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Ten-year clinical evaluation of posterior fixed-movable resin-bonded fixed partial dentures

Walter Y.H. Lam[a], Ronald S.T. Chan[a], K.Y. Li[a], K.T. Tang[b], Tony T. Lui[c], Michael G. Botelho[a,*]

[a] Faculty of Dentistry, The University of Hong Kong, Hong Kong Special Administrative Region
[b] Private practice, Hong Kong Special Administrative Region
[c] Department of Health, Hong Kong Special Administrative Region

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ABSTRACT

Objectives: Two-unit cantilevered resin-bonded fixed partial dentures (RBFPDs) offer long-term retention for anterior and premolar-sized spans. At this center, molar and longer spans have been restored with fixed-movable (FM) RBFPDs to overcome the lower retention rates of fixed-fixed RBFPDs. This retrospective study aimed to evaluate the long-term longevity and the patient-reported outcomes of posterior FM-RBFPDs.

Methods: Posterior FM-RBFPDs that had been inserted at least five years were reviewed. Survival was "retention of the original prosthesis in mouth" and success was "survival of prosthesis and absence of complications requiring treatment intervention". Prosthesis location, number of units, insertion year, tooth/teeth replaced and operator experience were collected. Patients' acceptance to FM-RBFPDs were assessed using prosthesis satisfaction questionnaire and Oral Health Impact Profile (OHIP-49). Results were analyzed using log-rank and cox-regression tests at significance level $\alpha = 0.05$.

Results: One-hundred-and-one prostheses were examined. The mean observation time was 126.4 ± 32.2 months. Thirty-six (35.6%) and 63 (62.4%) FM-RBFPDs were rated as success and survival respectively. Prostheses inserted after year 2001 ($n = 69$) experienced 42.0% ($n = 29$) success and 75.4% ($n = 52$) survival, and its survival rate was significantly better than those inserted in or before 2001 ($p = 0.01$). Five- and ten-year cumulative survival probability of FM-RBFPDs inserted after year 2001 were 82.3% and 74.1% respectively. The most frequent complications were debonding among 34 (33.7%) prostheses. Patients' acceptance were high.

Conclusions: More recently inserted prostheses showed improved longevity and patients' acceptance to posterior FM-RBFPDs were high.

Clinical significance: Fix-Movable RBFPDs are a viable tooth replacement option in the posterior region.

1. Introduction

Two-unit cantilevered (CL2) resin-bonded fixed partial dentures (RBFPDs) are a highly successful and reliable tooth replacement option [1–15]. These prostheses are supported by a single retainer at one side and is bonded to the abutment teeth by resin cement [16] usually with minimal tooth preparation [17]. They are used in the replacement of anterior and premolar-sized missing teeth spans [18], and their longevity and patient-reported outcomes are comparable to that of implant-supported crowns in a bounded single tooth space [19–21].

The success of CL2 RBFPDs is attributed to the nature of the single retainer, single abutment design that eliminates inter-abutment movements that occurs with fixed-fixed (FF) designs [18,22]. This is supported by *in vitro* cyclic loading of RBFPDs showing the superiority of CL2 over equivalent FF3 design [23]. Clinically this is also supported in an 18-year randomized clinical trial comparing CL2 and FF3 metal-ceramic RBFPDs for replacing maxillary incisors, all CL2 prostheses were successful while only two (20%) of the FF3 prostheses were retentive [24]. In a similar study comparing CL2 and FF3 all-ceramic RBFPDs, while no prosthesis debonded, the FF3 prostheses demonstrated a much higher framework fracture incidence than the CL2 prostheses (37.5% *vs.* 4.5%) [25] which was attributed to the adverse inter-abutment tensile stresses in the frameworks.

At this centre, for the replacement of molar-sized or longer missing teeth spans using metal-ceramic RBFPDs, two retainers are traditionally required to support the pontic on both sides and a modified non-rigid connector is used to allow some lateral and slight vertical tooth movements between two abutment teeth so that it acts like a stress breaker [22,26]. Usually the distal abutment tooth with better retention/resistance form is selected as the major abutment tooth thereby

* Corresponding author at: Room 3B19, Prince Philip Dental Hospital, 34 Hospital Road, Sai Ying Pun, Hong Kong Special Administrative Region.
E-mail address: botelho@hku.hk (M.G. Botelho).

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Fig. 1. Example of a posterior fixed movable (FM) resin bonded fixed partial denture (RBFPD).

supporting the pontic with a fixed connector. The extracoronal *movable* connector is housed under the pontic and the patrix associated with the minor retainer that is situated external to the contour of the tooth. No intracoronal box is cut in tooth tissue to house the matrix which is placed extracoronal to the contour of the tooth (Fig. 1).

This centre has published preliminary data of short- (three-unit) [27] and long-span (four-unit or more) FM RBFPDs [28], and showed higher than 90% survival proportion and good patient satisfaction over a mean time of 31.8 and 46.9 months respectively. In addition, a clinical report had demonstrated a 16-year survival of one FM RBFPD [29], there are few studies, if any, auditing the long-term longevity and patient acceptance of posterior FM RBFPDs.

1.1. Objectives

The main aim of this study was to investigate the long-term longevity and patient-reported outcomes of posterior FM RBFPDs inserted at least five years at a dental teaching hospital. The other aim of this study was to investigate the association of clinical factors with posterior FM RBFPDs longevity and the null hypothesis was no factors have impact on the prostheses longevity.

2. Materials and methods

Patients who had received a posterior fixed-movable (FM) resin bonded fixed partial denture (RBFPD) at least five years prior to the planned clinical review date in the dental teaching hospital, Prince Philip Dental Hospital (PPDH), were retrieved from the hospital record system. From this sample population, patients who were medically fit to attend the review appointment were invited to the Prosthodontics clinic, for clinical examination. One prosthesis was randomly selected for clinical examination if the patient has received more than one eligible FM RBFPDs to avoid clustered data and multilevel result analysis [30–32]. The prosthesis was clinically examined for any technical complications such as debonding and fracture of the framework or veneering porcelain. The abutment teeth were examined for any biological complications such as probing depth greater than 5 mm, caries related to the retainer, tooth fracture and tooth extraction/loss. Other positive clinical findings were recorded as appropriate. Periapical radiograph of the abutment tooth was updated to observe for any apical pathology. Hospital treatment records were reviewed and the details of any complications and treatments/interventions related to the prosthesis/abutment teeth were recorded. History of complications and/or treatments/interventions outside PPDH was also recorded [19,24]. This study was approved by the Institutional Review Board of the University of Hong Kong/Hospital Authority Hong Kong West Cluster (UW 15–445), and written informed consent was obtained from all included patients.

Survival was defined as the retention of the original prosthesis in mouth, irrespective of its condition and history of debonding. Success was defined as the survival of the original prosthesis and the absence of complications requiring treatment intervention beyond routine periodontal maintenance. Prostheses in this study were classified as (1) success or not success, and (2) survival or failure. A complication may end the success of a prosthesis but it may not affect the prosthesis survival *i.e.* a debonded original prosthesis can be recemented and classified as "not success" and "survival". The dates of occurrence of these complications were collected and the rate of success (*i.e.* time-to-complication or time-to-repair) and survival (*i.e.* time-to-failure or time-to-replacement) as well as their proportions were calculated. Since debonding was the most commonly seen complications in RBFPDs [33–35], the number of debonds and the retention rate (*i.e.* time-to-debond) were also recorded and calculated.

A proforma was used to collect the data such as patient's gender, age (at the time of prosthesis insertion and at the time of clinical review) and number of occluding units, prosthesis location (maxillary/mandibular), number of units, insertion date, tooth/teeth replaced, teeth used for abutment and operator experience (undergraduate dental students, junior hospital dental officers, postgraduate dental students and teaching staff). Patients' acceptance were assessed using a prosthesis satisfaction questionnaire and Oral Health Impact Profile (OHIP-49).

Prosthesis satisfaction questionnaire [24] contains 15 questions related to patient's satisfaction about the prosthesis. There is a question asking patient's *general satisfaction* to the prosthesis; eight questions related to the prosthesis's performance including *appearance*, *comfort*, *chewing ability*, *speech*, *ease of cleaning*, *firmness of the prosthesis*, *confidence with the prosthesis* and *its comparison with natural teeth*; four questions related to the treatment procedure including *treatment time for completion*, *treatment comfort*, *cost* and *operator*. Patients were instructed to draw a vertical line across a 100 mm horizontal straight line with one end (0) denotes totally unsatisfied and another end (100) denotes totally satisfied (visual analogue scale VAS) [36]. Patients were also asked if they would *select this prosthesis again* and if they would *recommend to others* (Yes or No).

Oral Health Impact Profile (OHIP) questionnaire was used to assess patients' oral health-related quality of life (OHRQoL) [37,38]. There were 49 questions in seven domains including *functional limitation*, *physical pain*, *psychological discomfort*, *physical disability*, *psychological disability*, *social disability* and *handicap*. This is based on the theoretical conception that oral conditions can produce physical, social and psychological impacts that can disable and handicap an individual's quality of life. For each question, patients were asked if they have suffered negative impacts particularly related to the prosthesis in the last two weeks and indicate their frequency in a Likert scale: never (score 0), hardly ever (score 1), occasionally (score 2), fairly often (score 3) and often (score 4). Individual scores were then summed up. The smaller the summary scores the less negative impacts the patient had experienced and therefore the better OHRQoL.

Prostheses' success, survival and retention time were plotted using the Kaplan Meier curves [30]. Log rank test and cox-regression test were used to analyze the association of single and multiple factors on the success/survival/retention rate respectively. Factors such as the operator experience, the span, location and insertion year of prostheses and tooth/teeth replaced were analyzed in this study. The significance level was set at α = 0.05. All data were analyzed with Statistical Product and Service Solutions (SPSS) 25.0 (IBM Corporation, Armonk, NY, USA). Sample size of 100 was suggested for the regression models [39].

2.1. Design and fabrication of FM RBFPDs

It has been considered that metal-ceramic RBFPDs are the "first treatment consideration" for fixed-prosthesis tooth replacement [40]. Usually the abutment teeth are sound or minimally restored with adequate enamel for bonding, having clinical crown height of at least 3 mm occluso-gingivally and periodontally healthy following the standard treatment approach of such prostheses in this hospital [18,22,41]. The early prosthesis design involved tooth preparation of the abutment teeth to include lowering the height of contour (survey line) of the clinical crown axially to allow apical extension of the metal framework to 1 mm above the gingival margin and greater than 200° axial wraparound. This was to maximize the surface area and resistance form for bonding on the abutments. The tooth preparation is confined to enamel and minor dentine exposure is treated with a dentine bonding agent during cementation. Over the years there was an improvement of tooth preparation and framework design in response to clinical debonds of earlier prostheses and wraparound was extended and extension of the framework on the occlusal surface to control occlusal contacts. The RBFPDs framework was cast in Nickel-Chromium (Ni-Co) alloy (Optimum; Matech Inc, Sylmar, California, USA) and was designed to be at least 0.8 mm thick and extended over at least two-axial surfaces, usually the lingual and edentulous proximal surfaces, of the abutment tooth. An occlusal bar 2–3 mm wide and 0.8 mm thick would be prepared, following the occlusal fissures if possible, to join the ends of retainer so as to give a geometrically rigid D-shaped retainer or alternatively the lingual cusp would be covered if there was interocclusal clearance – particularly on the mandibular first premolars. If the interproximal contact was open, the retainer framework would be extended to allow three-axial surfaces wrap around (mesial, lingual and distal). For long-span (four-unit and more) or replacement of failed RBFPDs, the retainer framework would be 1.0 mm thick if feasible, extended through the interproximal surface and the use of auxiliary resistance features such as grooves, slots or pin-holes considered [22,41].

All RBFPDs were fabricated by the Dental Technology Unit of the PPDH following a standard procedure [18,22,41]. Preformed 0.8 mm thick casting wax sheets (Dentaurum; Ispringen, Germany) were laid down on refractory cast (V.H.T. refractory die material; Whip Mix Corp., Louisville, Kentucky, USA), sprued, invested and cast in Ni-Co alloy. The FM connector was either custom made in resin (GC Pattern Resin, GC Dental Industrial Corp, Tokyo, Japan) or using a preformed plastic pattern (Mini Rest; J.M. Ney Dental, Bloomfield, Connecticut, USA). FM RBFPDs were fabricated in two-pieces casting and the minor retainers were seated before the major retainers. After casting both the patrix and matrix connectors would be trimmed with a bur such as a tungsten carbide tapered fissure bur (number 170) in an air-turbine handpiece to allow pitching, yawing and rolling movement in both vertical and horizontal planes between the abutment teeth during occlusal loading to act like a stress breaker. Veneering porcelain (Vita-Omega; Vita Zahnfabrik, Bad Säckingen, Germany) were fired on the metal framework of the pontics which were designed to receive light or no occlusal contacts in both static and dynamic occlusions. After the clinician confirmed the fit of a prosthesis and performed necessary adjustments, the fitting surfaces of the retainers were abraded using 50 µm aluminum oxide at a pressure of 520 kPa. The abutment teeth were cleaned thoroughly with pumice paste, the prepared enamel surfaces were etched with 33–40% phosphoric acid for 30 s [42,43] and were thoroughly rinsed and dried. The prosthesis was cemented with resin cement (Panavia F and F2.0; Kuraray, Osaka, Japan) under rubber dam isolation if possible.

3. Results

3.1. Descriptive

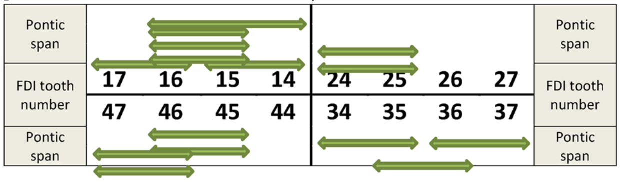
At the time of review, the hospital record system retrieved a list of 694 patients who had received FM RBFPDs of at least five years prior to the planned clinical review date in PPDH. To fulfill the sample size requirement (n = 100) for regression modelling [39], 190 patients were invited to PPDH for clinical examination and 101 patients were clinically reviewed. Those who refused to attend the examination was attributed to time conflicts, live remotely or no interest in attending review appointment. For recruited patients, 32 (31.7%) were male and 69 (68.3%) were female. Their mean age at examination and at the time of prosthesis insertion were 59.0 ± 10.7 years (range 33–86 years) and 48.5 ± 10.4 years (range 19–77 years) respectively. Number of occluding units at the time of review was 12.3 ± 3.3 for recruited patients.

Based on the hospital treatment records of recruited patients, there were 132 eligible posterior FM RBFPDs. Thirty-one patients had received two eligible posterior FM RBFPDs and one prosthesis was randomly selected from each of them for clinical review. There were 86 three-unit short-span prostheses (Table 1a), 14 four-unit and one five-unit long-span prostheses (Table 1b). Forty prostheses were located in the maxilla and 61 located in the mandible. Eighty-eight prostheses

Table 1a
Frequency distribution of the missing teeth replaced by the *three-unit* posterior FM RBFPDs reviewed in this study.

Frequency	1	17	1	1	0	2	10	0
FDI tooth number	**17**	**16**	**15**	**14**	**24**	**25**	**26**	**27**
	47	**46**	**45**	**44**	**34**	**35**	**36**	**37**
Frequency	0	24	1	0	2	2	25	0

Table 1b
Frequency distribution of the missing teeth replaced by the *four-unit or more* posterior FM RBFPDs as indicated by arrow lines.



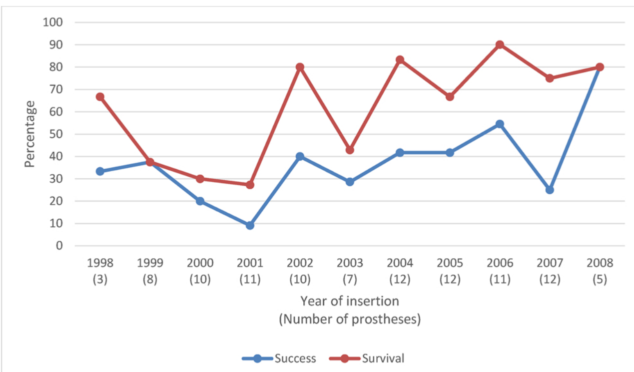


Fig. 2. The percentage of success and survival posterior FM RBFPDs inserted from 1998 to 2008. Prostheses inserted after year 2001 shown better clinical performance.

replaced a single molar unit or more *i.e.* molar pontics and 13 prostheses replaced premolar(s) only *i.e.* premolar pontics. All the major abutment teeth were a molar except on one occasion was a second premolar. Ninety-two of the minor abutment teeth were a premolar, eight were a canine and one was a molar. Sixty-nine prostheses were inserted after year 2001 (Fig. 2). Seventy-nine FM RBFPDs were inserted by undergraduate dental students and the remaining (n = 22) were inserted by qualified dentists including 15 by junior hospital dental officers in their year after qualification and four by taught postgraduate students and three by teaching staff.

3.2. Longevity

In this study, the mean observation time was 126.4 ± 32.2 (range from 62 to 188) months. Only 36 (35.6%) posterior FM RBFPDs were successful and 63 (62.4%) prostheses survived. Due to the different observation time of the prostheses, the estimated mean success (time-to-complication/repair) and survival time (time-to-failure/replacement) as well as the median success and survival time were calculated (Table 2a and 2b). The estimated mean and median success time were 101.4 (Standard error, S.E. = 6.3) and 104.4 (S.E. = 7.2) months respectively. The estimated mean and median survival time were 131.5 (S.E. = 7.2) and 157.0 months respectively. Five- and ten-year cumulative success probabilities were 74.2% and 42.4% respectively while five- and ten-year cumulative survival probabilities were 79.0% and 64.4% respectively.

Table 2a
The estimated mean and median success (time-to-complication/repair) time as well as the five- and ten-year cumulative success probabilities of posterior FM RBFPDs reviewed in this study.

Overall	
The estimated mean success time (standard error)	101.4 (6.3) months
The estimated median success time (standard error)	104.4 (7.2) months
Five- and ten-year cumulative success probabilities	74.2% and 42.4%

Table 2b
The estimated survival times (time-to-failure/replacement) and cumulative survival probabilities of posterior FM RBFPDs reviewed in this study.

Overall	
The estimated mean survival time (standard error)	131.5 (7.2) months
The estimated median survival time^{+}	157.0 months
Five- and ten-year cumulative survival probabilities	79.0% and 64.4%
Prostheses inserted after year 2001^	
The estimated mean survival time (standard error)	***135.9 (7.3) months**
Five- and ten-year cumulative survival probabilities	82.3% and 74.1%
Prostheses inserted in or before year 2001	
The estimated mean survival time (standard error)	***111.5 (12.2) months**
The estimated median survival time (standard error)	116.0 (10.6) months
Five- and ten-year cumulative survival probabilities	71.9% and 50.0%

*** Significant difference by log rank test (p = 0.01).**
$^{+}$Standard error of the median survival time could not be calculated as the cumulative survival probability just dropped to 50%.
^Median survival time could not be calculated as the cumulative survival probability did not drop below 50%.

4. Single factor in success/survival analysis

Five categorical factors were examined i) undergraduate dental students *vs.* qualified dentists (operator experience), ii) molar pontics *vs.* premolar pontics, (tooth/teeth replaced) and iii) three-unit *vs.* four-unit or more (number of units), iv) maxillary prostheses *vs.* mandibular prostheses (prosthesis location) and v) prostheses inserted in or before year 2001 *vs.* prostheses inserted after year 2001 (insertion year). These factors were analyzed for their association with the success/survival rate.

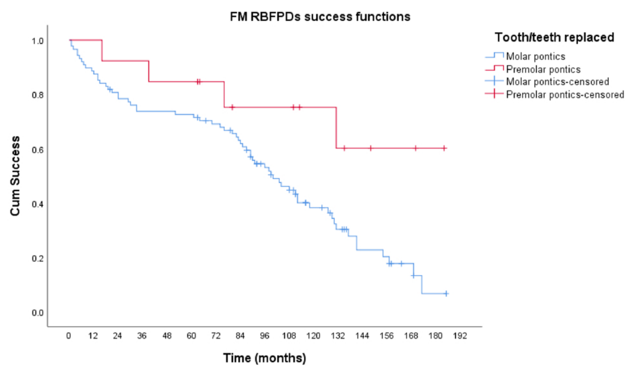
For success rate of the prostheses, the Kaplan Meier life table and log rank test revealed that posterior FM RBFPDs with molar pontics had a significantly lower success rate than these with premolar pontics (p = 0.03) (Fig. 3a). It was also observed that the prostheses inserted by undergraduate dental students shown significant higher success rate than those inserted by qualified dentists (p = 0.04) (Fig. 3b). However, other factors such as the number of units, prosthesis location and insertion year did not result in any statistically significant difference in the success rates (p > 0.05).

For survival rate of the prosthesis, the Kaplan Meier life table and log rank test revealed that posterior FM RBFPDs inserted after year 2001 had a higher survival rate than those inserted in or before 2001 (p = 0.01) (Fig. 4 and Table 2b). The five- and ten-year cumulative survival probability of prostheses inserted after year 2001 were 82.3% and 74.1% respectively compared to 71.9% and 50.0% for those inserted in or before 2001. Other factors such as the operator experience, tooth/teeth replaced, the number of units and location of prosthesis did not result in any statistically significant difference in the survival rates (p > 0.05).

5. Multiple (categorical) factors in success/survival analysis

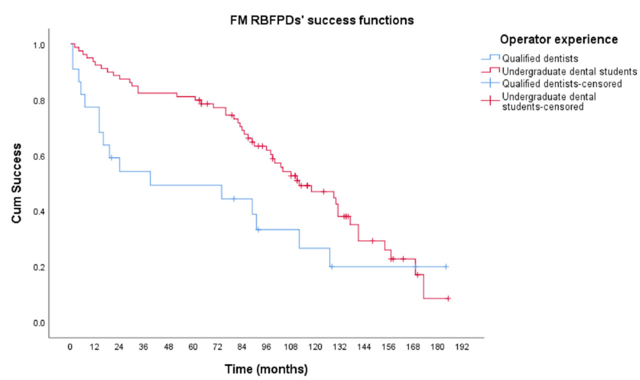
Cox regression were performed for the multivariate success- and survival-rates analysis. FM RBFPDs inserted by qualified dentists were associated with a reduced time to complication with a complication hazard ratio 2.16 (95% Confident interval CI: 1.15–4.05) when compared with prostheses inserted by undergraduate dental students (p = 0.02). Moreover, prostheses with molar pontics were associated with a reduced time to complication with a complication hazard ratio 3.39 (95% CI: 1.20–9.55) when compared with prostheses with premolar pontics (p = 0.02). Prostheses that were inserted in or before year 2001 were associated with a reduced time to failure with a failure hazard ratio 2.46 (95% CI: 1.25–4.83) when compared with prostheses that were inserted after year 2001 (p = 0.01).

a)



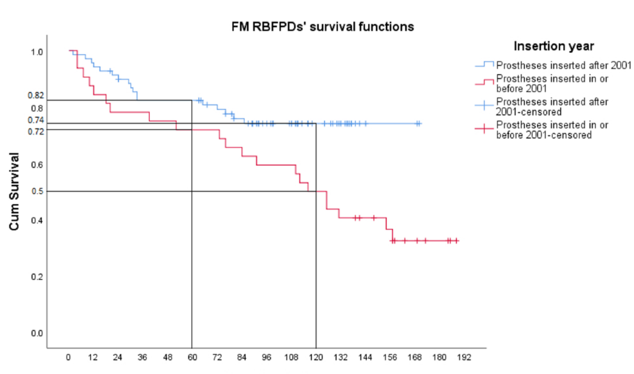
p=0.03

b)



p=0.04

Fig. 3. Kaplan Meier life tables and log rank analysis of the success functions of FM RBFPDs reviewed in this study.



p=0.01

Fig. 4. Kaplan Meier life table and log rank analysis of the survival functions of FM RBFPDs reviewed in this study.

6. Complications

6.1. Technical complications

In this study, the most frequently observed complications were debonding of prostheses (Table 3a). There were 54 debonds among 34 prostheses, from which 26 of these failed (lost or replaced). Forty-eight debonds (88.9% of all debonds) occurred on 28 major retainers (82.4% of all debonded prostheses) (Fig. 5). Three prostheses experienced fracture of the framework or patrix connector with all failures. Four prostheses presented with veneering porcelain fractured with one failure in which the major retainer also debonded.

Table 3a
Incidence of technical complications occurred at the retainers and pontics of posterior FM RBFPDs reviewed in this study. *Failure* = Original prosthesis not clinically present in patient's mouth.

Technical complications
Debonding of prostheses - 34 prostheses: 54 debonds with 26 *failures*
Major retainers debonded
● Twenty-eight retainers: 48 debonds with 22 *failures*
● Number of debonds: 15 retainers once; seven retainers twice, five retainers thrice and one retainer four times
Minor retainers debonded
● Two retainers: two debonds with one *failure*
Both major and minor retainers debonded
● Four prostheses had both major and minor retainers debond once each with three *failures*
Fracture of prostheses - 7 prostheses with 3 *failures*
● Four fractured veneering porcelain with one failure - debonded
● One fractured patrix connector (*failure)*
● Two fractured frameworks (both *failures)*

Table 3b
Incidence of biological complications occurred at the abutment teeth of posterior FM RBFPDs reviewed in this study. *Failure* = Original prosthesis not clinically presented in patient's mouth.

Biological complications
Probing depth greater than 5 mm - 16 prostheses
● Eight MjT, two MnT and in six subjects both abutment teeth had probing depth > 5mm
● ^One MnT had probing depth > 5mm, caries and apical radiolucency
● +One case both abutment teeth had probing depth > 5mm and the MjT had apical radiolucency
Periodontics -1 prosthesis - failure
● One case both abutment teeth were extracted/loss due to periodontal reason (*failure*)
Caries related to the retainer -5 prostheses (two major and three minor abutment teeth) with 2 failures
● Of two MjT had caries, one was extracted (failure)
● One MnT was extracted (failure)
● ^One MnT had caries, probing depth > 5mm and apical radiolucency
● #One MnT had caries and apical radiolucency
Endodontic – 5 prostheses (two major and three minor abutment teeth) with 2 failures
● One MjT was endodontically treated and the prosthesis was removed (*failure,* abutment tooth survived)
● +One MjT had apical radiolucency and both abutment teeth had probing depth > 5mm
● One MnT had apical radiolucency, was endodontically treated and was extracted due to root fracture (*failure*)
● ^One MnT had caries, probing depth > 5mm and apical radiolucency
● #One MnT had caries and apical radiolucency
Periodontal-endodontic -1 prosthesis and failure
● One case both teeth were extracted due to the periodontal-endodontic involvement (*failure*)
Undefined -3 prostheses with all failures
● One MjT was extracted due to "pain" (*failure*)
● One case both abutment teeth were extracted due to "pain" (*failure*)
● One case both abutment teeth were found "inflamed" and the FM RBFPD was replaced by the conventional FPD (*failure*, abutment teeth survived)

^ # + Prostheses suffered from multiple biological complications.
MjT = Major abutment teeth; MnT = Minor abutment teeth.

7. Single and multiple factor(s) in retention analysis

Due to differences in the service life of the prostheses, Kaplan Meier analysis was used to determine the estimated mean time-to-debond

Fig. 5. Example of debonded major retainer showing residual cement on the abutment tooth. On reseating, the retainer framework demonstrated distortion and a poor fit which appeared to be related to a thin framework less than the recommended 1.0 mm for a long span RBFPD. The major retainer was not re-cemented *i.e.* failure and was remade.

Table 4
The estimated mean retention time (time-to-debond) and cumulative debonding probabilities of posterior FM RBFPDs reviewed in this study.

Overall	
The estimated mean retention time (standard error)	131.7 (7.4) months
Five- and ten-year cumulative retention probabilities	77.9% and 62.2%

Median retention time could not be calculated when the cumulative retention probability did not drop below 50%.

(retention rate). Overall this was 131.7 months (S.E. = 7.4). The five- and ten-year cumulative retentive probabilities were 77.9% and 62.2% respectively (Table 4 and Fig. 6a). Log rank test revealed that prostheses inserted by undergraduate dental students showed significantly higher retentive rate than those inserted by qualified dentists ($p = 0.01$) (Fig. 6b). No statistically significant relationship between the time-to-debond and factors such as the number of units, prosthesis location and insertion year as well as the tooth/teeth replaced ($p > 0.05$).

For multifactor analysis, Cox regression revealed the prostheses inserted by qualified dentists were associated with decreased retention time with debonding hazard ratio 3.59 (95% CI: 1.60–8.09) when compared with prostheses inserted by undergraduate dental students ($p < 0.01$).

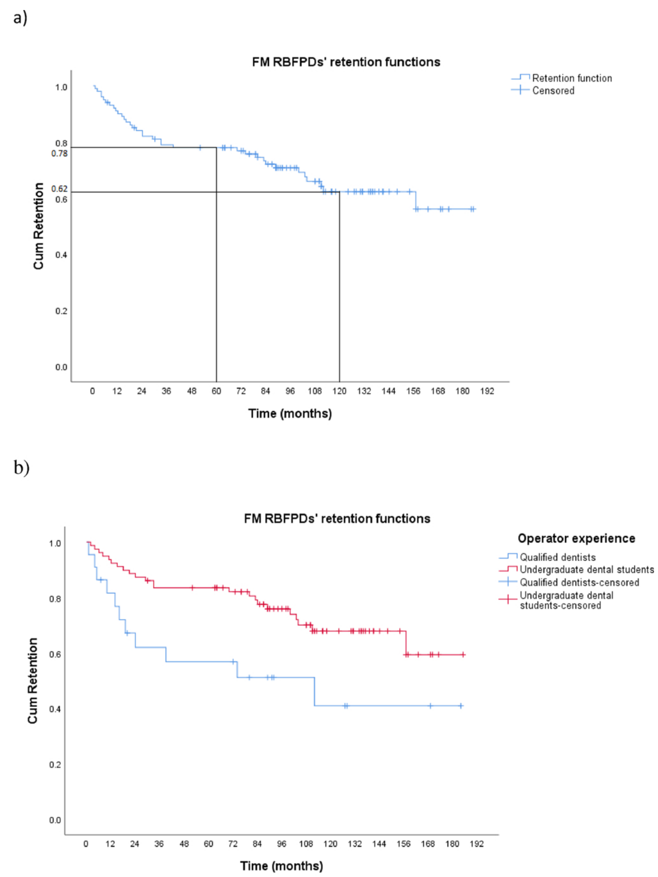
7.1. Biological complications

The most frequently observed biological complications in this study were probing depth greater than 5 mm around the abutment tooth/teeth of 16 prostheses (Table 3b). Five abutment teeth were found to have caries (5.0% of all prostheses). Abutment teeth also suffered from complications such as periodontics, endodontics, root fracture and "pain" *etc.*: nine prostheses failed and of these, seven cases and ten abutment teeth (7.0% of all cases and 5.0% of all abutment teeth) were extracted or lost.

7.2. Patient reported outcomes

7.2.1. Prosthesis satisfaction questionnaire (visual analogue scale 0–100)

Patients' mean *general* satisfaction to the FM RBFPDs were 84.3 ± 13.5 out of 100 indicating high satisfaction (Fig 7a). The mean satisfaction to *appearance*, *comfort*, *chewing ability*, *firmness of prosthesis*, *confidence with that prosthesis* were all above 80 and the mean satisfaction to *speech* was over 90. The mean satisfaction to *ease of cleaning*



p=0.01

Fig. 6. Kaplan Meier life table and log rank analysis of the retention functions of FM RBFPDs reviewed in this study.

and *its comparison with natural teeth* were above 75. The mean satisfaction to the *treatment time for completion* (one missing data), *treatment comfort*, *cost* and *operator* were around or above 80. Eighty-five patients (84.2%) would select this treatment again (three missing data) and eighty-six patients (85.1%) would recommend this treatment to others (two missing data).

7.2.2. Oral health impact profile 49 (Likert scale 0–196)

The mean OHIP-49 summary score was 20.5 ± 19.6. The *functional limitation* (0–36) and *physical pain* (0–36) domains have mean scores 5.3 ± 4.5 and 7.1 ± 5.6 respectively (Fig. 7b). The mean scores of *psychological discomfort* (0–20), *physical disability* (0–36), *psychological disability* (0–24), *social disability* (0–20) and *handicap* (0–24) domains were all below 4. Two patients did not complete the OHIP-49 questionnaire and were regarded as missing data.

8. Discussion

This study evaluated the clinical longevity of posterior fixed-movable (FM) resin bonded fixed partial dentures (RBFPD) in terms of *success*, *survival* and *retention*. ***Success*** is a strict longevity criterion in which absence of complications requiring treatment intervention beyond routine periodontal maintenance *i.e.* sound condition of both the prosthesis and the abutment teeth. Therefore, low success rate and cumulative probabilities were perhaps anticipated after 10 years. After five-year three-quarter and after ten-year less than half of FM RBFPDs were rated as success.

Survival was defined as the original prosthesis retained in patient's mouth irrespective of its condition. Therefore, survival rate and cumulative probabilities were expected to be higher than that of success.

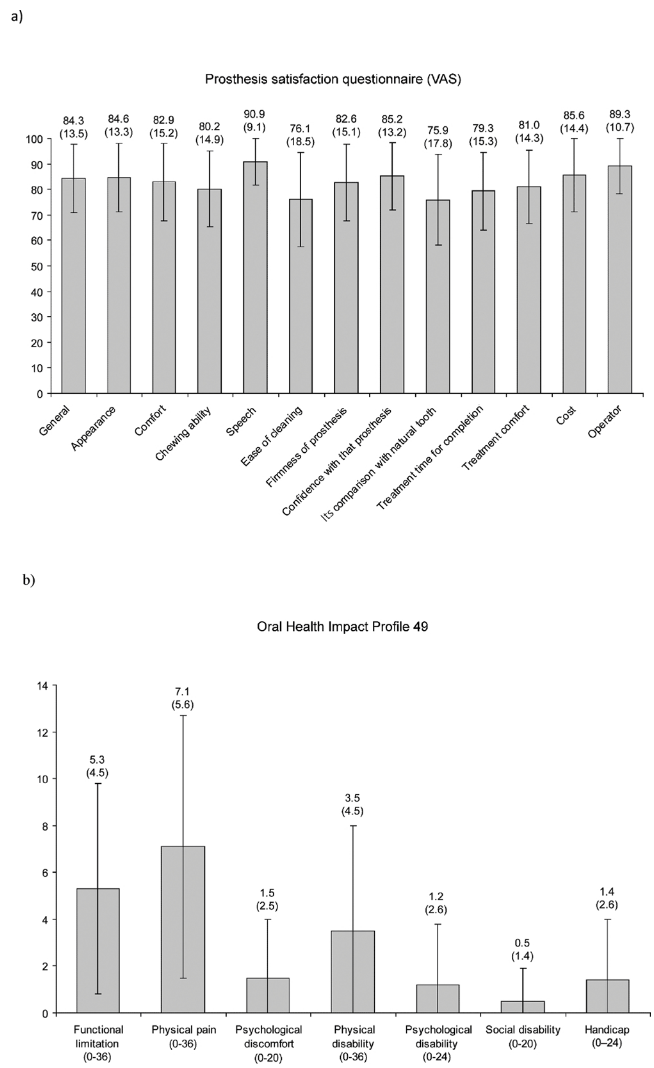


Fig. 7. Results of a) Prosthesis satisfaction questionnaire and b) Oral Health Impact Profile 49 in this study.

FM RBFPDs inserted after year 2001 presented a clinically acceptable five-year 82.3% and ten-year 74.1% cumulative survival probabilities. This result was in agree with our preliminary study on three-unit FM RBFPDs which had 93.9% survival proportion after mean 2.6-year (31.8 months) observation [27] and lies within the of estimated five-year survival rate 87.7% (95% confident interval 81.6–91.9%) of pooled RBFPDs in a systematic review [34].

Since debonding was the most frequent complication in this and in many other RBFPDs studies [11,33,34], the ***retention*** rate and cumulative probabilities were also investigated. Five- and ten-year cumulative retention probabilities were 77.9% and 62.2% respectively. This is similar to a clinical study of three-unit FM RBFPDs with 77.6% retention proportion after mean 2.6-year observation [27].

The five- and ten-year *survival* probabilities of posterior FM RBFPDs inserted after year 2001 in this study (82.3% and 74.1% respectively) are lower than the two-unit cantilevered (CL2) design of our previous study (97% and 91% respectively) [11]. However, it has to be stressed that CL2 RBFPDs have been used in the replacement of mostly anterior teeth and premolars and in general RBFPDs in posterior region have lower survival than those in anterior region [44]. Three-quarter (n = 29) of all failures (n = 38) in this study were related to technical complications with 26 of these (68.4%) failed due to debonding and three (7.9%) due to fracture of framework or connector. Nine cases (23.7%) had complex biological complications and of these, ten abutment teeth (5% of all abutment teeth) were extracted or lost. Loss of abutment teeth due to periodontal reason was around 2.1% of RBFPDs over 5-year [34] and more teeth were expected to be lost in the posterior region and for a longer observation period [45].

More FM RBFPDs debonded in this study (five- and ten-year cumulative retention probabilities 77.9% and 66.2% respectively) in comparison to the CL2 design for which 86.7% retention probabilities after mean 9.4 years (113.2 months) observation time [11]. This is in agreement with the finding that annual debonding rate for posterior RBFPDs (5.03%) were higher than that of anterior (3.05%) from a systematic review [34]. Possible explanation for this observation is increased occlusal force received by posterior FM RBFPDs with molar-sized or longer pontics [46,47]. The increased loading in the posterior region may also contribute to the fracture of frameworks. While FM-RBFPDs experience higher debonding rates that two-unit cantilever designs, the non-rigid connector allows recementation of debonded major retainers which is 82.3% (n = 28) of all 34 debonded prostheses in this study.

The mean retention rate (time-to-debond) of the FM prostheses in this study (131.7 months, S.E. = 7.4), however, was higher than that of CL2 design (mean time to first debond 52.5 months and to second debond 48.7 months). For the increased time-to-debond among FM RBFPDs, this may be due to an improved retainer design such as increased abutment teeth coverage and the use of auxiliary resistance features [41]. In this study posterior FM RBFPDs inserted after year 2001 shown better survival rate and cumulative probabilities than those inserted in or after 2001. This may be explained by the improvement of tooth preparation and framework design in response to clinical debonds and wraparound was extended and extension of the framework on the occlusal surface to control occlusal contacts [29].

Prostheses that replaced molar(s) *i.e.* molar pontics in this study have significantly higher complication (*i.e.* lower success) rate than premolar(s) pontics and this may explained by molar pontics having a longer span or their location receiving greater occlusal loading [46] and this may increase the frequency of technical complications.

In this study, mandibular prostheses have similar longevity as the maxillary ones. This is also observed in other studies [48–50] however more failures were found among the mandibular prostheses in some studies [11,51,52]. Moreover, no statistical significance was found for association of the number of units of prostheses to the longevity which is contrary to other studies with a reduced longevity with an increase in the number of units of fixed-fixed RBFPDs [48,53]. However from this center, long-span (4-unit or more) FM RBFPDs have been shown to have a higher retention rate of 92.2% (mean age 46.9 months) compared to three-unit FM RBFPDs with a retention rate of 77.6% (mean age 31.8 months) [27,41]. This may be related to more attention to planning and execution of a longer span prostheses with more wraparound and resistance features of these RBFPDs as well as including some of prostheses that replaced two premolars (*i.e.* premolar pontics) which receiving less occlusal loading.

Most of the prostheses were inserted by the undergraduate dental students with limited clinical experiences. Some studies have reported on the effects of operator experience impacting prostheses longevity [11,54] while others have not [52]. Despite the FM RBFPDs inserted by qualified dentists had higher complication and debonding rate, this anomaly may be due to more challenging cases managed by them at the teaching hospital. Therefore the result of this study should be applicable to most of the dental practices provided that the clinician and the dental laboratory followed the recommended treatment approach [18,22,41], have good case selection and maintenance.

The patient-reported outcomes of posterior FM RBFPDs have shown high patients' satisfaction and relatively low negative impact of posterior FM RBFPDs on patients' oral health related quality of life. Given the knowledge of the apparently shorter longevity of FM RBFPDs compared to CL2 RBFPDs, a randomized clinical trial on replacement of molar-sized missing teeth span using three-unit FM (FM3) or CL2 design is being conducted [55] and the preliminary result shown that FM3 RBFPDs behave similar to that of CL2 design.

9. Conclusion

This long-term clinical audit showed that the posterior fixed-movable (FM) resin bonded fixed partial dentures (RBFPDs) have high patient acceptance and can be considered a viable restorative option for replacing missing posterior teeth. It was of interest to know that the more recent designs of RBFPDs cemented after 2001 have improved longevity.

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