al. reported that the direct abutment teeth of RPD have affected on continuous overload and hygiene from RPD and have a higher risk of periodontal tissue damage than non-abutment teeth［11］. The denture design in this study is considered to have high rigidity using a metal framework. Therefore, it seemed that the suitable force distributed to the abutment tooth, and the overload leading to tooth extraction was not loaded.

Yamazaki et al. reported that the difference between ISFP and RPD prostheses was not a significant

risk factor for loss of teeth adjacent to edentulous spaces [17]. The subjects of their study were selected for the edentulous space exceeding at least four continuous missing teeth. In our study, there were contained a single to multiple missing teeth, and no significant difference was observed. Therefore, it is suggested that a rigid and well-designed RPD could be expected to have an A-teeth prognosis comparable to that of ISFP.

There is little literature on the prognosis of R-teeth. Indirect abutment devices of RPD have been reported to affected hygiene and become a risk factor for the prognosis of indirect abutment teeth [11], but there are few reports of long-term progress. The effect of indirect abutment devices on R-teeth can help us predict abutment tooth survival prospects at diagnosis based on individual characteristics. In this study, the 10-year survival rate for ISFP was 98.1% and the 10-year survival rate for RPD was 91.6%, and differences in prostheses were significant differences in both survival and complication-free rates. Tada et al. reported that the indirect abutment device deteriorates hygiene and can be a risk factor for the prognosis of indirect abutment teeth. In this study, it was not possible to confirm the indirect abutment teeth, but it is thought that they were included to R-teeth because the RPD had a metal frame connector with high rigidity. As the hygiene of RPD seems to be worse than that of ISFP, a significant difference might be observed in the difference in the prosthesis. Indeed, RPD has a higher rate of periodontal disease related to tooth extraction and complications.

For O-teeth, there was no significant difference in survival rate and complication-free rate when

comparing ISFP and RPD. Yoshino et al. reported that ISFP were not a risk factor for the loss of opposing teeth [24]. ISFPs may overload opposing teeth due to lack of proprioceptive function due to the absence of periodontal ligament [25]. However, there is no difference from RPD in this study, it is considered that the effect of ISFP on the opposing teeth might be not high.

4-2. Limitation of the study

The survival rate of prosthetics has been evaluated to deteriorate rapidly 100 months after installation [26]. In this study, the observation period is longer than 10 years, which may be a significant result. However, it may be affected by missing data such as the differences of dentist skills, the periodontal condition, the type of post-core, and the type of cements [27-32]. Therefore, prospective studies or randomized clinical trials would be necessary to take these effects into account.

5.Conclusion

In the partially edentulous space, the difference between ISFP and RPD did not affect the prognosis of the tooth adjacent to edentulous spaces and the tooth opposing to edentulous space. However, it was suggested that it would affect the prognosis of the remaining tooth except for teeth adjacent to edentulous spaces.

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Figure Legends

Fig. 1. Comparison of survival rates of ISFP and RPD in A-teeth.

Fig. 2. Comparison of survival rates of ISFP and RPD in R-teeth.

Fig. 3. Comparison of survival rates of ISFP and RPD in O-teeth.

Fig. 4. Comparison of survival rates of A-teeth, R-teeth and O-teeth in RPD.

Fig. 5. Comparison of survival rates of A-teeth, R-teeth and O-teeth in ISFP.

Fig. 6. Comparison of complication-free rates of ISFP and RPD in A-teeth.

Fig. 7. Comparison of complication-free rates of ISFP and RPD in R-teeth.

Fig. 8. Comparison of complication-free rates of ISFP and RPD in O-teeth.

Fig. 9. Comparison of complication-free rates of A-teeth, R-teeth and O-teeth in ISFP.

Fig. 10. Comparison of complication-free rates of A-teeth, R-teeth and O-teeth in RPD.

Table 1 Baseline characteristics of subjects

Variables		ISFPs	RPDs	P-value
Sex	Male	24	37	0.0080*
	Female	65	107	
Age (SD) (year)		58.60(8.81)	66.94(9.01)	＜0.0001**
Eichner classification	B1	37	15	＜0.0001*
	B2	23	34	
	B3	18	47	
	B4	11	48	
Number of remaining teeth		21.04(3.60)	16.70(3.77)	＜0.0001**
Number of occlusal supports		8.06(2.68)	5.24(2.59)	＜0.0001**
Jaw	Upper	22	97	＜0.0001*
	Lower	69	49	

* ： χ 2-test

** ：t-test

Table 2 Baseline data of the teeth adjacent to partial edentulous spaces

Variables		A-teeth	R-teeth	O-teeth
prostheses	ISFP	192	988	210
	RPD	512	1147	698
Endodontic therapy	Without	193	1048	318
	With	398	797	511
Restorations	Without	36	601	88
	Partial restoration	47	324	129
	Crown	508	920	612
Presence of opposing teeth	Absence	192	1323	768
	Presence	399	522	61
Splint of teeth	Without	484	1590	670
	With	107	255	159

Table 3 Distribution of tooth extraction for each tooth

	A-teeth		**R-teeth**		**O-teeth**	
	ISFP	RPD	ISFP	RPD	ISFP	RPD
Caries	0	3 (0.7%)	1 (0.1%)	6 (0.6%)	0	7 (1.1%)
Periapical disease	0	1 (0.2%)	2 (0.2%)	13 (1.3%)	1 (0.5%)	3 (0.5%)
Periodontal disease	1 (0.6%)	3 (0.7%)	2 (0.2%)	8 (0.8%)	0	6 (0.9%)
Fracture	6 (3.6%)	16 (3.8%)	6 (0.7%)	13 (1.3%)	2 (1.0%)	5 (0.8%)
Unknown	0	2 (0.5%)	0	0	0	1 (0.2%)
Without	158	401	843	951	193	611

Table 4 Distribution of the first complications for each tooth

	A-teeth		R-teeth		O-teeth	
	ISFP	**RPD**	**ISFP**	**RPD**	**ISFP**	**RPD**
Loss of retention	6 (3.6%)	30 (7.0%)	12 (1.4%)	31 (3.1%)	5 (2.6%)	13 (2.1%)
Fracture of facing crown	0	3 (0.7%)	6 (0.7%)	4 (0.4%)	0	1 (0.2%)
Caries	10 (6.0%)	25 (5.8%)	51 (6.0%)	80 (8.1%)	13 (6.6%)	46 (7.3%)
Periapical disease	6 (3.6%)	7 (1.6%)	18 (2.1%)	29 (2.9%)	4 (2.0%)	13 (2.1%)
Periodontal disease	3 (1.8%)	6 (1.4%)	4 (0.5%)	17 (1.7%)	2 (1.0%)	7 (1.1%)
Fracture	7 (4.2%)	18 (4.2%)	6 (0.7%)	18 (1.8%)	5 (2.6%)	7 (1.1%)
Unknown	4 (2.4%)	7 (1.6%)	20 (2.3%)	15 (1.5%)	10 (5.1%)	30 (4.7%)
Without	129	330	736	797	157	516

Table 5 Risk factors for teeth survival

Variables		A-teeth			R-teeth			O-teeth		
		HR	95%CI	P-value	HR	95%CI	P-value	HR	95%CI	P-value
Age	<65	1			1.74	0.96-3.15	0.0665	1.7	0.74-3.89	0.2088
	≧65	1.32	0.63-2.80	0.4637	1			1		
Sex	Male	1			1.44	0.74-2.64	0.2716	1		
	Female	1.97	0.80-5.94	0.1459	1			1.10	0.43-3.41	0.8545
Eichner classification	B1,B2,B3	1			1			1		
	B4	1.51	0.65-3.60	0.3422	2.33	1.21-4.45	0.0120*	2.38	1.06-5.40	0.0351*
Protheses	ISFP	1.43	0.51-3.59	0.4728	1			1		
	RPD	1			2.47	1.22-5.38	0.0110*	1.98	0.63-8.78	0.2640
Endodontic therapy	With	6.71	1.59-58.3	0.0057*	4.95	1.39-25.4	0.0103*	1.14	0.38-4.69	0.8359
	Without	1			1			1		
Restorations	Without	1.12	0.05-10.1	0.9284	1			1		
	Crown	1			3.55	0.73-21.3	0.1246	6.65	0.93-134	0.0601
Opposing teeth	With	1.09	0.47-2.71	0.8528	1					
	Without	1			1.34	0.68-2.67	0.3985			
Splint of teeth	With	1.47	0.59-3.41	0.3926	1			1		
	Without	1			3.68	1.47-12.3	0.0033*	1.65	0.63-5.15	0.3246
Type of teeth	Anterior	1			1			1		
	Posterior	1.63	0.67-4.25	0.2903	2.26	1.14-4.61	0.0189*	3.6	0.96-23.6	0.0579
Jaw	Upper	3.17	1.43-7.55	0.0042*	1.13	0.63-2.04	0.6720	1		
	Lower	1			1			2.15	0.94-5.23	0.0703

Table 6 Risk factors for teeth complication

Variables		A-teeth			R-teeth			O-teeth		
		HR	95%CI	P-value	HR	95%CI	P-value	HR	95%CI	P-value
Age	<65	1			1			1.21	0.87-1.70	0.2448
	≧65	1.15	0.80-1.66	0.4372	1.08	0.84-1.39	0.5309	1		
Sex	Male	1			1.13	0.87-1.46	0.3698	1		
	Female	1.27	0.85-1.94	0.2438	1			1.12	0.77-1.65	0.5664
Eichner classification	B1,B2,B3	1			1			1		
	B4	1.53	0.99-2.35	0.0511	1.69	1.27-2.23	0.0004*	1.71	1.23-2.39	0.0018*
Protheses	ISFP	1.18	0.76-1.81	0.4601	1			1.47	0.95-2.23	0.0839
	RPD	1			1.15	0.88-1.51	0.2993	1		
Endodontic therapy	With	1			1.38	0.94-2.06	0.1010	1		
	Without	1.07	0.68-1.64	0.7596	1			1.28	0.82-1.98	0.2738
Restorations	Without	1.08	0.60-1.90	0.7954	1.31	0.74-1.73	0.5670	1		
	Crown	1			1			1.28	0.77-2.10	0.3383
Opposing teeth	With	1.08	0.71-1.67	0.7268	1.61	1.21-2.16	0.0011*			
	Without	1			1					
Splint of teeth	With	1			1			1		
	Without	1.48	0.90-2.58	0.1263	1.29	0.91-1.87	0.1586	1.16	0.76-1.85	0.4924
Type of teeth	Anterior	1			1			1		
	Posterior	1.12	0.73-1.74	0.6193	1.47	1.12-1.93	0.0053*	1.19	0.78-1.84	0.4113
Jaw	Upper	1.51	1.04-2.21	0.0313*	1.55	1.20-2.00	0.0007*	1		
	Lower	1			1			1.90	1.30-2.78	0.0008*

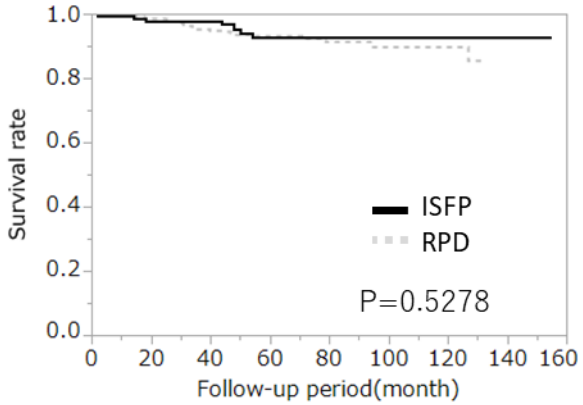

Fig. 1

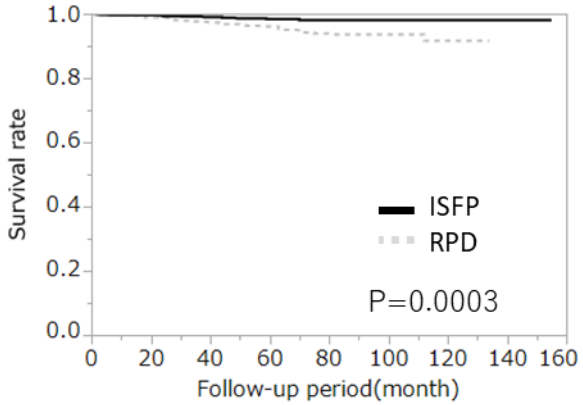

Fig. 2

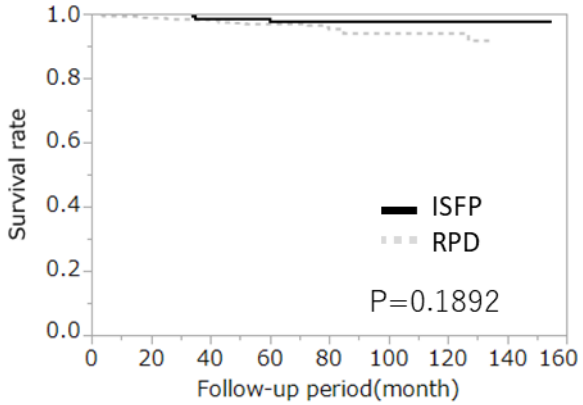

Fig. 3

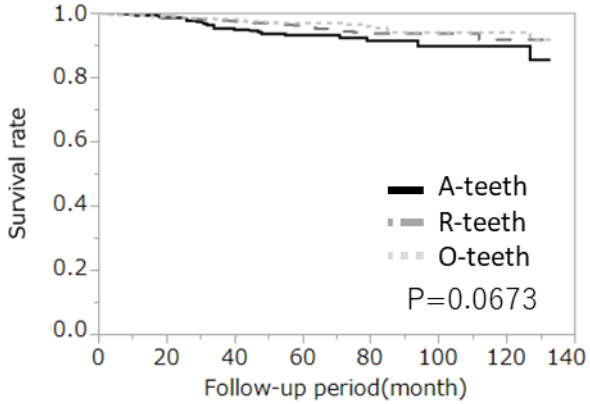

Fig. 4

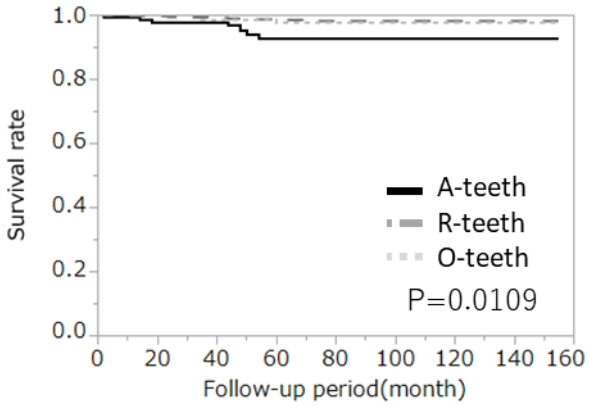

Fig. 5

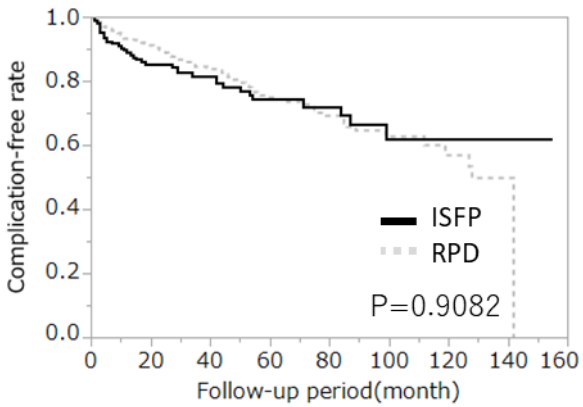

Fig. 6

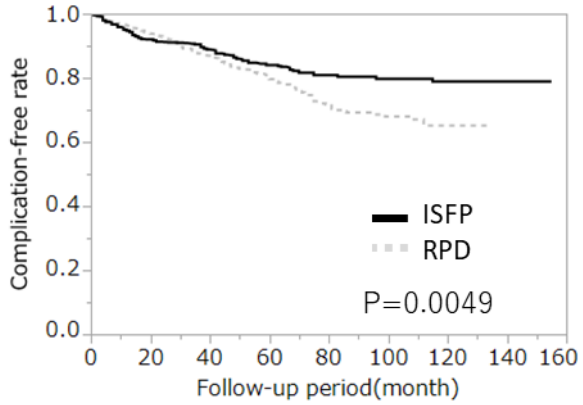

Fig. 7

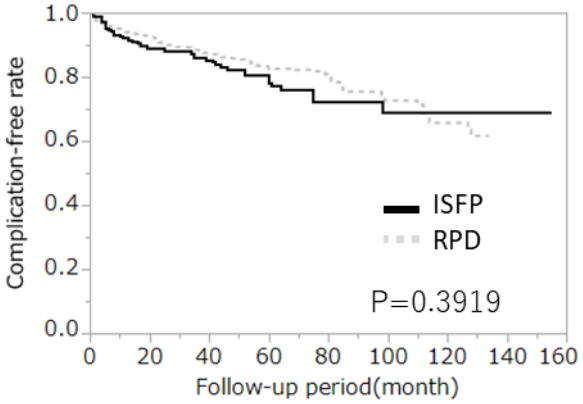

Fig. 8

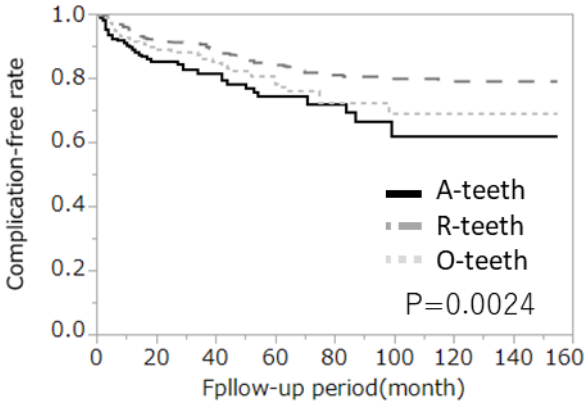

Fig. 9

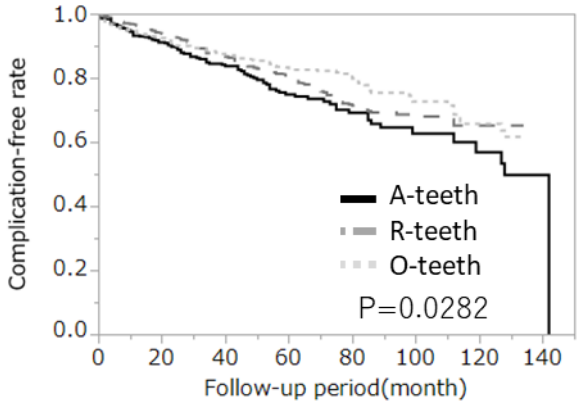
1.0
0.8
0.6
0.4
0.2
0.0
Complication-free rate
A-teeth
R-teeth
O-teeth
P=0.0282
0
20
40
60
80
100
120
140
Follow-up period(month)

Fig. 10