www.sada.co.za / SADJ Vol. 78 No.8

A simplified and evidence-informed approach to designing removable partial dentures

Part 1: Evidence-informed design principles

SADJ September 2023, Vol. 78 No.8 p406-409

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SUMMARY

For many decades the literature has regularly reported that there is a discrepancy between what is taught in dental school and what is practised, especially in the field of removable partial dentures. Not only that, but for more than 60 years reports from around the world have shown that, usually, the majority of clinicians abdicate their responsibility to design a removable partial denture (RPD) and instead leave this to the dental technician, who has no knowledge of the clinical condition of the patient and works only from a cast. Most patients around the world who require RPDs to improve aesthetics and chewing can only afford a removable prosthesis simply because the majority are poor. But RPDs can improve these aspects and contribute to an improved quality of life.

The purpose of this series of articles is to derive the basic, evidence-informed principles of partial denture design and to suggest a simplified explanation and application of those principles in the hope that clinicians will increasingly take responsibility for the design of partial dentures. Part 1 summarises studies revealing what can only be described as the malpractice of abdication of responsibility for design by clinicians, and then explain the evidence-informed basic principles of design; Part 2 will look at the biomechanical basis of those principles in terms of support; Part 3 will do the same for the biomechanical basis of retention; Part 4 will provide a simple seven-step approach to design, applied to an example of an acrylic resin-based and a metal framework-based denture for the same partially edentulous arch; and Part 5 will provide examples of designs for RPDs that have been successfully worn by patients, for each of the Kennedy Classifications of partially dentate arches. Much of this is referenced from an electronic book on the Fundamental of removable partial dentures.[1]

Keywords

Removable partial denture, design, support, retention, acrylic-based, framework-based

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Conflict of interest

None

INTRODUCTION TO PART 1

As stated in the summary, many papers have reported on the lack of information prescribed by dentists to the dental technician. Rather than setting these out in narrative form, studies from the last 45 years are summarised in Table 1. The inevitable conclusion from these studies is that little has changed over the last many decades, where there still seems to be an enormous amount of what can only be described as malpractice when clinicians abdicate their responsibility for the design of removable partial dentures. This is the motivation for this series of papers, to try to simplify both the understanding and the application of design principles.

THE DESIGN PRINCIPLES

An article that discussed key turning points in RPD philosophy revealed that RPDs have been described in the literature for just over 300 years.[18] However, there seems to have been few changes over the last nearly 100 years. While there are no universally accepted principles for the design of RPDs, these can in fact be derived from evidence in the literature.

Tooth support

Early attempts to provide retention were described in the early 19th century as metal bands encircling the teeth. These often extended into the gingival sulcus with somewhat disastrous effects on the periodontium. A fortuitous effect of this was the realisation that tooth support was required, and the first occlusal rest was described in 1817.[19] This prevented components such as the bands sinking into the gingiva and mucosa and should have become a universally accepted principle. Sadly, there is much evidence that RPDs are still being made, more than 200 years later, with no tooth support (see Table 1), most notably as acrylic resin-based dentures or, more recently, as the so-called flexible denture.[16,20,21]

In a study comparing dentures with and without tooth support, it was found that patients who had adequate and sufficient rest seats were more satisfied with their dentures than those whose dentures had inadequate support.[22] Adequate support was one of the few criteria that correlated with successful wearing of mandibular Kennedy Class I RPDs.[23]

Clasps

A century after the concept of a clasp as a band, Roach pioneered the use of wrought wire as a circumferential clasp and as an "infra-bulge" clasp.[24] Clasps provide

Table 1. A selection of studies from the last 45 years on information supplied by clinicians to dental laboratories for removable partial dentures.

Year	Country	Study	Results	Reference
1978	England and Wales, UK	124 metal-based dentures and 44 maxillary acrylic-based dentures	54% had no instructions	2
1978	UK	14 laboratories, 1,858 partial dentures	36% had a written prescription of the design; 4.6% of the casts showed any evidence of tooth preparations such as for rest seats	3
1984	USA	303 laboratories	78% of the technicians designed most or all of the dentures; 76% of the master casts did not show adequate tooth preparation	4
1993	South Africa	148 dentists	82% of dentists instructed the technician to design the RPD; 64% did not survey the casts; 55% were not mounted on an articulator	5
1986	Scotland, UK	539 casts and dentures in one laboratory	34% were acrylic-based, 6% of which had clasps, but none had occlusal rests; 3.4% gave detailed instructions for acrylic-based dentures and 21.3% for metal-based dentures	6
2003	Ireland	122 sets of instructions to dental laboratories	53% lacked any design instruction; 9% of those requested the technician to design the framework; 7% of all the instructions included a diagram	7
2005	UK	8 laboratories, 134 prescriptions	40% included a diagram for a metal-based denture; 9% included surveyed study casts; 28% requested the dental technician to design the case	8
2006	Tanzania	328 prescriptions to a hospital laboratory	2.4% indicated a design for acrylic-based RPDs; 13.4% requested clasps; no other design parameters were requested	9
2007	Bahrain	131 prescriptions to 5 laboratories	76% requested the dental technician to design the denture, 79% for acrylic-based dentures and 57% for the metal-based dentures; 18% mentioned any design variables	10
2011	Wales, UK	68 master casts from impressions taken by 45 dentists using predetermined criteria for cingulum and occlusal rest seat preparations	48% did not have prescriptions or designs including rest seats; of those that did, only 30% had an obvious and visible rest seat preparation on the cast	11
2014	China	5 commercial laboratories in major cities across China	90% of the written instructions showed the type and position of clasps; 88% gave information regarding connectors; 48% of the tooth preparations were inadequate: there were no proper guide planes, rest seats or contours to accommodate components; 33% of technicians would contact the dentist for clarification when they felt it was needed	12
2018	Turkey	25 laboratories	38% of clinicians provided any instructions to the dental technician: 58% of prosthodontists, 33% of dentists. For those who did provide instructions, (47%) a diagram was the preferred choice	13
2020	Saudi Arabia	9 commercial laboratories, 162 prescriptions and casts	64.2% had no design instructions; 6% provided a diagram; 10% drew a design on the cast	14
2020	South Africa	60 cases from 3 commercial laboratories	55% had no rests overall; 65% of the acrylic-based dentures had no rests; 85% had no clasps, and none of the “flexible” dentures had rests or clasps	15
2022	South Africa	3 commercial laboratories, 114 cases	0% prescribed the design; 119 clasps were made, but only one cast was surveyed; 92% of the acrylic-based dentures had no tooth support; 11 (14%) of the 81 rests (in 25 of the dentures) were pre-prepared on the teeth	16
2023	China	916 prescriptions to a laboratory	86.8% had inadequate design diagram information; 74.2% were assessed as failing to meet an acceptable clinical quality standard	17

retention by the force exerted against the tooth as they flex while emerging from the undercut below the bulge of the tooth. However, the amount of this force and the ability of all clasp materials to bend many times without distortion has not been fully elucidated. A recent paper has provided some guidelines for cast clasps and stainless steel round wire[25] but there are still other casting alloys and pre-formed wrought wire clasps that need to be tested. Pre-formed and cast gingivally-approaching clasps were shown almost 40 years ago to be potentially more damaging to gingival health than circumferential clasps[26] so their use will not be advocated here.

Guide planes and guiding surfaces

A guide plane is the prepared surface of a tooth adjacent to to an edentulous space, and a guiding surface is that part of the denture which contacts the guide plane. Close contact of these provides for frictional resistance when the denture moves. It is important to realise that this resistance is least along the path of insertion, and greatest if the denture is

removed along any other path, rather like a drawer in a desk. This is a much underestimated contributor to retention, and when the remaining teeth are sufficiently distributed can provide all the retention needed without the use of clasps.[27]

These three basic design principles govern the features that should be considered for all RPDs. There are, of course, other factors that contribute to the successful use of RPDs. These include minimal gingival coverage wherever possible, and the elimination of redundant components without compromising biomechanical requirements.[28,29]

THE BIOLOGICAL PRICE OF RPDS

For too long, the observation of increased tooth loss following the wearing of RPDs was attributed to the forces placed on the abutment teeth, as the teeth usually carrying the clasps. This wasn't helped by the theoretical studies of Kratochvil as far back as 1963 in which he surmised that a distal extension base produced a tipping force on the abutment tooth, and advocated an RPI clasp (mesial rest, proximal plate and I-bar) to offset this.[30] This was based on the difference between compression of the mucosa under the distal extension and the compression of the periodontal ligament of the abutment tooth. It seemed logical and was followed by purely laboratory studies using photoelastic resin to "prove" the effects that the RPI design was supposed to overcome.[31] These are mentioned here because some believe it to this day, but there have never been any clinical studies to show this is indeed the case and it was refuted, also many years ago. [32]

So, while it seemed logical that a partial denture gripping an abutment tooth would exert a tipping and torquing force on that tooth, this has never been shown clinically. What has been shown clinically is that abutment teeth are indeed more likely to be lost,[3] but the reasons are multifactorial, not least of which is the influence of plaque. This is the severest biological price because a prosthesis provides many more surfaces for plaque to accumulate on, and this changes the ecology of the mouth, resulting in gingival and periodontal disease, root caries and stomatitis, especially in dentures without tooth support.[34-38]

The common conclusion of all studies is that intensive and meticulous oral hygiene should be a prerequisite for the insertion of RPDs.

DO THEY REALLY WORK?

This seems at first a strange question to ask, when so many RPDs are made all over the world. But it must be asked, because many papers have reported fairly high levels of dissatisfaction expressed by patients,[39] with one retrospective study finding that 39% of the dentures were no longer used after 5 years.[40] The adage that all dentures are easy to wear but not all are easy to use certainly applies to RPDs. The conclusion above has implications not only for the need to change patient behaviour but also, and importantly, for the design of the denture so that it can actually be used – and used successfully.

ARE THEY REALLY NEEDED?

This is not a strange question because, as will be shown in Part 4, the first step in designing an RPD is to establish the need. Not all missing teeth need to be replaced. The most common requested needs are to improve aesthetics and chewing ability. Aesthetics is an obvious one, but improving chewing ability may be vital for a number of reasons. The link between chewing ability and food choices has been established through several national surveys of large numbers relating loss of all or some teeth to adverse food choices.[41] Such (wrong) food choices place patients at risk of increasing morbidity, and so it would seem logical that improving masticatory ability by replacing missing teeth would also remove those risks of morbidity. Unfortunately, this is not necessarily the case, and merely improving mastication by providing prostheses does not guarantee an improvement in food choices and therefore overall nutrition.[42] The answer, therefore, is not to make such assumptions, but to provide, whenever placing a prosthesis for a patient, nutrition analysis and counselling. Unfortunately, this appears to be as rare among practitioners as is the designing of RPDs.

A somewhat still controversial additional reason for improving chewing ability is the link between the ability to chew and cognition, and especially cognitive decline and dementia. Interest in this aspect has increased in the last two decades, with the use of such instruments as functional magnetic resonance imaging and electrical brain activity recordings. A large body of literature now exists on this and it is generally accepted there is indeed an association between loss of teeth and masticatory ability and dementia. The question is, is this just an aspect of dementia in that dementia is a part or maybe a cause of loss of teeth (among other things), or is it the loss of teeth and difficulty with chewing that causes cognitive decline and dementia? The case for the latter is increasingly being made,[43,44] which has the potential to make the replacement of teeth, especially in the elderly, a public health measure.

Flying somewhat in the face of these arguments is the concept of the Shortened Dental Arch. Once again there is a large body of literature on this concept, first proposed in 1981, that for a dentition with loss of posterior teeth, bilateral contact on the premolars was sufficient.[45] There have been many papers testing this and, recently, some reviews of the clinical studies and while the concept remains somewhat controversial, it is generally considered to be valid, with the *proviso* that methodological problems with the clinical studies made it difficult to advocate for all cases.[46,47] This is a fair conclusion for many aspects of prosthodontics and means that treatment must always be patient-centred. The main problem is that the lack of posterior teeth can affect food choices adversely, so perhaps a nutrition analysis should always be the first step.

There is no doubt that if a prosthesis can be omitted then it should be.

SUMMARY

It is essential that all dentists and dental technicians have a clear understanding of the evidence-informed principles of all aspects of RPD design, and especially of the biological price exacted by these dentures. Meticulous preparation of the mouth prior to treatment is required, so that dentures are placed in a plaque-free environment, and that the patient must be committed to thorough oral hygiene practice and regular recalls.

The next part will deal with the biomechanical basis of support.

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CPD questionnaire on page 422

The Continuing Professional Development (CPD) section provides for twenty general questions and five ethics questions. The section provides members with a valuable source of CPD points whilst also achieving the objective of CPD, to assure continuing education. The importance of continuing professional development should not be underestimated, it is a career-long obligation for practicing professionals.