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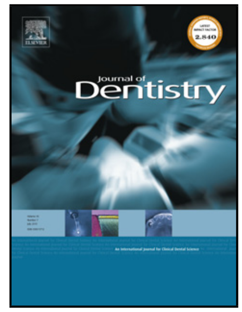

Title: Clinical audit of posterior three-unit fixed-movable resin-bonded fixed partial dentures – A retrospective, preliminary clinical investigation

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Clinical audit of posterior three-unit fixed-movable resin-bonded fixed partial dentures – A retrospective, preliminary clinical investigation.

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Abstract

Background**:** Two-unit cantilevered resin-bonded fixed partial dentures (RBFPDs) have higher retention rates over longer span fixed-fixed RBFPDs. It has been hypothesized that interabutment stresses associated with fixed-fixed designs cause prosthesis debonds therefore for the replacement of molar-sized and longer spans, non-rigid connectors have been used to allow independent movement between two abutment teeth.

Objectives**:** This preliminary study evaluates the clinical longevity and subjects' satisfaction of three-unit fixed-movable (FM3) RBFPDs provided at a dental teaching hospital.

Materials and Methods: Subjects who had received FM3 RBFPD(s) in the posterior region were clinically reviewed for complications. History of any debonds and subjects' satisfaction to the prosthesis were recorded. Time-to-debond (retention rate) and time-to-loss (survival rate) of these prostheses were presented in life tables.

Results**:** Ninety-eight prostheses in 84 subjects were examined. Their mean service life was 31.8 months (SD 11.5, range 3-67 months). Twenty-two prostheses had a history of debond, resulting in a retention proportion of 77.6 percent; seventeen of these were rebonded and still present at the time of review. One prosthesis was lost after extraction of a periodontally-involved abutment tooth, giving a survival proportion of 93.9 percent. High subject satisfaction and no adverse outcome was reported.

Conclusion**:** Three-unit fixed-movable RBFPDs have a shorter success than two-unit cantilevered RBFPDs. However, non-rigid connectors allow the possibility of rebonding giving satisfactory short-term survival rate. Further research is needed to investigate their long-term efficacy.

Clinical significance**:** Three-unit fixed-movable RBFPDs incorporating non-rigid connectors may be a feasible option for replacement of molar-size pontic in the posterior region.

Keywords: Resin bonded bridge, Dental Prosthesis Retention, fixed-movable, non-rigid, connectors, Longevity, Patient satisfaction

Introduction

While the first generation of resin-bonded fixed partial dentures (RBFPDs) with perforated retainers showed high debonding rates, their subsequent developments have demonstrated enhanced clinical outcomes. This improvement has been attributed to the use of non-perforated retainers [1] and increased framework extension on the abutment [2, 3], abutment tooth preparation and resistance features [4-6] as well as improvement in bonding protocol [7]. While the dental literature shows good clinical retention rates for shorter span two-unit cantilevered (CL2) RBFPDs of both metal-ceramic [8-11] and all-ceramic prostheses [12-14], higher debonding rates have been associated with RBFPDs with fixed-fixed (FF) designs and with a greater number of units [8, 11, 15-19].

At the Faculty of Dentistry, University of Hong Kong, a series of clinical audits have showed high retention rates for CL2 RBFPDs of 86.7 percent up to more than 9 years [20-26]. These prostheses have been recommended for replacing single missing anterior or posterior teeth of premolar-sized and their success has been attributed to the free-standing nature of a single-abutment, single-pontic prosthesis as there are no interabutment stresses [21, 22, 27, 28]. For molar-sized and longer edentulous spans, cantilevered design RBFPDs may not be possible for supporting the prostheses. However, the longevity of three-unit FF prostheses has been reported to be less favourable than CL2, especially anteriorly and over the longer term [21, 26]. This is considered to be due to the differential movements between abutment teeth causing increased stresses on the bonding interface of the FF prosthesis, such interabutment stress is not possible with CL2 designs [29, 30]. In addition, occlusal contacts on the abutment teeth is not fully controlled by a partial coverage FF RBFPD retainer. While this design is conservative to tooth tissue, occlusal contacts on the tooth tissue of the abutment tooth rather than on the retainer of a FF prosthesis may load one abutment tooth apically relative to the another FF abutment tooth and cause a “bite-out” effect [31-33]. Over repeated forces debond may occur in one abutment tooth only such that the prosthesis will still be retained in the mouth which may have the possibility of caries over time under the debonded retainer.

Non-rigid fixed-movable (FM) connectors have been used for RBFPDs to accommodating abutments with different mobility [34-37]. To allow independent movement between the prosthesis abutments in both horizontal and vertical planes, modified FM connectors have been advocated for three-unit and longer RBFPDs to act like an exaggerated stress breaker [38-40]. This is thought to reduce interabutment stresses and therefore improve retention rate and if a debond were to occur it may allow rebonding of the loose retainer. The aim of this clinical audit was to investigate the clinical longevity and subject satisfaction of three-unit fixed movable (FM3) RBFPDs in replacing a molar-sized posterior edentulous spans.

Materials and Methods

The sample population was identified from the computer records of patients attending the dental teaching hospital of the University of Hong Kong, Prince Philip Dental Hospital (PPDH). Inclusion criteria are subjects who had received three-unit fixed-movable (FM3) resin-bonded fixed partial denture(s) (RBFPDs) in the posterior region and are medically fit to attending the review appointment. Ethics approval was obtained from the Institutional Review Board of the University of Hong Kong/Hospital Authority Hong Kong West Cluster, Hong Kong (IRB UW 15-445). Informed consent was obtained from all subjects.

Design and fabrication of 3-unit fixed-movable RBFPDs

At the Prince Philip Dental Hospital, metal-ceramic RBFPDs are usually the first line of choice for fixed-prosthesis tooth replacement [41]. Following the control of active dental disease, patients would have been selected for FM3 RBFPD treatment based on the need to replace one posterior tooth of molar size (mesial-distal width 8-11 mm) and their wish for a tooth-supported fixed replacement. The abutment teeth would have been sound or minimally restored with sufficient enamel for bonding, having clinical crown height of at least 3 mm occluso-gingivally, and healthy periodontal tissues. Design of FM3 RBFPDs would follow the standard teaching philosophy of such prostheses [38]. The abutment tooth with a better resistance form and larger surface area for bonding (usually molar) would be selected as the major abutment tooth supporting the retainer and the pontic. The pontic is designed to receive light or no occlusal contacts in both static and dynamic occlusions. The other abutment tooth would support the minor retainer. The patrix part of the FM joint usually connected to the minor retainer extra-coronally.

Tooth preparation would confine to lowering the height of contour of the tooth axially to allow apical extension of the framework to no less than 1 mm above the gingival margin and allow wraparound greater than 200° so as to maximize the surface area and resistance form for bonding. The use of an FM joint would allow separate paths of insertion of the major and minor retainers and thereby allow a more conservative tooth preparation usually confined to enamel. If dentine is exposed, this will be sealed with dentine-bonding agent during framework cementation.

The Nickel-Chromium (Ni-Co) framework was designed to be at least 0.8 mm thick and extended over at least two-axial surfaces (usually lingual and edentulous proximal) of the abutment tooth. This has been the historical material of choice [42] for well over 30 years and there have been no known cases of nickel allergy in patients requiring an RBFPDs in the past 20 years. An occlusal bar also 0.8 mm thick would be prepared to allow joining of the ends of retainer to give a geometrically rigid D-shaped retainer or alternatively the lingual cusp be covered if there was interocclusal clearance – particularly on the mandibular premolars. If a proximal tooth contact was present on the abutment tooth, extension onto this proximal surface of the abutment tooth would not routinely be prepared. If the contact point was open, the retainer framework would be extended to allow three-axial surfaces wraparound. The use of auxiliary resistance features such as grooves, slots or pin-holes was not routinely recommended for short span single molar prosthesis (Fig. 1).

All RBFPDs were fabricated by in-house dental technicians in the Dental Technology Unit of the PPDH following a standard procedure [38, 39]. To ensure adequate thickness of the retainer, preformed casting wax sheets of 0.8 mm thick (Dentaurum; Ispringen, Germany) were laid down on refractory cast (V.H.T. refractory die material; Whip Mix Corp., Louisville, Kentucky, USA), sprued and invested. Nickel chromium alloy (Optimum; Matech Inc, Sylmar, California, USA) was used to cast the frameworks. The fixed movable connector was either custom made in resin (GC Pattern Resin, GC Dental Industrial Corp, Tokyo, Japan) or cast using a preformed plastic pattern (Mini Rest; J.M. Ney Dental, Bloomfield, Connecticut, USA). After casting, both the patrix and matrix connectors were trimmed with a tapered tungsten carbide fissure bur (No. 170) in an air-turbine handpiece to allow pitching and rolling movement in both vertical and horizontal planes between the abutments during loading to act like an exaggerated stress breaker. Porcelain (Vita-Omega; Vita Zahnfabrik, Bad Säckingen, Germany) was build-up on the metal framework. The fitting surfaces of the retainers were abraded using 50 µm aluminum oxide at a pressure of 520 kPa. All RBPDs were cemented with Panavia F cement (Kuraray, Osaka, Japan) under rubber dam isolation if possible.

A proforma was used to collect the following data for each subject including: gender, age, operator's experience, cementation date, any debonding history and remedial treatments received. Clinically the RBFPDs were examined for debonding and prosthetic complications such as porcelain fracture. The abutment tooth status such as the presence of dental caries and occlusal contacts on antagonist tooth as well as its radiographic bone level were recorded. Prostheses were investigated for its retention, survival and success. **Retention** was defined as a prosthesis that did not debond over the observation period, which also included any prosthesis that was loss/extracted together with the abutment. **Survival** was defined as a prosthesis that was *in situ* at the time of review irrespective of its condition and history of recementation. **Success** was defined as a prosthesis that remained unchanged over the observation period without intervention [25]. Time-to-debond (i.e. retention rate), time-to-loss (i.e. survival rate) and time-to-complication (i.e. success rate) of these prostheses were calculated and presented in life tables.

Subjects were also asked a series of questions including their satisfaction with the prosthesis on a 10-point scale with score of '0' representing 'Not satisfied at all' and score of '10' representing 'Very satisfied', if they were concerned about the appearance of the metal of the RBFPD (yes/no), and if they avoided chewing on the prosthesis to protect it (yes/no). Prior to statistical analysis, the normality of continuous data was checked using the Kolmogorov-Smirnov test. Categorical and continuous data were analysed with chi-square/Fisher's exact test and parametric independent t-test/non-parametric Mann-Whitney U respectively, at significance level $\alpha=0.05$. All data were analysed with SPSS 23.0 (IBM, NY, USA).

Results

A total of 116 subjects received FM RBFPD(s) in the Prince Philip Dental Hospital were retrieved by the computer, 32 were excluded. One excluded subject received conventional crown as minor retainer, 9 subjects received anterior FM RBFPD(s) and 22 subjects received posterior FM RBFPD(s) longer than 3-units. Ninety-eight three-unit FM RBFPDs in eighty-four subjects fulfilled the inclusion criteria and were clinically examined. Of whom 29 were male and 55 were female with a mean age of 50.6 and range 19-78 years. Fourteen subjects had received two FM3 RBFPDs in their mouth. Ten prostheses replaced molar-sized pontic in premolar region, and 88 replaced a molar (Table 1). The mean service time of the prostheses at the time of examination was 31.8 months (SD 11.5, range 3-67 months) (Table 2).

Twenty-two RBFPDs had debonded and in all cases it was the major retainer that had separated (Fig 2). The retention proportion was 77.6 percent (76 prostheses) and the mean retention life of the prostheses was 27.8 months (SD 13.6, range 0-67 months). There was no statistical significance in the retention proportion between maxillary (29/36=80.6 percent) and mandibular arch (47/62=75.8 percent) (Chi square test, p=0.63) and between premolar (7/9=77.8 percent) and molar region (69/89=77.5 percent) (Fisher's exact test, p=1.00) (Table 1). There was total 26 debondings. Besides debonding, one RBFPD was lost together with extraction of the periodontal involved major abutment tooth (tooth 37). This subject may be periodontitis susceptible and was under the care by the discipline of periodontology, PPDH, before the insertion of RBFPD. The success proportion was 76.5 percent (75 prostheses) and the mean success life of the prostheses was 27.8 months (SD 13.6, range 0-67 months).

Seventeen of the rebonded RBFPDs were still in situ at the time of review. The survival proportion was 93.9 percent (92 prostheses) and the mean survival life of the prostheses was 30.6 months (SD

12.2, range 2-67 months). There was no statistical significant difference in the survival proportion between maxillary (36/36=100.0 percent) and mandibular arch (56/62=90.3 percent) (Fisher's exact test, p=0.08) and between premolar (9/9=100.0 percent) and molar region (83/89=93.3 percent) (Fisher's exact test, p=1.00). The life tables of FM3 RBFPDs were presented in Figure 3 and the 48-month cumulative probability of retention, success and survive was 0.72, 0.72 and 0.94 respectively.

The majority of RBFPDs (n=73, 74.5 percent) in this study were prepared and inserted by undergraduate dental students. Remaining RBFPDs were inserted by junior residents (n=17, 17.3 percent), postgraduate dentist (n=1, 1.0 percent) and academic staff (n=7, 7.1 percent) respectively. No statistical significant difference in the retention (Chi-square test, p=1.00) and survival proportion (Fisher's exact test, p=0.64) of RBFPDs were found between those inserted by undergraduates (retention: 56/73; survival: 69/73) and by dentists (retention: 20/25; survival: 23/25).

In this study no abutment teeth were found to have dental caries. The vast majority of major (85.7 percent) and minor abutment teeth (89.8 percent) had occlusal contacts present on an antagonist tooth as judged by 10 µm shimstock contact. However, it was not possible to differentiate if the contact was on the tooth or retainer framework. Two-third of pontics (64.3 percent) had occlusal contacts present on an antagonist tooth. Fifty-seven major abutment teeth and fifty-nine minor abutment teeth were judged to have less than 20 percent bone loss, and 32 abutments of each abutment teeth to have 20-50 percent bone loss. There were two instances of major retainers with greater than 50 percent bone loss and one instance of a minor retainer abutment with greater than 50 percent bone loss. All three RBFPDs with greater than 50 percent bone loss at its abutment tooth were survived and only the RBFPD with minor abutment tooth bone loss has debonded once.

High subject satisfaction with mean score of 8.2 out of 10 (SD 1.8) was reported in this study. Three subjects (and four prostheses) did not answer this question as missing data. Subjects with survived RBFPD(s) (mean rank 48.6, mean 8.3) have higher satisfaction than those with failed RBFPD(s) (mean rank 30.8, mean 6.5) but this do not reach statistical significance (Mann-Whitney U test, p=0.11). Subjects with RBFPD(s) that have no debond history (mean rank 50.6, mean 8.4) have statistical significantly higher satisfaction than those with debond history (mean rank 35.3, mean 7.3) (Mann-Whitney U test, p=0.03). Only 5 subjects (6.0 percent) were concerned with the appearance of the metalwork of the RBFPD and only 15 subjects (17.9 percent) reported they avoided chewing on the prosthesis to “protect” it. No major adverse outcome was reported.

Discussion

This preliminary clinical audit of 98 posterior three-unit fixed-movable (FM) resin bonded fixed denture prostheses (RBFPDs) in 84 subjects demonstrated satisfactory short-term survival rate of 93.9 percent with a mean age of 31.8 months and few major biological complications associated with the abutment teeth. The FM joint may reduce interabutment stress and therefore reduce the risk of debond. Moreover, it permits rebond if a debond in the major retainer was occurred. High subject's acceptance to this prosthesis was observed particularly if the prosthesis did not have history of debond. A challenge could occur as in any fixed-movable prosthesis would be if the minor retainer debonds. This usually requires removal and remake of the whole prosthesis.

Based on a previous result of a clinical audit of 43 long-span (i.e. four or more unit) fixed movable RBFPDs at the Prince Philip Dental Hospital a 92.2 percent retention with a mean service time of 46.9 months was observed [39] and based on this FM design became the standard of care for shorter three-unit RBFPDs. However, it was unexpected to find that 3-unit FM RBFPDs in this study should show lower retention probability (0.72 in 48 months) when compared to the previously reported longer span prostheses given the fact that would receive lower load and that from the literature that longer span fixed-fixed RBFPDs have a higher debond rate than shorter span prostheses [8, 11, 15-17]. This might be explained by the fact that the more experimental long-span prostheses were placed or supervised by the lead author (MB) or that the abutments on longer span prostheses were prepared with more resistance and retention features including the use of grooves and 270° to 360° wraparound. Most three-unit RBFPDs in this study were placed by undergraduate dental students providing their first few prostheses. However, the factor of operator experience improving prosthesis retention does not always have a direct association as in this and other studies [25].

There is limited information in the dental literature supporting the use of non-rigid connectors, however what there is, supports their clinical benefit. In a clinical review of 515 fixed partial dentures (FDPs), Walton [43] found that FDPs with one or more non-rigid connector had a significant decrease in retreatment rates when compared to fixed-fixed prostheses. This was attributed to individual and differential tooth movement allowed by non-rigid connectors which it was suggested reduced harmful flexural forces on the prosthesis. In an evaluation of 2000 retainers, Roberts [44] showed both posterior and anterior fixed-movable three-quarter crown retainers to have lower failure rates than their fixed-fixed counterparts. In a study of nine conventional fixed-movable posterior FDPs, Foster [45] observed greater longevity of these prostheses when compared to fixed-fixed designs however, the sample size was small and therefore this difference was not statistically significant. The use of connectors that distribute stress between different components of prostheses is also supported by Studer et al. [46] who observed significantly more failures in the abutment supported partial dentures that had "rigid" rather than "semi-rigid" crown attachments.

The use of movable connectors for RBFPDs have other considered advantages in that they may reduce the load on compromised minor abutments, allow abutments with different paths of insertion to be prepared conservatively along their long axis and also allow the use of minor retainers with reduced occlusal coverage. However, fixed-movable designs have been suggested to place greater loading on the major abutment teeth, are technique sensitive and have increased laboratory costs. Longer review time may be needed to prove our hypothesis [21] [26] provided that satisfactory 5-year retention of FF RBFPDs in the posterior region has been reported [47].

Debonding was the major complication associated with FM3 RBFPDs in this study. The higher debonding rate of FM3 RBFPDs compared to 2-unit cantilevered (CL2) design (retention proportion of 86.7 percent in 113.2 months) may be related to the fact that FM connector may still have interabutment stress when compared to free-standing CL2 abutment tooth. In addition, the occlusal contact on the tooth tissue of an abutment tooth is not fully controlled by the partial coverage FM RBFPD retainer and may result in a "bite-out" effect. For a FM3 prosthesis, when an occlusal contact is possible on the tooth tissue of an abutment tooth, it may be loaded apically relative to the retainer and another abutment tooth, stressing the tooth-to-prosthesis bonding interface. This have been previously identified as potential risk factors for early failure in fixed-fixed RBFPDs [2, 3, 48]. Based on these observations and those of the current study, the control of adverse tooth contacts on the abutment may be a consideration for improved RBFPD retention. This may be achieved by extending the framework of the major retainer over the occlusal surface to control static and dynamic tooth contacts or by performing an occlusal adjustment to remove possible adverse tooth contacts. Higher subjects' satisfaction was resulted from a retentive RBFPD in this study. Further and longer observation period is required. Seventeen out of the twenty-two (77.3 percent) debonded prostheses were recemented and were still functioning at the time of review. However, one recemented prosthesis had debonded twice and two debonded RBFPDs were remade in the first instance, their clinical notes stated that the cause for the need to replacement was due to distortion of the prosthesis or insufficient retainer extension. Distortion of the prosthesis framework and failure of rebonded RBFPDs was also observed in our previous study [26]. Therefore, careful investigation of the fitting of debonded retainer framework is required before consideration of recementation.

As with any study there are limitations and a retrospective study such as this is no exception. Patients with failed prostheses may not attend for review if disappointed with the outcome and so this may mean an under reporting of the true failure rates. The preliminary nature of this study is relatively short-term and may means it may well be likely that over increasing time of review, higher failure rates will be observed. Further prospective studies may be required to examine improved designs of prosthesis using major retainers with improved resistance form and so success.

Conclusion

Three-unit RBFPDs with a modified non-rigid connector show a high debond rate over this short term review when compared to two-unit cantilevers and four-unit fixed-movable RBFPDs. However, such debonds always allowed the possibility of recementation of the fixed movable design and because of this a 95 percent functional survival of the prostheses at time of clinical review with no caries was observed. Future improvements to the current design may include greater wraparound, retention features and control of adverse occlusal contacts by the extending the major retainer framework.

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Figure 1. Examples of posterior three-unit fixed movable RBFPDs.

Figure 2. Flowchart showing the retention, success and survival of RBFPDs in this study.

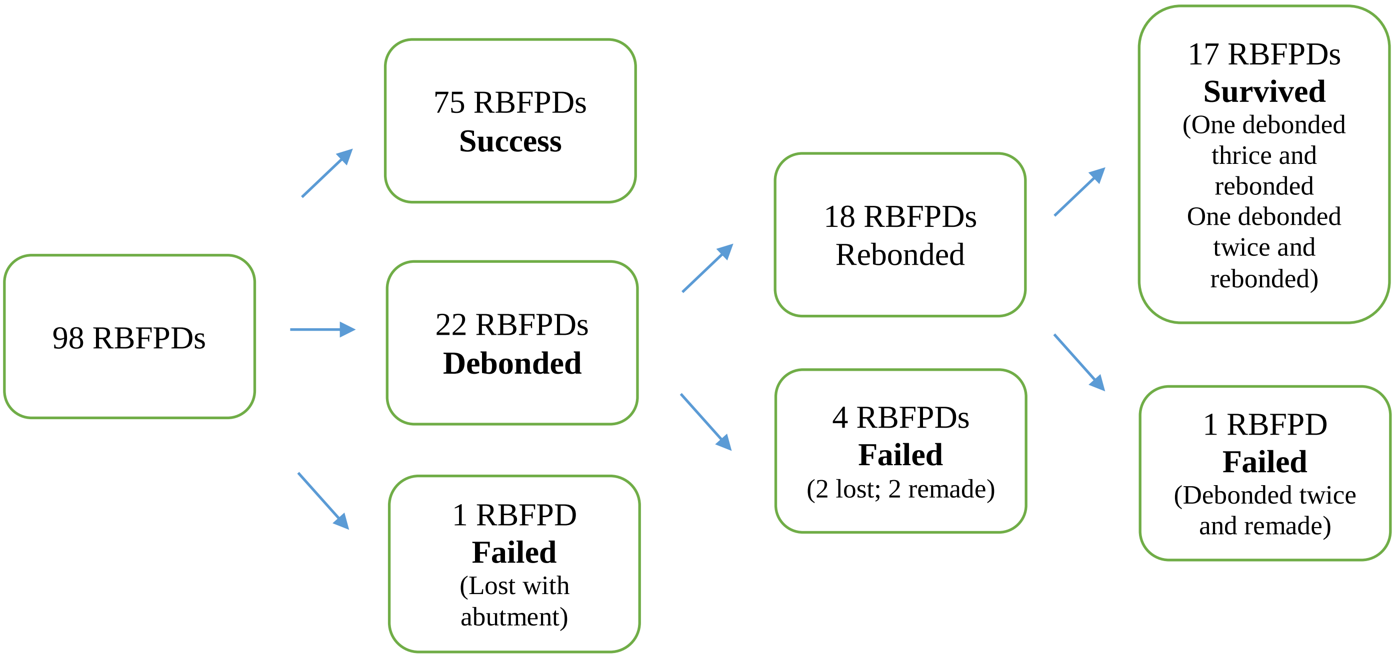
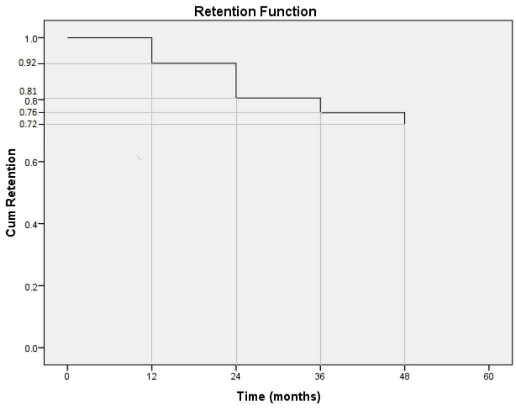
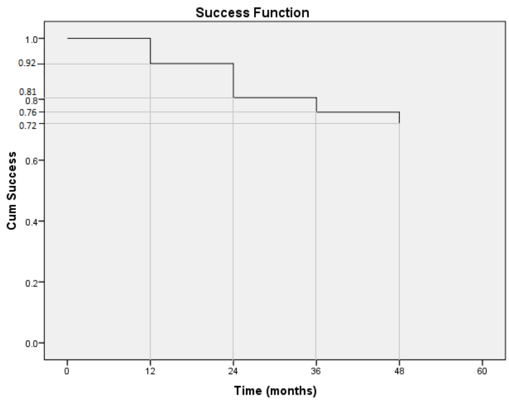


Figure 3. Life tables of the a) retention rate, b) success rate and c) survival rate of FM3 RBFPDs in this study.

a)



b)



c)

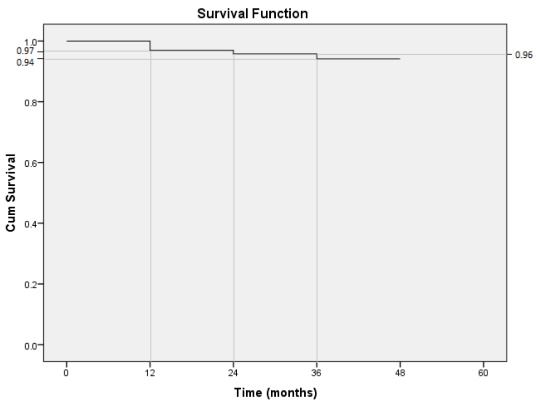


Table 1. Frequency distribution and the number of debonded and failed three-unit fixed movable RBFPDs at each location (n=98).

Debonded/Failed	2/0	1/0	1/0	0/0	0/0	3/0
Number of RBFPDs	15	1	2	1	1	16
Location of pontics	**16**	**15**	**14**	**24**	**25**	**26**
Location of pontics	**46**	**45**	**44**	**34**	**35**	**36**
Number of RBFPDs	31	0	1	2	1	27
Debonded/Failed	9/2	0/0	0/0	0/0	0/0	6/4

Failed RBFPD: prostheses debonded or were not present at the time of review

The bold values are FDI tooth numbers of the pontics

Table 2. Frequency distribution of the service time of posterior three-unit fixed-movable RBFPDs.

Service time (months)	No. of prostheses (%)
0-6	3 (3.0)
7-12	1 (1.0)
13-24	13 (13.3)
25-36	44 (44.9)
37-48	32 (32.7)
48+	5 (5.1)
Total	**98 (100)**