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Removable Partial Denture Design: A Study of a Selected Population in Saudi Arabia

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Abstract

Determination of the incidence of various classes of removable partial dentures (RPDs) including their designs and their comparison with previous studies provide clinically useful information for dental training and continuing education. The purpose of this study is to determine the pattern of partial edentulism, the major connector, clasping, and design of 740 cobalt chromium RPD frameworks constructed for a selected population in Saudi Arabia. RPD framework design information and patient personal data were obtained from the work authorization form and the dental records respectively. The relationship among age, sex, nationality, and various Kennedy classes of the RPDs was determined by chi-square statistical analysis. Results indicate that Kennedy Class III removable partial dentures were the most frequently constructed. Although gender had no significant relationship, age and nationality had statistically significant relationship with the distribution of various Kennedy classes of removable partial dentures. Lingual bars and anterior posterior palatal straps were the most commonly used mandibular and maxillary major connectors. Lingual and palatal plates, however, were more frequently used than any major connectors for distal extension RPDs. Comparison with previous findings confirms the established variation in designing RPDs. The distribution of partially edentulousness revealed the influence of the general pattern of tooth loss, which could be modified by patient's demands and socio-economic status. Practitioners need to avail themselves fully of basic RPD design principles concerning the most commonly encountered classes of RPDs.

Keywords: Partial edentulism, RPD frameworks, removable partial denture design, Kennedy classification

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Introduction

Removable partial prosthodontics is a versatile, cost effective, and reversible treatment method for partially edentulous patients at any age. With the changing trends in dental treatment that favor retention of natural teeth, a decline in the number of complete dentures with an increase in the number of removable partial dentures (RPDs) is anticipated.[1]

The objectives of RPD design have been well established. They include the restoration of function, enhancement of esthetic and, most importantly, the preservation of the remaining teeth and periodontal structures.[2] The primary purpose for the classification of partially edentulous arches is to identify potential combinations of teeth to edentulous ridges in order to facilitate communications among dental colleagues, students, and technicians. Such classification should allow longitudinal comparison of the incidence of the various classes of RPDs. Moreover, the trends in the incidence of the various classes of RPDs being fabricated should be reviewed periodically to serve as teaching guidelines.[3] A survey by Stratton and Wiebelt included three thousand partially edentulous mandibular arches and two thousand partially edentulous maxillary arches. The distribution of various Kennedy Classes of RPDs were predominated by Kennedy Class I in the mandibular arch (Figure 1) and Kennedy Class III in the maxillary arch (Figure 2).[4]

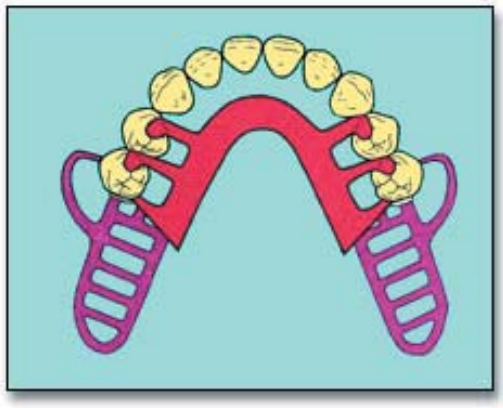

Figure 1. A mandibular Kennedy Class 1 RPD framework.

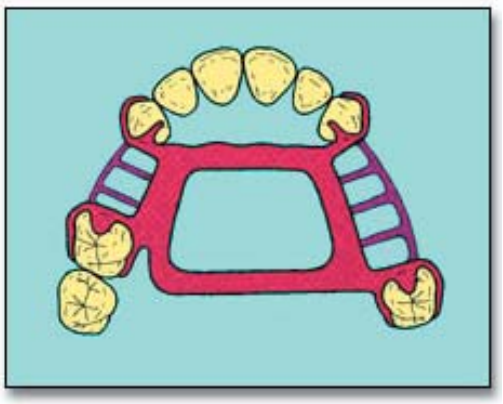

Figure 2. A maxillary Kennedy Class 3 RPD framework.

Variations in RPD design have been demonstrated among dentists and laboratories.[5-8] Similarly, variations in teaching and practice of design concepts is also known to occur among countries as exemplified by the documented differences in the types of major connectors used in Sweden compared to North America.[9,10] A survey of the dental profession and dental laboratories in the United Kingdom has revealed that up to 60% of casts received by laboratories has little or no input from the dentists in the design of their patients' dentures.[12] Over the years, the concepts of RPD design have been predicated on many factors such as clinical conditions, scientific research findings, social acceptance, dogmatic traditions, and philosophical axioms.[3,10,11]

The patterns of tooth loss have been evaluated in many selected populations in different countries.[13-18] The objectives of this study were to determine the patterns of partial edentulism

and design frequency of cobalt chromium RPD frameworks constructed for patients who attended the clinic at the College of Dentistry, King Saud University, Riyadh, Saudi Arabia to establish a database for trend comparison and to what extent current design concepts are being followed.

Materials and Methods

The work authorization forms for 650 patients requiring RPDs from the clinics of the College of Dentistry, King Saud University, Riyadh written during a one-year period were reviewed for this study. Dental students under faculty supervision, interns, and faculty staff treated the patients. Excluded from this study were work authorizations for transitional RPDs (29%) and non-conventional RPDs such as swing lock RPDs (0.6%), obturators (1%), precision-attachment retained RPDs (2%), and situations in which the designs and instructions were ambiguous (2.5%). Of the 650-work authorizations reviewed, 422-work authorizations for conventional cobalt chromium RPD frameworks were included in the study.

The Kennedy classification with the guidelines advocated by Applegate for each partially edentulous arch was recorded.[19,20] Categorization of the modifications for the Kennedy RPD classes was expanded to five categories:

1. No modification area
2. Anterior modification area
3. Posterior modification area
4. Combined anterior and posterior modification area and
5. Extensive RPD where only one or two teeth present on either or both sides of the arch.

The number of modification areas, the type of major connector, the number and type of direct retainer, the use of indirect retainer, and location of rest seats on distal extension RPDs were also recorded. The age, gender, and nationality of the patients were obtained from the dental records, and their relationship with the various Kennedy classifications was determined by chi-square statistical analysis.

Results

Table 1 indicates the number, age, and gender distribution of the sample population. The mean age was 42 for both males and females. Out of 422 patients, 319 had RPDs in both arches and 103 had RPDs in one arch only. The total number of RPD frameworks was 740. Their distribution based on the Kennedy classification is delineated in Table 2. Class III (40.8%) were the most frequently constructed and Class IV (5.9%) RPDs were the least frequently constructed (Figure 3).

Figure 3. A maxillary Kennedy Class 4 RPD framework.

While maxillary Class III and Class IV RPDs were more common than their mandibular counterparts, more mandibular than maxillary distal extension RPDs (Classes I and III) were found. Of the anticipated 16 combinations of various classes of RPDs among the 319 patients with RPDs in both arches, only the maxillary Class IV RPD opposing mandibular Class IV RPD combination was absent. The maxillary Class III RPD and opposing mandibular Class III RPD combination was the most common (22.5%), followed by the maxillary Class III RPD opposing mandibular Class II RPD combination (13.1%). Next most common were the maxillary Class I RPD opposing mandibular Class I RPD and the maxillary Class II RPD opposing mandibular Class II RPD combination, both at a frequency of 11.3%.

Among the RPDs without modifications, Class I RPDs [maxillary (6%) and mandibular (12%)] were the most common, (Table 3). RPDs with combined anterior and posterior modification areas as well as extensive modifications were more frequently found in the Kennedy Class III followed by Class II of the maxillary arches than in the mandibular arch where the posterior

Table 1: Age and sex distribution of the sample.

Age Group	Male	Female	Total n (%)
15-24	21	9	30(7)
25-34	56	25	81 (19.1)
35-44	91	49	140(33.1)
45-54	85	32	117 (27.7)
55-64	30	7	37 (8.7)
>65	15	2	17 (4)
Total	298	124	422(100)

Table 2: Distribution of RPD frameworks according to Kennedy Classification by arch.

Arch	Class I	Class II	Class III	Class IV	Total
	n (%)	n (%)	n (%)	n (%)	n (%)
Maxilla	72 (20)	96 (27)	162 (45)	32 (8)	362 (100)
Mandible	116 (30)	110 (30)	140 (37)	12 (3)	378 (100)

Table 3: Distribution of RPD classes according to pattern of modification areas by arch (n=740).

Class	No Modification Area		Anterior Modification Area		Posterior Modification Area		Combined Modification Area		Extensive Modification Area	
	Max n (%)	Mand n (%)	Max n (%)	Mand n (%)	Max n (%)	Mand n (%)	Max n (%)	Mand n (%)	Max n (%)	Mand n (%)
Class I	45 (6.0)	92 (12.4)	14 (1.9)	15 (2.0)	2 (0.3)	3 (0.4)	6 (0.8)	5 (0.7)	4 (0.5)	2 (0.3)
Class II	15 (2.0)	15 (2.1)	11 (1.5)	5 (.07)	40 (5.4)	81 (10.9)	26 (3.5)	9 (1.2)	3 (0.4)	1 (0.1)
Class III	20 (2.7)	30 (4.1)	31 (4.2)	8 (1.1)	61 (8.2)	84 (11.4)	36 (4.9)	16 (2.2)	15 (2.0)	1 (0.1)
Class IV	21 (2.8)	11 (1.5)							11 (1.5)	1 (0.1)

modification areas were predominant. Of the 740 frameworks, 491 (approximately two-thirds) exhibited one or more modification areas.

The relationship between age, gender, nationality, and the distribution of RPD classifications is demonstrated in Table 4. Although gender had no significant relationship, age and nationality was statistically significantly related to classification ($x^2=61.2$ $p<0.0001$ and $x^2=33.79$; $p<0.0001$ respectively). There was a tendency for RPD designs to increase in numerical values from Class I to Class III between the 15-24 age group and the 35-44 age group. On the other hand, the designs tended to decrease from Class IV to Class I from 45-54 age group upwards to 64 years of age. Both Saudi (mean age 44± 12.9) and non-Saudi Arabs (mean age: 44.9±10.4) tended to have similar patterns of RPD classification distribution. Both groups had more Class I RPDs

Table 4: Distribution of RPD Classes by age, gender and nationality (n=740).

	Class I	Class II	Class III	Class IV	Total
	n (%)	n (%)	n (%)	n (%)	
Age Group*					
15 – 24	6 (0.8)	13 (1.8)	24 (3.2)	5 (0.7)	48 (6.5)
25 – 34	21 (2.8)	34 (4.6)	80 (10.8)	11 (1.5)	146 (19.7)
35 – 44	53 (7.2)	65 (8.8)	110 (14.9)	12 (1.6)	240 (32.4)
45 - 54	67 (9.1)	64 (8.7)	64 (8.7)	11 (1.5)	206 (27.8)
55 – 64	34 (4.6)	17 (2.3)	13 (1.8)	4 (0.5)	68 (9.2)
>65	7 (0.9)	13 (1.8)	11 (1.5)	1 (0.1)	32 (4.3)
Gender					
Male	128 (26)	154 (30)	209 (40)	32 (4.3)	522 (60)
Female	60 (28)	52 (24)	94 (43)	12 (5.6)	218 (29.5)
Nationality					
Saudi	79 (10.7)	68 (9.2)	97 (13.1)	4 (0.5)	248 (33.5)
Non-Saudi Arab	35 (4.7)	23 (3.1)	50 (6.8)	10 (1.4)	118 (15.9)
Filipino	47 (6.3)	85 (11.5)	124 (16.7)	19 (2.5)	274 (37.0)
Non-Arabs	27 (3.6)	30 (4.1)	32 (4.3)	11 (1.5)	100 (13.5)

than Class II RPDs. The Filipino patients (mean age: 36.9 + 8.4) and other non-Arab patients (mean age: 42.1+11.1) tended to have a steady increase in the number of RPDs from Class I to Class III.

Table 5 indicates that lingual bars (76.9%) and anterior-posterior palatal straps (38.7%) were the most commonly used mandibular and maxillary major connectors when all classifications were included. The distribution of the major connectors by Kennedy classification revealed the palatal strap was numerically the most prescribed single maxillary major connector. Close to two-thirds (61.4%) of the total number of direct retainers used were circumferential clasps. This clasp type was almost evenly distributed between both arches. Ring clasps were used to retain mandibular RPDs approximately twice as frequently as were the clasps used to retain maxillary RPDs. On the contrary, infrabulge clasps were used twice as frequently for maxillary RPDs compared to mandibular RPDs. Likewise, embrasure clasps were more frequently seen in the maxillary RPDs.

Table 5: Distribution of major connector by Kennedy Classification.

	Class I n (%)	Class II n (%)	Class III n (%)	Class IV n (%)	Total
Maxilla					
Palatal Plate	16 (4.4)	15 (4.1)	10 (2.8)	7 (1.9)	48 (13.3)
Palatal Strap	6 (1.7)	26 (7.2)	82 (22.6)	7 (1.9)	121 (33.4)
U-shaped Palatal Strap	2 (0.5)	4 (1.1)	16 (4.4)	16 (4.4)	38 (10.5)
Ant. Post Palatal Strap	37 (10.2)	48 (13.3)	54 (14.9)	1 (0.3)	140 (38.7)
Palatal Bar	0	0	0	1 (0.3)	1 (0.3)
Combined Palatal Metal Plate & Resin Base	11 (3.0)	0	0	0	14 (3.9)
Total					**362 (100)**
Mandible					
Lingual Bar	72 (19.0)	85 (22.5)	125 (33.0)	9 (2.4)	291 (76.9)
Lingual Plate	44 (11.6)	21 (5.6)	14 (3.7)	3 (0.8)	82 (21.7)
Interrupted Lingual Plate	0	4 (1.0)	1 (0.3)	0	5 (1.3)
Total					**378 (100)**

RPI and RPA clasp assembles were more frequently used in the mandibular arch than in the maxillary arch. Figures 4 and 5 indicate the distribution of the types of clasps and the locations of rest seats on the abutment teeth of distal extension RPDs. On the average, 75.6% of Class I RPDs and 78.9% of Class II RPDs had indirect retainers incorporated into their designs. Indirect retention was used more often in the mandibular Class I than in the maxillary Class I frameworks. Whereas, its use was more frequent in the maxillary Class II than the mandibular counterpart.

Discussion

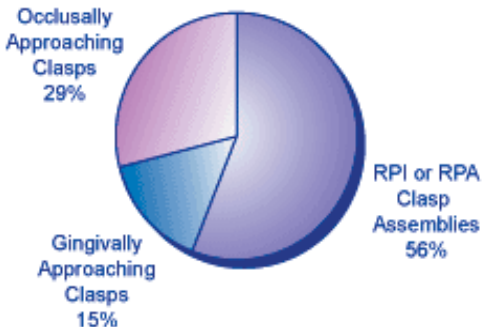

Figure 4. Distribution of clasp types on the abutment teeth of distal extension removable partial denture. (Class I and Class II RPDs).

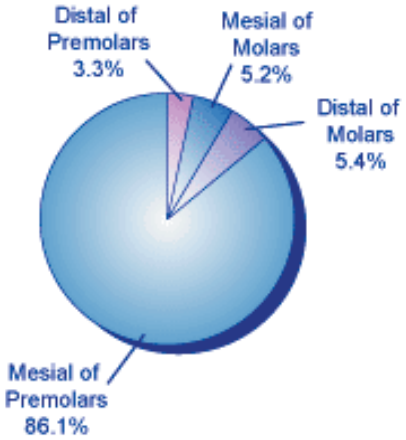

Figure 5. Distribution of rest seats on the abutment teeth of distal extension removable partial denture. (Class I and Class II RPDs).

The RPD services are provided at no charge at King Saud University, College of Dentistry clinics and both Saudis and non-Saudis avail themselves to this opportunity. Thus, the study population is a diverse cross section of the society.

A comparison between studies where age and gender distribution of the RPDs was indicated reported that more Class I followed by Class II RPDs were found in a study with a higher proportion of females, older adults (>50 yrs), and mandibular prostheses.[18] On the contrary, in a study where there were higher proportions of males, younger adults (<50 yrs), and maxillary RPDs, more Class III followed by Class II RPDs were found.[12] This study had higher proportions of younger adult males and approximately equal numbers of maxillary and mandibular prostheses.

Previous reports indicated mandibular distal extension RPDs (Classes I and II) are more common than maxillary distal extension RPDs (Classes I and II).[12,18] The opposite case with Class III and Class IV RPDs is supported by this study and is in agreement with the established patterns of tooth loss.[11,13-17] When a comparison was made between this study and the survey that included 3,000 partial edentulous mandibular arches and 2,000 maxillary arches,[4] there was an agreement in the proportion of various classes of RPDs in the maxillary arch only.

A previous study of the patterns of tooth loss in Saudi Arabia reported that females had a significantly higher rate of mandibular molar tooth loss compared to males, suggesting there is a greater likelihood of finding mandibular distal extensions among females.[16] Nevertheless, this study did not find significant gender differences for extension base RPDs possibly because males outnumbered females by more than half in the study population. Moreover, in this study, the increase in the record number of distal extension RPDs with advancing age was consistent with the finding of a proportionate number of edentulous spaces without distal abutments in patients with a significant increase in age. This finding is further reinforced in this study because the Filipino patients with the lowest mean of age had a higher proportion of Class III and Class IV RPDs compared to nationalities that had higher age averages. For information purposes, Filipino

dentists may routinely extract maxillary anterior teeth rather than to restore them because they feel the esthetics of the anteriors are better with a removable appliance.

Restoring Class III and Class IV partially edentulous arches with fixed partial dentures (FPDs) is not totally free of charge like the RPDs services at King Saud University, College of Dentistry clinic. However, since the FPD service is not free of charge, this may influence the number of partially edentulous patients with Kennedy Class III to seek RPDs instead.

The preference for anterior–posterior palatal strap major connectors found in the study as opposed to the U shaped palatal strap[11] or single strap[16] reported in other studies confirms the established variation that exists in RPD design concept. The anterior–posterior palatal strap appears to have been used indiscriminately especially in Kennedy Class II and III when the simpler palatal strap was more of a logical choice giving more comfort to the patient because there is less tissue coverage and fewer borders to bother the tongue.[4] In this study as well as the North American study[9] the lingual bar was found to be the most common major connector, but this is not the case in Sweden[7-8] where the dental connector cingulum bar is the preferred choice of mandibular major connector because of patient comfort. Frenum attachment depth of the lingual alveolar sulcus and the presence of tori have been found to have the greatest influence on the choice of mandibular major connectors, while compromised periodontium and existing dentures were found to have less influence.[21] The influence of the clinicians preference has yet to be fully investigated. (Figure 6, 7)

Similarly, the lingual plate was more frequently used than the lingual bar for mandibular distal extension RPDs (Class I and Class II) confirming a previous finding.[18] Factors such as rigidity, support, and indirect retention probably played a significant role in influencing the choice of these major connectors. The overwhelming preference for circumferential clasps was demonstrated in this study (where over 50% of the RPDs were Class I and Class II) in accordance with a previous study (where 73% of the RPDs were

Figure 6. Mandibular RPD frameworks with various lingual major connectors.

Figure 7. Maxillary Kennedy Class 1 RPD frameworks with mofified palatal metal plates and full coverage metal plates with and without resin base combinations.

Class I and Class II).[11] In spite of the reported mechanical and esthetic advantages of a gingivally approaching clasp over an occlusally approaching clasp, many factors such as plaque formation and unfavorable anatomical factors often mitigate against its use.[22]

It was also anticipated that more frequent use of the infrabulge clasp in the maxilla than in the mandible indicates the higher priority for esthetics in the maxilla. On the other hand, the more frequent use of the ring clasp in the mandible than the maxilla may suggest the higher tendency of finding mesially inclined mandibular terminal molar abutments than the maxillary counterparts.

The prescription of RPI and RPA clasp assemblies for only 55.4% of distal extension cases were not

comparable to the reported, wherein there is a very limited use of these clasp systems for similar cases constructed in a regional commercial dental laboratory and in a general practice set up (Figure 4).[11,18] On the contrary, an overwhelming use of mesial rests (91.3%) on distal extension abutment teeth found in this study was noticed (Figure 5).

The result of this study showed treatment philosophy in King Saud University, College of Dentistry has been effective in teaching the benefits of the RPI/RPA and mesial rest. During function, the rotation occurs in the area of mesial rest; the I-bar and proximal plate disengage from the tooth and the abutment tooth is usually braced by a mesial adjacent tooth.[2]

The RPI is shorthand designation for a clasp assembly where "R" represents the occlusal rest that is placed on the mesial occlusal aspect of a distal abutment. The "P" represents the proximal plate and the "I" designates I bar retention. The principle of the RPI design is to minimize unfavorable forces on abutment teeth in RPD cases. The RPA is an alternative designation for the same concept with the "A" representing "clasp assembly".

Although more mandibular Class II RPDs were constructed than maxillary Class II RPDs in this study, indirect retainers were incorporated more often in the maxillary Class II RPD than in the mandibular Class II RPD despite the fact that indirect retention is required more on the mandibular arch than on the maxillary arch. However, there will always be a higher tendency of finding a third abutment anterior to the fulcrum in the maxillary Class II RPDs suitable for both direct and indirect retention as in the case of this survey and another[9] where more posterior and combined anterior and posterior modification areas are found.

A descriptive study of dental school samples may not be representative to what might be obtained in a general dental practice. The variation in conventional RPD design concepts with international studies reflects the influence of teaching philosophy and diversity of faculty members' background. The results of this study suggested design concepts leaning towards the North America philosophy of a basic design principle. A careful methodical treatment, sound biomechanical concepts, preservation of oral health, functions and esthetics, and lastly the use of the simplest type of clasp and major connector that will accomplish the treatment objectives should always dictate the type of RPD designed for patients rather than to a stereotyped treatment philosophy.

Conclusions

1. Patterns of partial edentulousness of patients who attended the clinics of King Saud University were similar between Saudi and non-Saudi Arabs but differ compared to Filipinos and other non-Arab patients.
2. The incidence of various classes of RPDs may not only be a reflection of the pattern of tooth loss but also patients demand and affordability of alternative prosthetic treatment.
3. Kennedy Class III RPDs are most frequently used, whereas Class IV were the least used. Both classes were more common in the maxillary than their mandibular counterparts.
4. Younger adults had more Kennedy Class III and IV RPDs. Older adults had more distal extension RPDs (Classes I and II).
5. Circumferential direct retainers were the most commonly prescribed. RPI and RPA slightly predominated distal extention cases. However, an overwhelming use of mesial rests on distal extention abutments was noticed.
6. A infrabulge clasp was used more frequently in the maxilla than in the mandible. On the other hand, the ring clasp was used more frequently in the mandible than in the maxilla.
7. The most common maxillary major connector was the anterior-posterior palatal strap followed by the palatal strap. On the mandible, the lingual bar was used in 77% of the cases.

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