Turning Points in Removable Partial Denture Philosophy

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Abstract

This article discusses key turning points in removable partial denture (RPD) philosophy. Early advancements tended to focus upon improving the technical quality of the prosthesis itself. The beginning of the 20th century brought significant public pressure upon the dental profession due to consequences associated with poor quality fixed prostheses. The result was dramatic improvement and heavy demand for RPDs. Technical and efficiency issues conspired to temper this enthusiasm, eventually resulting in reduced respect for RPDs. By highlighting key writings and technical issues during these periods of change it is hoped the reader will gain a more precise understanding of the current status of RPD philosophy.

Recent investigations have analyzed trends in demand for prosthodontics in the United States.[1,2] Over 90 years ago Hillyer pointed out that as the fully edentulous population decreases, the partially dentate will increase.[3] Despite decreasing rates of tooth loss, the need for removable prosthodontic treatment remains high.[4-6] It appears that a consequence of the profession's improved preventive measures has been an increase in the number of patients who require partial prosthodontic treatment. Likewise, an aging population retaining more teeth results in an increased number of teeth at risk for disease. Joshi et al and Manski et al have evaluated some of the aspects of the more teeth/more disease hypothesis.[7,8] Conservative treatment modalities used to treat partial edentulism, such as dental implants, also happen to be the most expensive. This continues to limit their availability to lower socioeconomic groups in whom the highest rates of tooth loss occur.[9-11] It should not be a surprise, then, that conventional removable prosthodontic treatment modalities continue to outnumber implant tooth replacements in general practice.[12] Despite its frequency of use, the removable partial denture (RPD) receives minimal interest in the prosthodontic literature or at professional meetings. The past 150 years of RPD literature demonstrates several interesting turning points. A critical review of this history may encourage clinicians to reevaluate their RPD treatment philosophy.

Historical biases persist in RPD construction, perhaps more than in any other aspect of prosthetic dentistry. Lack of understanding regarding dental disease etiology, absence of appropriate dental materials, and the complex and varied nature of RPD applications were all large obstacles to the logical or sequential development of RPD philosophy. Operator experience rather than standardized clinical comparison tended to drive changes in removable partial prosthodontics. In North America the modern everyday result seems to be a design with little difference from the first one-piece castings described in the early 1920s. This is unfortunate, considering these historical design concepts predate key standardization, material, and philosophical advances in RPDs.[13] Ultimately due to late discovery of the true etiologic factors for many of the clinical problems associated with RPDs, well-intentioned design modifications addressed the consequences of the problem rather than the cause. The question exists if this was and continues to be due to the profession's overwhelming desire for efficient and productive treatment strategies or a lack of understanding regarding developments in RPD construction.

Early developments: The band, the clasp, and sectional construction

Some excellent review papers summarizing the early development of RPDs served as starting point for this literature review.[14-16] Some of the earliest partial prosthetic tooth replacements were carved ivory, stone, or detached tooth crowns ligated to adjoining teeth with gold bands or wire ligatures.[15,17,18]

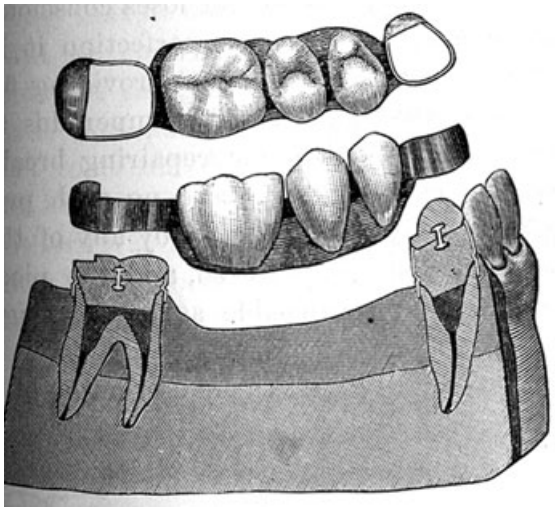

Figure 1 Illustration of typical band-clasp RPD, *Dental Cosmos* 1900.

According to several literature searches, the first recorded description of an RPD was a block of bone carved to fit the mouth in 1711.[19] Terrell discusses similar examples and how early authors were focused primarily on the esthetic rather than functional improvements offered by these prostheses.[17] Dentistry moved beyond this very crude "carved fit" stage with Fauchard's innovative RPD designs.[20] In 1728 he described and demonstrated the use of a connector. Fauchard used both a labial and lingual metal bar to achieve rigidity in the prosthesis.[14] Several reviews credit Mouton and Bourdet as the first to describe the use of retentive clasps.[21,22] By the year 1810, Gardette of Philadelphia began using wide wrought band clasps in an attempt to improve prosthesis retention.[23] The bands completely encircled the tooth and often extended into the gingival sulcus (Fig 1). The destruction of the marginal gingiva and the tooth due to constant vertical movement of the prosthesis led to the first description of an occlusal rest in 1817.[24] Delabarre described "little spurs" and their prevention of excessive vertical settling of the RPD and the resulting gingival or wear issues. By 1820, dentistry had already discovered the connector, the clasp, and the rest.[14,16]

Very little changed in the use of these three components until several writings by Bonwill in the 1890s.[25,26] Bonwill described in detail the common consequences of RPD use at the time. These included movement of the teeth, gross caries, wear of abutment teeth, and the clinician's inability to achieve a well-fitting prosthesis.[25] Bonwill's attempt to manage RPD fit was to fabricate in pieces and then join these parts with solder using a pick-up impression. This was mainly dictated by the materials available at the time. The only available impression materials at the turn of the century stable enough for use in RPD creation were plaster or compound, both very rigid once set.[27] This limited the clinician's ability to manage undercuts and mal-positioned teeth. Another obstacle was the inherent limitation of available prosthesis fabrication materials. The various gold, nickel, or chrome alloys used today did not exist. In fact, precision castings of any material were not available until William Taggart popularized the lost-wax casting technique for

Figure 2 Bonwill's depiction of his new clasp design.[26]

dentistry in 1907.[15] Instead, various gauges and dimensions of gold wire or plate had to be bent, cut, and/or swaged to create the metal components.[28,29] A precise fit or rigid connector was a major challenge with this technique.[14]

The main focus of Bonwill's writings was his idea to move away from the use of bands for RPD retention (Fig 2).[25,26] The high incidence of gross caries due to food impaction between the imprecisely fit bands and teeth was of obvious concern. Bonwill therefore advocated a change to a retentive arm with much less vertical height. Such a dramatic reduction in clasp surface area was possible due to Bonwill's attention to fit, support, and stability of the prosthesis. Bonwill stated that occlusal rests and preparation of the tooth to accept them were absolute necessities.[26] Through clinical experience Bonwill believed that much of the damage to the tooth and surrounding gingiva was prevented by using rest seats. By routine use of rest seats and attention to fit, Bonwill reduced the need for the clasp arm to provide support. With the reduction in band size, Bonwill was able to discuss details regarding clasp flexibility. His statement regarding thickness and length as variables in clasp flexibility foreshadowed modern force management and clasp dimension strategies. Although the band design continued to be used for some time, its frequency of use faded quickly following the turn of the century.[3,28]

A force for change: Hunters' sepsis

Due to increased attention, major advances in RPD technology and construction began occurring at the turn of the century. The demand for RPDs was increasing because of major issues with fixed partial dentures (FPD) at the time. Turn of the century FPDs suffered from the same material and method shortcomings as the RPD. Bonwill stated that it requires no skill to whittle a natural crown to a point and slip over it a loose gold crown cap and cement it to fill up a bad fit.[26] The combination of poor retainer fit and weak water soluble cements encouraged de-bonding, and marginal leakage followed quickly by decay. These consequences were often irreparable, as the remaining retainers held the bridge in place, thus preventing diagnosis of the issue. Even if diagnosed, endodontic understanding and technology was still in its infancy despite the frequent use of posts (Fig 3). The inability to remove the FPD for cleaning was seen as the reason for all these problems. Consequences of this poor quality care became so pervasive that William Hunter, a

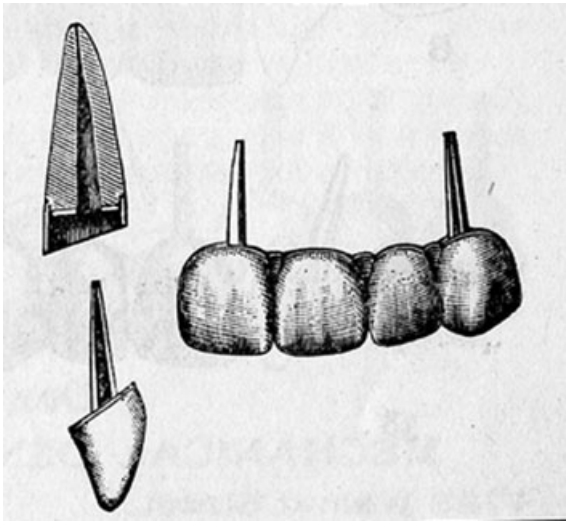

Figure 3 Image of pre-manufactured FPD, circa 1908.

Figure 4 Component castings for RPDs became common after 1916.

physician from Britain, campaigned against dental practices of his time.[30] Beginning with his 1900 publication, Hunter proposed a causal connection between oral disease and systemic disease.[30] This connection was made after he repeatedly found multiple carious and abscessed teeth present in the mouths of patients with FPDs. His vivid descriptions are direct in their assessment of cause: "The worst cases of anemia, gastritis, colitis, obscure fever of unknown origin, or nervous disturbances of all kinds are those which owe their origin to, or are gravely complicated by, the oral sepsis produced in patients by these gold traps of sepsis."[31] The dental disease which he found was rightly attributed to the aforementioned FPDs, which he termed "gold traps of sepsis," "mausoleum of gold over a mass of sepsis," or "septic dentistry."[31] He attacked the dental profession for its lack of attention to patient oral hygiene and prosthesis cleansability. These harsh attacks from the medical profession had a profound effect upon prosthetic dentistry. Clinicians, afraid of being accused of causing "Hunters' Sepsis" began focusing their attention upon RPDs. The ability to remove and clean the RPD was supposed to prevent the septic infections caused by FPDs. Indeed, the most prominent dental professionals at that time were strongly in favor of removable over fixed bridgework for this reason.[26,32-34]

The ultimate result of this RPD enthusiasm was significant advancement in the RPDs development. Clasp designs evolved quickly. It took a mere 20 years to move from the band clasp to the circumferential cast clasp, which is still used today. Roach was a leader in infra-bulge and wire designs,[32,35-39] whereas Nesbett was the first to publish on cast clasp arms in 1916.[33] The driving forces behind these changes were the supposed improvements to oral hygiene maintenance; however, authors began to debate clasp advantages in regards to the forces placed on the teeth.[29,36,40-45] This began a long period of RPD design focused upon force distribution during function.

Although most authors focused on clasps in this regard, several believed in minimal clasping.[28,40,42,43] They focused instead upon the benefits of stability and a precise fit. Using sectional construction, Woodworth believed clasps should merely aid in retention of the well-fitting RPD.[40] By 1915 Chayes was creating complex RPDs using attachments, sometimes referred to as *removable bridgework*.[43] Parallelism of the abutment surfaces and attachment devices were the hallmark of his RPDs. Prothero stated that by using frictional contact between teeth and the RPD, stability is maximized, thus reducing the need for clasps.[42] This design improves esthetics, hygiene, and retention but required the use of complex restorations. Although these designs did exist, they were for an elite few.[45] Very few possessed the clinical or technical expertise to create such prostheses, and fewer still could afford to pay the high cost to have one made. In addition, the complexities of these designs meant frequent adjustments, repairs, and often substantial tooth preparation.[44] For these reasons most dentists continued to use conventional RPDs for their patients.

Since RPDs were being made in parts with limited material choices, the time and effort to achieve an accurate fit was substantial. Soon after William Taggart introduced the lost-wax technique to dentistry in 1907, this principle was applied to RPDs by Norman B. Nesbett (Fig 4).[33] In 1916 he described the technique for casting clasp assemblies for RPDs. His refinement of the alloy and prosthetic tooth attachment allowed the successful creation of short-spanned unilateral RPDs. Nesbett described the "inlay fit" of the clasp assemblies attained after assembling the separately cast components on a plaster cast. At that time, casting RPDs in one piece was not done. Nesbett says why: "*Under no circumstances* should the attempt be made to cast the two clasps and middle section in *one piece*, for while this can easily be done, no *proper fit can be obtained*. The warpage and shrinkage of such a large and irregular casting is uncontrollable."[33] This statement is very telling when one considers it applies to small single-tooth RPD castings. Rudd preferred to deal with the challenges of RPD fit in the laboratory.[46] To do this he created a full-arch definitive cast. This was a major feat in the 1920s. Full-arch impressions with plaster were challenging to accurately make, let alone reassemble, after removing plaster in pieces to preserve the undercuts. In addition, the lack of refined dental stones required the creation of amalgam dies; however, if all went well, the benefit was a large reduction in the amount of chairside time with the patient, as the major fitting procedures occurred without the patient present.[46]

The RPD was cast in pieces as normal, but each piece would then be fitted back to the definitive cast. Once fit, the pieces were soldered using an index from the cast rather than the mouth. After assembly, the RPD was again fitted back to the definitive cast. This basic technique sequence would continue to be used after RPD castings were made in one piece.

Access to care: Akers' one-piece casting technique

The leap into full-arch, one-piece RPD castings was officially made by Akers when he published this technique in 1925.[47] The allure of the one-piece casting technique was its efficiency. The time savings meant the possibility of offering RPD service to the general public. At the time, Akers was a strong proponent of improving access to quality dental care, and he stated that from an economic standpoint, RPDs made this way could be used by the person of average means.[47] Access to care was very much a hot-button issue for dentists in that era. Part of the "Hunter's Sepsis" scare included Hunter's observations that those most affected by dental disease and low quality care seemed to be those of lower socioeconomic status.[31] It is clear these attacks on the profession were taken to heart by many prominent dentists.[48] It appears that Akers' one-piece casting technique was not only a great contribution, but a positive response to the issue.

Not everyone was as excited about the one-piece technique as Akers. Indeed, a heated debate as to the quality of these restorations began. As making RPDs in pieces was routine, to change this meant a major change in construction philosophy. In the discussion section following Akers' article, Roach responded by supporting the benefits of sectional construction.[47] Roach argued that full-arch impressions, which are still being made with plaster, are challenging. In addition he observed that the shrinkage of the large and often complex castings results in poor fit of the prosthesis just as Nesbett had discussed.[33]

Three major reasons existed as to why the one-piece casting technique gained almost complete support within a decade. First, the admonishment of fixed bridgework by Hunter was still fresh in people's minds, resulting in great built-up demand for affordable RPDs.[31,48] Authors often encouraged this demand by citing supposed benefits of RPDs, such as positive effects upon underlying bone structure compared with fixed bridge work.[49] Second, improvements in refractory materials and gold casting alloys continued.[50] This resulted in more reliable materials to manage the technical issues of the fabrication process (Fig 5). Third, the one-piece technique was much easier for the dentist. The many challenges of the sectional technique included multiple sectional impressions with rigid materials, pick-up impressions, and soldering. These assembly procedures eventually gave way to the time-saving single impression and one-piece casting. Widespread acceptance was evident within a matter of years.[51,52] By 1930, a mere 5 years following Akers' article, even former opponent Roach was using the one-piece casting technique.[36]

It is interesting to note that the unilateral tooth-bound RPD contributed greatly to the success of the one-piece casting (Fig 6). Schott in particular advocated how the unilateral RPD restoring a solitary bounded space could become practically a

Figure 5 The Akers technique required the use of newly discovered refractory stones to withstand high burn-out temperatures.

fixed bridge.[51] Roach preferred making individual rather than a single RPD when more than one tooth-bound space existed.[53] No doubt the reduced volume of metal resulted in better control over the casting shrinkage; however, for several reasons the unilateral RPD would slowly lose favor. Improved FPD treatment and the passing of the "Hunter's Sepsis" scare was the biggest reason; however, issues such occasional swallowing of the prosthesis were also to blame.[54] Currently, the unilateral RPD restoring a bounded space is not a commonly offered treatment modality.[55]

Persistent use of old methodologies and lack of standardization complicated consistent and proper application of the new changes in treatment.[34] In an attempt to address this issue, Cummer provided an excellent summary of the theory and practice of partial denture service.[41] In 1922, he discussed RPD design as it related to the four basic components then being used. The terms used are now considered standard: saddle (base), connector, retainer, and occlusal rest.[41] Cummer promoted new force management strategies, such as use of an indirect retainer, limiting clasps to one on either side of the fulcrum line, and rebasing of the saddle areas when appropriate. He also repeatedly commented on the major clinical challenge of RPD fit management. Of particular interest is his outline regarding the sequence of RPD service. A distinction is made between

Figure 6 A single-unit RPD for a unilateral bounded edentulous space was once considered the standard of care.

the four phases: design, construction, insertion, and maintenance. In essence this article was a predecessor in thought and organization to the RPD textbooks that have followed since then. With the RPD now a much more common treatment, it became apparent that the profession also still lacked a standardized classification system. Lack of agreement regarding what type of clinical situation was being discussed prevented agreement about the principles with which to approach each case. When discussing force management strategies in particular, authors of the time rarely agreed, because they were often promoting or debating strategies that applied to entirely different partially edentulous situations. Construction techniques, materials, and concepts were changing rapidly and being promoted without complete understanding of their clinical consequences. Although several classification systems had been introduced, none had proven simple and applicable on a consistent basis until Edward Kennedy presented his system.[40,41,56] The Kennedy classification system was simple, easy to use, and proved almost universally applicable. Its main differentiating factor was its ability to quickly and clearly demonstrate the location of tooth support in relation to edentulous spaces. Although not universally accepted for some time, strong established support for this system in both practice and education appeared by 1933.[57] Maintenance of this success is evident in that it is still the dominant partially edentulous classification system used by the most popular RPD textbooks in the United States today.[58,59]

Consequences of efficiency: Loss of respect for the RPD

With further refinement of the one-piece casting technique, demand for this method continued to grow.[52] Dental laboratories quickly became a common and indispensable part of RPD therapy. Dentists, who due to the nature of the sectional construction technique had previously completed all framework fabrication steps in-office, now began delegating this step.[60] The difficulties in mastering the new and ever-developing process of creating a refractory cast, patterning a wax framework, investing, and casting were time-consuming for the average dentist.[46,61] The time savings of delegating this step allowed the dentist to treat more patients, thus improving access to RPD treatment. In response to this, the number of dental laboratories began to increase. Unfortunately in many cases the laboratory was soon given the task of designing the RPD without being aware of the clinical situation.[62,63] The resulting designs were not based upon biologically sound philosophies and often violated the few principles adopted by that time.[57]

Another major advancement for RPDs in the 1920s occurred with the advent of the dental cast surveyor. Chayes had developed a parallelometer to help guarantee parallel precision attachment alignment both clinically and in the laboratory;[43] however, it is believed to be Fortunati who was first to demonstrate the advantages of using a mechanical device to map the contours of abutment teeth.[64] In 1921 Weinstein and Roth marketed the first commercially available surveyor;[64] however, its use was not routine until the advent of the hydrocolloid impression materials in the 1930s. Prior to the use of elastic materials, the undercut areas of the teeth were often blocked out, relieved, or lost during impression procedures.[47,57] Even after the advent of reliable elastic impression materials, a refractory cast was often made directly from the impression with blocked-out undercut areas.[36,57] This tended to complicate framework fit due to the lack of control over the height of contour of the abutment tooth; however, by analyzing a dental cast, one was able to determine which area of an abutment tooth might require modification (Fig 7). Although descriptions of these line tracings on the teeth occur prior to this time, the term "height of contour" is credited to Edward Kennedy.[64]

Figure 7 Dental surveyors led to the development of advanced RPD concepts such as guiding planes.

Willis was among the first to describe in writing the technique for dental model surveying.[65] He mentioned that blocking out of "undesirable undercut areas" was not new, but that establishing a common vertical plane angle was. He appears to be the first to use the term "path of insertion" for RPDs in relation to a chosen plane. This allows visualization and block-out of undercuts on the definitive cast prior to refractory cast creation and framework casting. Willis describes tripoding to record the path of insertion and along with others, promotes the use of reversible hydrocolloid as the impression material of choice for RPDs.[57,65] This technique allows the dentist to improve two major aspects of treatment. First, the dentist is able to more accurately design the RPD and confirm mouth modifications. This was required for a more scientific debate regarding force management strategies and eventually lead to

the use of guiding planes as key features of RPDs.[13,43,66] Second, using a surveyor further incorporates the dental laboratory into the RPD construction process. After the dentist records the path of insertion and then designates a design, the remaining laboratory procedures may be delegated to the laboratory. The basic technique sequence described by Willis in 1935 continues to be used in almost identical fashion for the vast majority of RPDs made today. Soon most prominent authors were using surveyors from the diagnostic stages on.[67]

Even with the addition of the surveyor, the fit of the framework continued to be a major issue mainly due to the inherent shrinkage of the large castings.[33,41,68] Despite improvements in refractory materials and duplication techniques, the expansion and contraction of materials was not perfected.[50] To make matters worse, handling of the casting often compounded the misfit.[68,69] By accepting the task of framework creation, laboratories were often making decisions regarding block-out. Extra block-out meant a greater likelihood of the framework dropping to place due to fewer tooth-frame contacts; however, it also meant reduced stabilization or tooth contact. The lack of knowledge most dentists had regarding the framework creation process and how this could handicap their ability to address fit issues was being mentioned as early as 1931.[63] Further control over framework fit was lost when laboratories polished all surfaces of the casting to maximize cleanliness.[52] Nesbett, the original author of cast clasps, recommended polishing all metal surfaces.[33] This polishing altered the tooth-contacting surfaces more still.[69] Addressing this issue, Chappelle proposed fitting the casting as-cast. He pointed out that laboratory-fabricated RPDs were "usually polished to the extreme," and to save time they are ground with coarse grit stones and polished with fast-cutting abrasives, thus compromising accurate contact.[69]

The end result of these uncontrolled aspects of laboratory procedures was an RPD that did not necessarily fit as intended. Authors such as McLean pointed out that "resilience of the Roach bars and the tolerance of the mucosa cloak the misfit of the average one-piece casting, but they do not eradicate it."[68] Cummer stated that the major clinical challenge in RPD construction was the maintenance of accuracy.[41] It is interesting, then, how the vast majority of authors in the 1930s and 1940s debated various methods of force transmission, stress distribution, and design whereas the RPD frameworks in general use often lacked precise fit as discussed earlier.[39,53,70-74]

Even frameworks that did fit well had some concerns. By the 1930s, rigidity of the framework was an established principle;[40,69,70,75] however, rigidity of the major connectors was not universally achieved.[14,70] While the gold alloys used at the time did lend themselves to fitting procedures as they would show "facets" on prematurities, they were also known to flex or even permanently distort under enough force. The size of major connectors and continued use of stock wire bars for bar-type connectors was also to blame.[14,70] In these instances, RPD philosophies dependent upon rigidity could thus be questioned.

In an attempt to deal with these issues, clinicians tended to add multiple clasp arms to the RPD design (Fig 8). This generally was done under the premise of preventing abutment tooth drifting or to improve support, stability, or retention. The ill-fitting RPDs made at the time placed uncontrolled forces upon the abutment teeth, thus encouraging them to move away from the partial.[36,69] The band retainers used at the turn of the century hid this consequence of misfit by encircling the clinical crown of the abutment tooth. With the advent of modern clasp arms, encirclement was no longer inherent to the design. The immediate solution to this tooth displacement problem was to again encircle each abutment tooth with a second clasp arm on the opposite side of the tooth as the retentive arm to prevent its migration.[36,41,69] Roach, who was among the first to describe reciprocation, was aware that most retentive clasps were actively exerting force on the abutment teeth.[36,53] The need for this protective feature is all the more evident considering that some authors encouraged the placement of an active force upon the tooth by the clasp.[37,60,75] The profession seemed to continue using pressure with retentive clasps. In 1935 Willis said, "the old idea of gripping a tooth with a clasp for retention has been so impressed on our minds that it is difficult to forget."[65]

Figure 8 Incorporation of multiple clasps became common as practitioners attempted to deal with ill-fitting RPD frameworks.

In addition to reciprocation, it was believed that additional clasps and encirclement would improve the RPDs lateral stability in function.[14] According to Roach, these additional clasp arms also improved support for the RPD.[36] Of more obvious consequence to novice clinicians was the retentiveness of the prosthesis. To avoid patient complaints or to achieve what they felt was the primary goal of the partial, designs often included numerous retentive clasps. Although the result was often a retentive partial, it was most likely not a well-fitting partial. Certainly the numerous clasps added to the oral hygiene maintenance challenges some associated with RPD components. Woodworth noted these trends and stated that clasps had been misused through expecting them to do too much; they will hold the bridge in place when it really does not fit.[40]

By accepting the chronic poor fit of the RPD frameworks amidst the challenge of shared tooth and tissue support, dentists were constantly faced with what they felt were the consequences of RPD use in general. Dentists soon began blaming the RPD for destruction of the supporting periodontal tissues. With the major etiologic factors of dental disease still not clearly determined, a period of great debate raged about how to manage the forces placed upon abutment teeth. As demonstrated in this review, the heightened importance of laboratory science reinforced the belief that an engineering solution existed to this issue.[76] The ingenious use of stress breakers is one example of

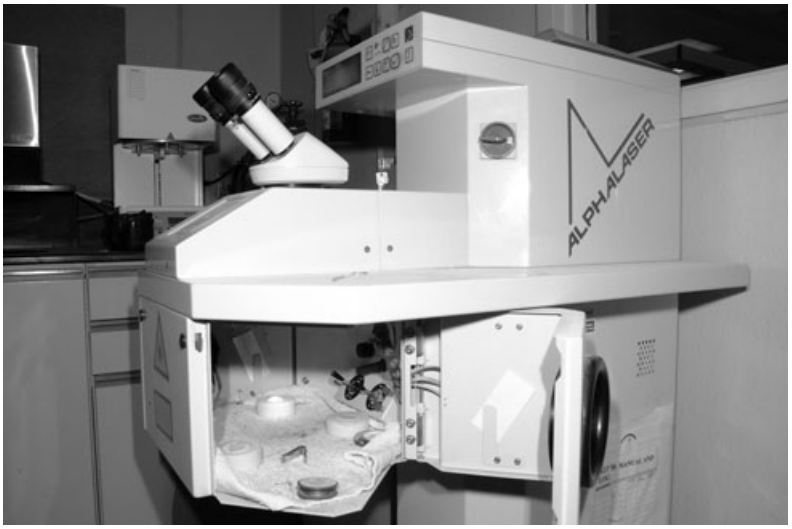

Figure 9 Laser-welding technology has proven helpful for many applications, including RPD framework unification and repair.

the profession's attempt to solve the clinical challenge of combined tooth and tissue support through engineering.[44-46,69,77,78] Unfortunately, few RPD authors focused on the etiology of the disease causing the dental destruction.[79] It was not until the 1950s that some of these clinical debates were resolved in an evidence-based approach. By this time, poor clinical results and dramatic improvements in fixed prosthodontics combined to greatly reduce the level of respect for the RPD both by the public and within the profession.[80,81]

Return to precision: Sectional construction revisited

Following the introduction of Akers' one-piece casting technique, several authors maintained that sectional construction was preferred due to the superior fit obtained;[62,63,68] however, the efficiency of the newer method guaranteed its use by the vast majority of dentists. Other than material improvements, RPD framework fabrication remains basically the same as the mid-1930s. It should not be surprising, then, that modern RPD framework fit continues to be less than ideal.[82-87]

Several modern methods of sectional construction have been discussed. If efficiency was the major reason for use of the one-piece casting technique, these options may present an appealing alternative. Although valid long-term outcome data are sorely lacking in the prosthodontic literature, acrylic resin RPDs continue to be used with great frequency.[88] Acrylic has also been used in combination with cast clasp assemblies in an attempt to improve the performance and long-term stability of the RPD.[89,90] More recently, improvements in laser-welding technology have allowed predictable unification of metal components (Fig 9). Cecconi et al described a component approach in which individual parts are fabricated and joined on the definitive cast by means of autopolymerized acrylic resin or laser welding (Fig 10).[91] Brudvik et al showed that this technique reduced distortion of large castings, the cumulative effect of which is optimum control of the framework fit.[92] Superior fit may also be attributed to the fact that the fit of individual components may be evaluated with ease in the laboratory. Cecconi et al noted that the need for time-consuming trial placement of the framework is thereby eliminated.[91] Additional advantages are that fabrication of tooth- and tissue-supported elements can be done separately, and dissimilar materials may be used. In component RPDs, cobalt–chromium or nickel–chromium alloys may be used for rigid major connectors, and gold alloys may be used for clasp assemblies where improved accuracy and flexibility may be required. Similarly, acrylic resin denture base and acrylic resin teeth may be combined with metal or porcelain where necessary.[93,94] Perhaps with newer techniques, more stable, hygienic, and comfortable RPDs could be fabricated as efficiently as the historic, conventional RPDs made today (Fig 11).

Conclusion

Key turning points in RPD philosophy included Bonwill's band-free RPD design, the Hunter's Sepsis scare, Akers' one-piece casting technique, and the ramifications of the one-piece

Figure 10 A component RPD fitted to the definitive cast, prior to unification with laser welding.

Figure 11 The completed component RPD with minimal clasping due to optimum framework fit.

technique's application. The driving force behind these events appears to have been technological improvements, high cost of alternative methods of tooth replacement, and a high demand for RPDs. Since these three forces appear to once again be active, perhaps another turning point in RPD philosophy is approaching?

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