Partial denture design comparisons between inexperienced and experienced undergraduate students and the teaching staff of a UK dental school

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IN BRIEF

- Highlights the need for more in depth teaching of removable partial denture (RPD) design at undergraduate level.
- Highlights the lack of conformity throughout dentistry when it comes to designing the same classifications of RPD.
- Highlights the low confidence levels seen in both undergraduates and graduates when designing RPDs.

EDUCATION

This study aimed to assess the ability of inexperienced and experienced BDS students and teachers of removable partial denture (RPD) design, to prescribe/design RPDs for an identical partial denture case. Second and fourth/fifth year BDS students and experienced teachers of RPD design were selected to provide a treatment plan for a patient requiring RPDs using identical models. The designs produced were compared against a design produced by the authors before the study began. Not one design for the 100 participants matched the author's design. Under 30% of second year students surveyed the models before designing. Only a small percentage of the participants indicated the path of insertion and removal they had chosen and less than half the student groups and only 60% of the staff group provided clear, correct instructions to the technician. Large disagreements existed between the individuals within groups and between individual groups regarding the selection of component parts. There were wide differences in opinion among the undergraduate student groups as to which are the best design options for particular cases. Teachers of RPD design were found to be far from confident and have no consensus of opinion when designing RPDs.

INTRODUCTION

The formal teaching of partial denture design for partially edentulous patients is given to undergraduate dental students in the second year of their study. At present there is a time delay between the end of this course and when students treat their first partial denture patient (this situation is being rectified from 2011 during the introduction of a new curriculum within the BDS course).

The General Dental Council, in their publication *The first five years*,[1] state that dental students should 'be competent at designing effective indirect restorations and complete and partial dentures'. The British Society for the Study of Prosthetic Dentistry[2] (BSSPD) recommend that for successful RPD designs to be produced a close relationship between clinician and technician should exist and that discussion of a proposed design should be carried out firstly with the technician and subsequently with the patient.

Juszczyk *et al.*[3] investigated contemporary attitudes and communication between dentist and technician from the technician's perspective. They concluded that effective communication between dentist and technician was often poor. The view of the technicians who responded was that newly qualified dentists do not have a good enough understanding of technical procedures and that dental schools are still not producing graduates who can communicate effectively with the dental laboratory. This has been found to be particularly true when looking at the prescribing of removable partial dentures (RPDs).[4-9] The majority of papers on this subject conclude that a lack of education and training in RPD design at dental school and vocational training is largely to blame for the lack of designs seen accompanying requests from clinicians for RPDs and poor communication skills.[10-13]

Eldred[4] has strongly advocated a team approach to designs, with the clinician engaging the technician much more in the design process. Equally there have been a number of surveys which show that in many cases the technicians are asked to design the RPD by the clinician[3,10] and this appears to have been a long standing problem.[14]

Previous studies[15] have been carried out which compared the qualified dental surgeons' ability to design partial dentures and communicate the design to the dental technician. The findings showed that newly qualified dental surgeons were more likely to provide designs which were understood by the technician than those surgeons who had been qualified longer.

In 1988 and 2005 Davis and Walter[16] asked members of the BSSPD to design a mandibular partial denture (79 surgeons in 1988 and 64 in 2005 participated). In both exercises none of the designs received were identical. This highlights the problems of achieving a uniform opinion of what constitutes an optimum design for a particular case and inevitably leads to difficulties regarding teaching this subject to undergraduate BDS students.

Allen *et al.*[6] in 2006 reported that in a national survey of dental surgeons

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Refereed Paper
Accepted 17 May 2010
DOI: 10.1038/sj.bdj.2010.817
©British Dental Journal 2010; 209: 287–292

regarding partial denture design a divergence between knowledge and practice was found.

AIMS OF THE PROJECT

The aims of this project were to assess the ability of inexperienced and experienced clinical dental undergraduate students to design and prescribe a partial denture case using identical models; and to compare the results of the above with those obtained from experienced teachers of partial denture design, designing the same case.

The study compared the ability of second and fourth/fifth year undergraduate BDS students with those of experienced teachers of partial denture design (45 participants from each student group and ten participants from the teacher group). The student groups contain equal numbers but the teacher group contains fewer participants due to a smaller cohort from which to choose. The experienced teachers were those employed to teach on the second year partial denture design course (pre-clinical staff) and those employed to teach design in the clinic during patient treatment (clinical staff employed by the University of Sheffield). The second year undergraduate group were chosen because they would have had their laboratory instruction in RPD design but not had any clinical experience in RPD provision and the fourth/fifth year group because they would have had both the laboratory instruction and clinical experience of RPD design and provision.

HYPOTHESIS

A hypothesis was that the teachers would produce designs that were closer to a design produced before the start of the study by the investigators than the second and fourth/fifth year students. It was also assumed that they will be more clinically effective and better able to maintain oral health and that the fourth/fifth year group would provide designs that were more clinically effective than the second year group. The alternative hypothesis is that the second year students, who will have just finished their laboratory based course on partial denture design, but have had no clinical experience, will produce more effective designs than the fourth/fifth year students, who have not had any formal teaching on partial denture design for two to three years, and will not be significantly different to those produced by the teachers who taught them.

MATERIALS AND METHODS

Two groups of BDS students (second and fourth/fifth year) were selected to produce a prescription for a partial denture case using identical study models and instructions stating that the patient was dentally and medically fit and that all the teeth were sound and had good levels of bone support and no periodontal problems. The models provided to all participants can be seen in Figures 1a-e.

As the two sets of models had an 'interlocking' definite and reproducible intercuspal position when hand held, it was not thought necessary to have the models mounted on an articulator.

Experienced teachers of partial denture designing, both laboratory and clinically based were also asked to undertake the same exercise as the two groups of undergraduate students.

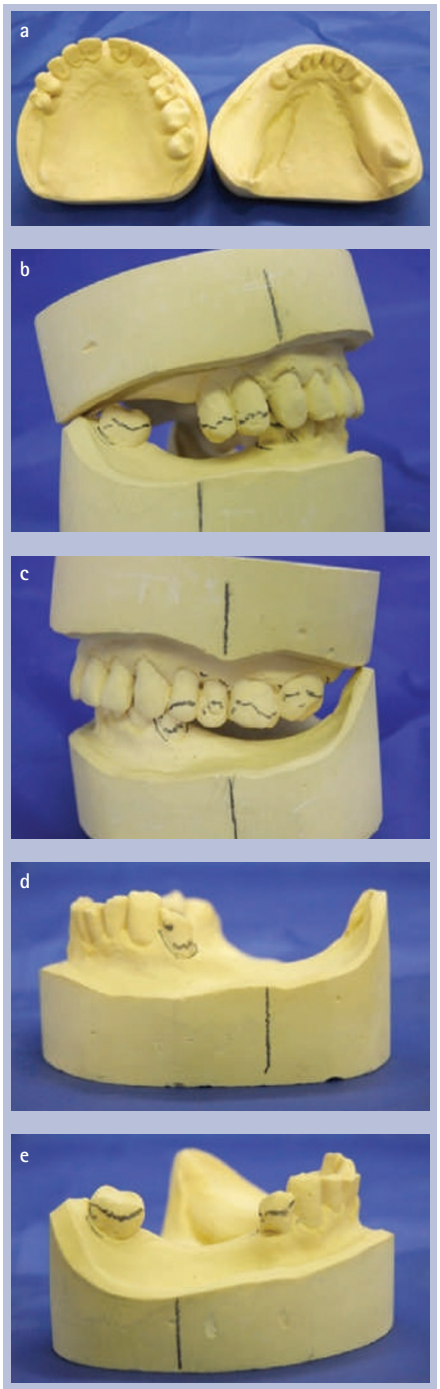
All participants were asked to produce a detailed drawing of their design including written instructions for the technician.

The authors, a non-clinical senior lecturer and a dental instructor, engaged in producing a definitive 'master design' before the study began (Fig. 2), against which the participant designs would be compared.

Analysis of the designs received was made to check how many identical designs had been produced and how often the same component parts had been used. The analysis was carried out 'blind' to the status of the participants (second years, fifth years and teachers). The following design components were evaluated for their suitability to provide effective treatment and their ability to maintain dental health and compared to a design produced by the investigators before the study starting:

- Clasp type used
- Tissue coverage
- Indirect retention
- Occlusal resting
- Direct retention
- Reciprocation
- Connector type.

The clarity of instruction was also evaluated. Two observers carried out the analysis of the design data independently to ensure



Figs 1a-e Study models of the case being designed with the teeth surveyed in the horizontal position

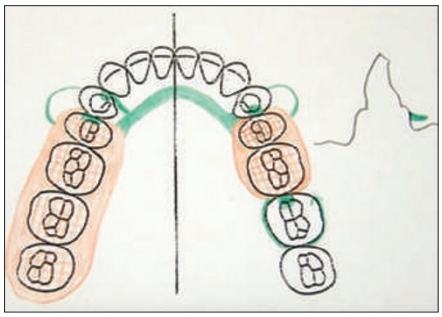


Fig. 2 The 'ideal' design produced by the authors

no mistakes were made with the data analysis. Because of the very subjective nature of partial denture designing and the variety of design components to choose from, it was not possible to produce a definitive mark sheet against which the designs produced could be assessed. Instead the investigators, course leaders in partial denture design at the Sheffield Dental School, produced what they considered, together with the current literature, to be the most appropriate design for the case to be used. All the designs produced in the study were compared to these criteria.

The primary outcome measure in this study was the total number of designs from the three groups, which met the hypotheses set before the study began.

The authors' own prescription and general comments about the case are given below.

General comments

- A mandibular denture is needed to improve function and to increase the vertical dimension, which has reduced and is causing excessive wear to the mandibular and maxillary anterior teeth and premolars
- The maxillary arch may not need a denture, as the benefit of replacing two teeth would not compensate for the damage caused by wearing a denture. It may also be unlikely that such a denture would be worn. The shortened dental arch principle could be applied in this case, unless the vertical dimension is to be increased
- If the mandibular left four were to be crowned the RPI system could be employed to reduce the stresses placed on the tooth. If the tooth is not crowned the same design can be employed but the tooth would need a guide plane ground into the distal aspect
- There is not enough room to employ a conventional lingual bar, the lingual fraenum would preclude the use of a sub-lingual bar and using a plate connector would be very unhygienic and aesthetically unacceptable owing to the gaps between the anterior teeth. The use of a 'hybrid' bar (this is a mandibular major connector, designed at the Sheffield Dental School, which combines elements of a lingual bar and sub-lingual bar in its design and has half the contact width with the tissues compared to a conventional lingual bar, this is then flared out to sit in the space, which exists between the floor of the mouth, and the tongue (neutral zone) but for rigidity still maintains the same cross-sectional area of a conventional lingual bar, see Fig. 2) is advocated here
- If crowns are constructed an acrylic resin transitional denture will need to be constructed to maintain the correct vertical dimension during crown construction and until the final denture is constructed.

Table 1 Shows the percentage of participants in each group that had surveyed the models, indicated the path of insertion required or indicated the depth of undercut that each clasp chosen should engage

Observation	2nd years (%)	4th/5th years (%)	Staff (%)
Models surveyed	28.5	74	80
Path of insertion indicated	25	7	20
Undercut depth for clasps indicated	8	2	0

Table 2 Shows the percentage of participants in each group that had not designed a maxillary denture because of the shortened dental arch principle, written clear and correct instructions to the technician or who had only provided very brief instructions

Observation	2nd years (%)	4th/5th years (%)	Staff (%)
No maxillary design – shortened dental arch principle	17	42	20
Written instructions to technician correctly given	41.5	44	60
Written instructions to technician given but only briefly	36	37	20

Table 3 Shows the percentage connector options chosen by the participants in each group

Mandibular connector	2nd years (%)	4th/5th years (%)	Staff (%)
Lingual bar	82	65	60
Lingual plate	16	35	40
Maxillary connector	2nd years (%)	5th years (%)	Staff (%)
Palatal plate	60	49	70
Skeletal design	21	5	10

The author's partial denture treatment plan for this case (Fig. 2) is given below.

Clasps: mandibular-right premolar - I bar (0.25-0.5 mm depth of undercut); mandibular-right molar – ring clasp (0.5-0.75 mm depth undercut); mandibular-left premolar – RPI system – I bar (0.25-0.5 mm depth undercut).

Rests: mandibular-right premolar – distal rest; mandibular-right molar – mesial rest; mandibular-left premolar – RPI system – mesial rest.

Saddles: mandibular-left quadrant – free-end saddle with three premolar teeth to oppose maxillary teeth; mandibular-right quadrant – bounded saddle with three premolars to oppose maxillary teeth

Connector: hybrid bar – no room for conventional bar so construct bar to have only 2 mm contact with the lingual tissues and to be equidistant from the gingival margins of the teeth and the lingual fraenum. Then flare the bar out to sit in the neutral zone. (A lingual plate option, although providing more indirect retention, would have been unsightly and unhygienic due to gaps between the anterior teeth).

Minor connector: arm to link the mesial rest of the mandibular right premolar to the hybrid bar connector.

Occlusion: the denture is also being used to re-establish the correct vertical dimension. Once the models have

been mounted onto the articulator the vertical dimension may then be opened appropriately.

RESULTS

Not one design from the 100 participants matched the design produced by the authors before the study began. None of the ten staff participants had a maxillary or a mandibular RPD the same. For the 45 second year group none of them had the same maxillary RPD but four pairs of students and a group of three students had identical mandibular designs. The fourth/fifth year students again failed to have any maxillary designs the same, for the mandibular design four students had the same design and two further students also had the same design.

Based on the authors' criteria of what would constitute a suitable design for the case presented it was found that only three out of ten staff members, three out of 45 second year students and none of the 45 fourth/fifth year students produced a clinically acceptable design.

Tables 1-6 show the percentage number of participant responses for the various categories analysed during the study.

Table 1 shows that 80% of staff and 74% of fourth/fifth year students surveyed the models before designing the dentures. However, only 28.5% of the second year students surveyed the models. Only 20% of staff, 7% of fourth/fifth year students and 25% of second year students indicated on their design/prescription the path of insertion they had chosen when designing the RPDs.

Having looked at the occlusion and condition of the remaining teeth the authors took the view that in this case the shortened dental arch principle could be adopted and no maxillary denture recommended. Encouragingly 42% of the fourth/fifth year students agreed. However, only 20% of the staff and 17% of the second year students opted for this recommendation (Table 2).

The main area of disagreement between the authors and the participants was the choice of major connector for the mandibular case. The distance from the floor of the mouth (lingual fraenum) to the gingival margins of the teeth was only 5 mm, which is insufficient room for a conventional lingual bar. However, the lingual bar was the connector of choice for second years (82%), fourth/fifth years (65%) and staff (60%). The authors chose a hybrid bar (Fig. 2) as it would fit into the space and would be more hygienic than a lingual plate, which was the only other option chosen by the second years (16%), fourth/fifth years (35%), and staff (40%). For those that chose to design a maxillary denture a palatal plate was the connector most favoured by the second years (60%), fourth/fifth years (49%) and staff (70%) (Table 3).

The choices of clasp type for the mandibular design are shown in Table 4. An I-bar clasp was the clasp of choice for the majority of participants for the premolar abutment tooth next to the free-end saddle. Both groups of students also selected a

Table 4 Shows the percentage mandibular clasp options chosen by the participants in each group

Mandibular clasp type	2nd years (%)	4th/5th years (%)	Staff (%)
Molar ring clasp	31	53	80
Molar single arm	26	23	10
Molar 3 arm	23	12	10
Molar I Bar	4	5	0
Premolar I bar	70	67	80
Premolar single arm	21	21	0
Premolar compound clasp	0	2	0
RPI system	0	0	10
No molar clasp!	0	9	0
No premolar clasp!	0	28	0

Table 5 Shows the percentage maxillary clasp options chosen by the participants in each group

Maxillary clasp type	2nd year (%)	4th/5th year (%)	Staff (%)
Molar ring clasp	12	9	0
Molar single arm clasp	41.5	16	10
Molar 3 arm clasp	0	0	20
Molar I bar	5	2	0
Molar compound clasp	8	18	10
Molar/premolar compound clasp	2.5	18	10
Premolar I bar	45	14	40
Premolar single arm clasp	36	21	20
Premolar compound clasp	0	18	20
Canine single arm clasp	0	0	0
Canine I bar	0	0	0
Molar ball –end clasp	1	0	0
Premolar ball-end clasp	1	0	0
No clasps!	0	18	0

Table 6 Shows the percentage number of participants in each group who correctly placed rests and provided effective reciprocation

Observation	2nd years (%)	4th/5th years (%)	Staff (%)
Rests correctly placed	17	7	70
Correct reciprocation used	45	53	80

single arm clasp for these teeth (21% from each group). The authors recommended the use of the RPI system for the abutment premolar next to the free-end saddle, with a recommendation that this tooth probably be crowned together with the right side premolar, due to the excessive wear and the fact that the mandibular denture would be acting as a space maintainer to open the over-closed occlusion. Only one (10%) of the staff group recommended using the RPI system, but did not recommend crowning the tooth.

A ring clasp was the most chosen clasp for the mandibular molar tooth by the staff group with the fourth/fifth year group showing half their number selecting this clasp type. The second year group were much less certain of their choice. An I-bar clasp was chosen for this tooth by 4% of second years and 5% of fourth/fifth years (Tables 4 and 5).

Only 8% of second year students, 2% of fourth/fifth year students and none of the staff indicated the depth to which clasp tips should engage the undercut.

When looking at the correct placement of rests it was found that only 17% of second years and 7% of fourth/fifth years correctly placed the rests. Seventy percent of staff placed the rests correctly. Adequate reciprocation, for retentive clasp action, was provided by 45% of the second years, 53% of the fourth/fifth years and 80% of the staff (Table 6).

There were very few instructions made by any of the groups regarding the saddles of the dentures and the teeth they would carry. The authors recommended using all premolars on the saddle areas to reduce the load on the underlying tissue/bone. By reducing the bucco-lingual width of the teeth they will be more efficient at cutting through the food bolus and therefore exert less pressure onto the underlying tissue and bone (Table 2).

Tables 3 to 5 show that for component part selection there was no consensus choice made within any of the three groups. The student groups had a wider spread of choice compared to the staff group, with very little differences seen between the two student groups.

All participants were asked to indicate how confident they felt in performing the treatment plan and RPD design for this case on a scale of 1 to 5, 1 being very confident and 5 not confident at all. The mean results were staff 2.9, second year students 3.3 and fourth/fifth year students 3.4.

DISCUSSION

With regards to the hypothesis set at the start of this project, it can be said that the staff did produce designs that were nearer the design produced by the authors for the mandibular RPD than the two student groups, particularly with regard to clasp choice and rest position and their clinical effectiveness. There was very little perceived difference between the two student groups. However, overall the conclusions must be that the hypothesis set at the beginning of the project was not met and none of the preconceived ideas about levels of staff and student understanding regarding RPD design were correct.

There were some significant differences seen between the three groups in the study and these can be seen in Tables 1-6. The most significant areas of differences were in the areas of:

- Choosing to provide a maxillary RPD
- Choice of major connector for the maxillary and mandibular RPD
- Choice of clasps for both the maxillary and mandibular RPDs
- Positioning of occlusal rests in the mandibular RPD
- Reciprocation of clasp arms
- Indication of path of insertion and removal
- Surveying the models before designing the RPDs
- Indication of undercut depth for clasp selection.

One rather worrying observation from this work was the number of participants (80% of staff, 83% of second years and 58% of fourth/fifth years) who chose to provide a maxillary RPD. These dentures would have provided little improvement in functional efficiency, no improvement in appearance and even if it were thought necessary to open the patient's vertical dimension this would have been better achieved by placing crowns on the left and right mandibular premolars and the left four and five maxillary premolars, particularly with the known biological effects of RPDs.[17,18] In cases like this cantilever bridges would offer a healthier option.[19]

The record of student patient treatment during their BDS course shows that during patient treatment at the dental school/hospital in the 2008/2009 period third/fourth year students (group of 61 students) made from 0-4 RPDs (it is not known whether these were acrylic or Co-Cr RPDs). There can be a considerable wait time for approved designs to be booked into the laboratory system. This does not help students achieve any kind of continuity and in many cases students have moved up a year between first impressions and second impressions being taken and in some cases students have qualified before the treatment is completed. Overall this does not help students to carry out the number of cases needed to become confident at RPD designing.

During their outreach training 61 fourth/fifth year students attended 20 weeks of outreach for four days per week and carried out from 0-20 acrylic RPDs (two students made 0) and 0-6 Co/CR RPDs (43 students made 0, 18 made from 1-6). This means that during their university training the most conscientious student could qualify having undertaken a maximum of 24 RPDs and some students can leave having completed no Co/Cr RPDs and only one or two acrylic RPDs!

The findings from this study suggest that students with clinical experience of RPD design and provision do not appear to be any more confident or competent at designing RPDs than students, who have only had laboratory tuition, but no clinical experience, of RPD design and provision.

Many staff involved in RPD design teaching would also appear to be far from confident in the process and show little consensus of thought regarding basic design options for given cases.

It is possible that the reason clinicians perceive that the technician is better than them at designing RPDs is the fact that in many dental schools undergraduates are taught RPD design initially by teaching technicians and throughout their career at dental school receive more advice from this group of staff than their clinical tutors! In practice the technician has to some extent been forced to design because of a lack of guidance from the clinician. The BSSPD recommend involving the technician who will construct the RPD in the design process. This is not part of the undergraduate curriculum at the Sheffield Dental School/

Hospital; however, such an introduction would foster this ethos at an early stage in the student's development and would hopefully be something they would transfer to clinical practice upon graduation.

Davenport *et al.*,[20] in their excellent book on RPD design, tried to bring together the consensus opinion of all staff within UK and Republic of Ireland dental schools who were responsible for teaching RPD design to undergraduate students and to answer a number of statements relating to RPD design. The 'experts' either agreeing, disagreeing or being neutral. The observation from this study appears to show that this consensus opinion is not being passed on to dental students or newly trained dentists.

The General Dental Council, in their publication *The first five years*,[1] state that dental students should 'be competent at designing effective indirect restorations and complete and partial dentures'. With regards to RPD design the authors would claim that upon qualifying dental students are in the main not competent at RPD design.

The literature would suggest that this report from a particular dental school is not an isolated case and that probably all dental schools are failing to deliver dental graduates who are competent in this area.

As patients live and retain more of their natural teeth longer, but tend to lose teeth later in life, more RPDs not fewer will be required, contrary to what was thought 10-15 years ago. A dental school curriculum needs to be flexible enough to reflect changing patterns in patient treatment requirements. Over the last 10-15 years many dental schools have lost staff, mainly through retirement, that specialised exclusively in removable appliances. Time devoted to teaching the clinical and technical aspects of removable appliance construction has been slowly reduced to reflect a preserved drop in the demand for these types of appliance, a drop which has not really materialised. Expert knowledge in both the clinical and technical aspects of this discipline is being slowly lost as a shift to a more fixed appliance curriculum is seen. The introduction of clinical dental technicians (CDTs) into dental schools, as teachers, or into general practice, could fill this potential hole in dental provision.

CONCLUSIONS

There is no general consensus of opinion on design principles for specific cases. Teachers of RPD design are not always confident, consentient or correct when designing RPDs. There is a wide chasm of opinion among undergraduate dental students as to which is the best design options for particular cases.

The author's final conclusion would be that as educators we appear to be failing miserably in providing our students and young dentists with the knowledge and basic skills required to design basic and functional RPDs.

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