A Systematic Review of the Scientific Documentation of Fixed Partial Dentures Made from Fiber-Reinforced Polymer to Replace Missing Teeth

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Purpose: Many restorative systems have become commercially available that are based on fiber-reinforced polymers (FRP) for production of fixed partial dentures. However, the clinical documentation of their use has not been systematically reviewed and critically appraised. This systematic review aimed to identify the scientific documentation of all commercially available products within this material group. ***Materials and Methods:*** MEDLINE was searched for all clinical and laboratory studies on FRP, and papers were browsed to identify product names. Moreover, the Internet was searched to find manufacturers of FRP products. Also, several large trade exhibitions were visited to identify products and manufacturers. All papers that included any data from a clinical setting of an identifiable product were critically appraised. Each product was categorized according to the scientific clinical documentation of their intended clinical use. ***Results:*** Eleven commercial products were identified. The scientific clinical documentation of these products varied markedly, but was generally poor. No randomized controlled trials have been carried out on FRPs versus, eg, conventional treatments, nor are any long-term cohort studies available. None of the products demonstrate good evidence for usage as a technical solution to permanently replace lost teeth. ***Conclusion:*** The use of FRP for fixed partial dentures must still be regarded as experimental.
Int J Prosthodont 2005;18:489–496.

Many clinicians and patients consider a fixed partial denture (FPD) as the best therapy for restoring missing teeth. The alternatives have traditionally been the acrylic resin or cast removable partial denture (RPD), which may be preferable in patients who need replacement of large amounts of tissue, when the prognosis of the remaining teeth is poor, and when there is a lack of posterior abutments as retainers. However, an RPD is associated with potentially negative adverse outcomes, such as increased caries incidence and nonphysiologic loading of the retaining teeth and patient dissatisfaction due to poor adaptation.[1] Implant-based prostheses may be the optimal solution in some circumstances, but many patients fear the required surgery and some also consider the treatment costly. A disadvantage with the FPD is the need for a substantial amount of hard tissue removal to allow for an optimal insertion path and material bulk for sufficient strength and masking of the underlying metal substructure.[2] The process is also time-consuming and requires a high level of operator clinical skills.[2] The biologic costs are reflected in a relatively high incidence of pulpal damage.[3] For these reasons, investigators have long searched for alternative tech-

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nical solutions. A technique that was favored for a period was the so-called pin-ledge preparation, where the retainers were only partially prepared. Unfortunately, the incidence of both technical as well as biologic complications with pin-ledge prostheses was high.[3] A more modern alternative is to cement a cast framework to acid-etched enamel with a resin composite.[4,5] Initially, it was believed that a tooth preparation was not required in these cases.[4] Clinical experience, however, has shown that some basic elements of preparation for FPD abutments are still required to resist the long-term effects of axial and horizontal forces.[5]

Today, rapid developments in biomaterial research have led to the promotion of a large number of alternative technical solutions. Most involve the use of fiber-reinforced composite resins, although attempts to use other types of materials have also been reported.[6] Many of these new products may seem promising on the basis of their mechanical-physical properties. However, it is mandatory that the strengths and weaknesses of these new fiber-reinforced polymer (FRP) materials be demonstrated in the oral environment before they can be embraced by dental practitioners.

The current study is a systematic review of all commercially available FRP products promoted as alternatives to conventional fixed prosthodontics. The aim of the study was to identify the documentation used to promote these products, and secondarily, to critically appraise this documentation for the strength of the research methodology, if any. Our hypothesis was that there is a lack of adequate clinical trials to demonstrate that this intervention benefits the patients in terms of FRP-FPD survival, esthetic results, and reduction of costs.

Materials and Methods

First, we identified all commercially available FRP products and manufacturer names. MEDLINE was searched to find papers published after 1990 using different key words—eg, denture, partial; dental prosthesis; alternative bridge construction; alternative fixed partial dentures; fiber composite; resin-bonded bridge—in combination with the "related articles" feature in PubMed. All abstracts were appraised to identify product names. In addition, the authors attended several large dental trade exhibitions, including the 2003 International Dental Society exhibition in Cologne and the Fédération Dentaire Internationale exhibitions in Sydney, Australia, in 2003 and New Delhi, India, in 2004 to search for products that use FRP technologies. Next, we identified the clinical documentation for all the different products. All the identified manufacturers were solicited for background information about their product, and their Internet home pages were searched for further information. All pamphlets, leaflets, and other promotional material were scrutinized for references to clinical data. The abstracts identified in the original MEDLINE search were reviewed again, this time to identify papers that possibly could contain clinical data. These papers were read in full by two of the authors, who assessed independently whether any clinical data was included. Moreover, the reference lists of these papers were hand-searched to identify other clinical trials and/or the names of other products.

Finally, the study characteristics of the papers containing clinical results were recorded and the methodologic strength of each study was established. Two of the authors extracted the clinical data, while the third author verified the accuracy of the extracted data.

Results

Different technologic solutions for the fiber reinforcement of polymers have been applied for commercial products (Table 1). Distinctions can be noted regarding fiber materials, fiber forms, and type of polymer. The most common fiber materials are glass (n = 6) and polyethylene (n = 3), either unidirectional (n = 6) or braided (n = 3).

Nine different combinations of fiber material and form were identified. These are presented below according to product name, with the supported identified clinical data sorted according to study methodology and year of publication.

Polyethylene, (Leno-)Woven Fibers

Ribbond (Ribbond). *Case series #1.* Thirty-seven inlay/onlay laboratory-made FRP-FPDs were monitored for 3 years.[7] Thirty-five FPDs were still in situ after 3 years, and the author concluded that the results were encouraging, but that 3 years is a short observation time.

Case report #10. One case is presented[8] involving the replacement of missing maxillary lateral incisors while waiting for implant treatment, using an intraorally made FRP-FPD.

Case report #9. Different clinical applications for FRP uses are described, but no clinical data are presented.[9]

Case report #8. An immediate tooth replacement using the extracted maxillary central incisor to replace itself is described.[10] It is claimed to function satisfactorily 1 year after placement.

Case report #7. A direct replacement of a maxillary central is described[11] and is reported to function adequately after 6 months.

Table 1 Fiber-Reinforced Polymer Products Promoted as Alternatives to Fixed Partial Dentures as of October 2004 and No. of Clinical Studies Documenting Their Use

Fiber material/ form	Product name (manufacturer)	Cohort study	Case series	Case reports
Polyethylene				
Weave (Leno-)	Ribbond (Ribbond)	-	1	10
Braid	Connect fibers (Kerr)	-	-	1
Unidirectional	DVA fibers (Dental Ventures)	-	-	-
Polyalkane				
Braid	Fiberspan NSI (Nulite Systems International)	-	1	-
Kevlar				
Unidirectional	Fibreflex (BioComp)	-	-	-
Glass				
Weave	Fiber-splint (Polydentia)	-	-	-
Braid	GlasSpan (GlasSpan)	-	-	1
Unidirectional	Splint-it (Jeneric/Pentron)	-	1	-
	FibreKor/Sculpture (Jeneric/Pentron)	1	-	3
	Stick/Sticknet/Everstick (Stick Tech)	1	1	3
Unidirectional mesh	Vectris/Targis (Ivoclar/Vivadent)	4	2	2

Case report #6. Two case reports are described[12] in which a direct technique is used to manufacture FPDs, and both are reported to function satisfactorily after 6 and 12 months.

Case report #5. An interim replacement of a maxillary central incisor is described[13] using an indirectly manufactured FRP-FPD.

Case report #4. The technique for manufacturing a FRP-FPD using a indirect technique is described.[14]

Case report #3. A technique for the direct fabrication of a FRP-FPD is described.[15] The FPD was reported to be in place for 6 months before being replaced with a conventional FPD.

Case report #2. The preparation of an inlay FPD manufactured at a dental laboratory to replace a missing mandibular premolar is described.[16]

Case report #1. An indirect method to replace 2 maxillary central incisors in a child is described.[17] The method included minimal tooth preparation, ie, shallow grooves on the labial surface of the maxillary lateral incisors.

Polyethylene, Braided Fibers

The single product in this category was Connect fibers (Kerr). A single article was found on Connect fibers[18] describing a case with the replacement of 2 missing maxillary lateral incisors, using an intraorally made FRP-FPD.[19] The clinical procedures are described. No product name is mentioned in the article, but the paper is referred to on the manufacturer's website.

Polyethylene, Unidirectional Fibers

The sole product in this category is DVA reinforcement fibers (Dental Ventures). The manufacturer claims on their website that the product has been used successfully for over 10 years to strengthen all type of dental appliances.

Kevlar, Unidirectional Fibers

Fibreflex (BioComp) is mentioned in one article published in 2001,[20] but it is not known whether the product is still being marketed. It is the only product that is based on Kevlar, which is produced by DuPont. There is no information regarding the use of this product in dentistry on the website of DuPont (www.dupont.com).

Glass, Woven Fibers

Fiber-splint (Polydentia) is promoted as an indirect system for fabrication by a Swiss dental laboratory. No references could be found in the dental literature.

Glass, Braided Fibers

One report was found regarding GlasSpan (GlasSpan).[21] In it, 2 cases are described to demonstrate the use of 1 direct and 1 indirect technique to manufacture 2 different types of FPDs (one using Kevlar-type fibers and another using GlasSpan).

Glass, Unidirectional Fibers

FibreKor/Sculpture (Jeneric/Pentron). *Cohort study #1.* Indirectly made FRP-FPDs with 2 different designs were observed for up to 37 months.[22] The 2 designs were extracoronal full coverage (n = 22) and intracoronal partial coverage (n = 17) FRP-FPDs. Several early failures with a low volume of polymer versus fibers prompted the investigators to change to a higher polymer volume. The high volume restorations demonstrated a 95% survival rate after 3 years.

Case report #3. The fabrication of 2 3-unit FRP-FPDs is described.[23]

Case report #2. Three cases in which 2 different FRP-FPD products, Splint-It and FibreKor, were used are described to highlight current clinical uses of FRP.[24]

Case report #1. One case is described in which a maxillary central incisor was replaced using the extracted tooth crown as a pontic in an intraorally made FRP-FPD.[25] The interim construction was reported to have been in place for 4 months prior to the final tooth preparation and placement of a definitive FPD.

Splint-it (Jeneric/Pentron). *Case series #1.* A method for manufacturing FPDs chairside is described. The method was applied to the treatment of 20 patients.[26] One patient had used the FPD for 42 months without any failure of the fiber structure or debonding. There was no mention of the fate of the remaining 19 FRP-FPDs in the study.

Stick/Sticknet/Everstick (Stick Tech). *Cohort study #1.* Thirty-seven FRP-FPDs were made on dental casts and then cemented in place.[27] Eight clinicians carried out the treatments using 3 different FPD designs. The patients were examined every 6 months. Partial or total debonding was considered failure, and the estimated survival rate using these 2 criteria was 93% after 23 months.

Case series #1. Twenty-nine FRP-FPDs were evaluated after up to 63 months (mean 42 months with a minimum of 24 months).[28] The estimated survival was 75% at 63 months, according to Kaplan-Meier statistics.

Case report #3. Four patient cases highlighting the use of FRP-FPDs are described.[29] In 1 case, an extracted tooth in a direct FPD is used; in another case the indirect replacement of the maxillary left first premolar by making a provisional FPD with wings labial and lingual on the adjacent teeth. The 2 last cases demonstrate how to make an FPD chairside on a dental cast and cementing the FRP-FPD.

Case report #2. One case is presented describing how to increase the bonding surface of an FRP-FPD by using labial and buccal undercuts with preparing abutments.[30] A successful 2.5-year follow-up period is claimed.

Case report #1. One case is described[31] in which an indirectly made FRP-FPD replacing a missing canine and premolar has functioned for 1 year.

Glass, Unidirectional Fibers in Mesh

Vectris and Targis (Ivoclar/Vivadent). *Cohort study #4.* Twenty-two FRP-FPDs were evaluated after up to 4.4 years, with a mean observation period of 2.5 years.[32] Two designs were used: adhesively fixed inlay-retained FPDs (n = 17) and conventionally cemented complete-coverage FPDs (n = 5). The estimated cumulative survival rate at 3 years was 72% for the inlay FPDs.

Cohort study #3. This retrospective study reported on 39 patients treated with 67 FRP-reinforced single crowns and 83 FRP-FPDs.[33] Twenty-eight FPDs were cemented with a temporary cement and 55 were cemented with a zinc-phosphate or glass-ionomer cement. The estimated survival rate was 59% at 3 years according to Kaplan-Meier statistics. A lower survival rate was observed for the FPDs cemented with temporary cement (55%) versus zinc-phosphate or glass-ionomer cement (68%). The authors concluded that glass fiber-reinforced FPDs with Vectris/Targis showed a lower success rate than metal-ceramic FPDs and that FRP-FPDs could not be regarded as definitive restorations.

Cohort study #2. Laboratory-manufactured FRP-FPDs with 2 different designs—parallel fibers (n = 19) versus parallel and woven fibers (n = 22)—were observed for 1 to 4 years.[34] The fracture rates were 16% and 5%, respectively, in the 2 groups. No other differences were noted regarding color match, marginal discoloration, secondary caries, surface texture, marginal adaptation, fracture, and postoperative sensitivity.

Cohort study #1. Twelve FRP-FPDs that had functioned for an average of 15 months were compared to 11 ceramic FPDs that had been in situ for an average of 10 months.[35] All the ceramic FPDs were of the inlay-retained type, of which one fractured during the observation period.

Case series #2. Forty FRP-FPDs, mainly of the inlay-abutment type, were made for 29 patients.[36] The FPDs were manufactured with a simplified laboratory technique and bonded to the abutments. The FPDs were clinically examined after 1 year, and 25 FPDs had been functioning with success for 2 years.

Case series #1. Twenty inlay FRP-FPDs were made for 15 patients using a simplified laboratory technique.[37] After 1 year, all the FPDs were intact.

Case report #2. A case describing a FRP-FPD replacing the maxillary right second premolar, with inlay retainers on the first premolar and first molar, is presented.[38] The FPD had been followed for 4 years without failure.

Case report #1. A case describing a laboratory-made FRP-FPD to replace a mandibular molar is described.[39]

Other Fibers

Descriptive paper #3. Twelve patients with 14 single-tooth replacements were monitored for 1 year.[40] No tooth preparations were carried out, with the rationale that the fiber system, named "experimental S2 glass fibers," represented a purely adhesive restoration system. The estimated survival was 50% at 1 year according to Kaplan-Meier survival statistics.

Descriptive paper #2. The literature concerning immediate prosthetic tooth replacement is reviewed with examples of different clinical techniques.[41] No actual brands of fibers are mentioned.

Descriptive paper #1. A presentation is made of the HTS carbon fibers,[42] manufactured at the time of publication by the Hercules Company, which are encapsulated with epoxy resin under the trade name Magnamite. It was introduced for esthetic crowns and FPDs, but no further reports about this product have been identified in the literature.

Quality of Scientific Documentation

The different FRP commercial products can be broadly categorized into 3 levels according to the scientific documentation of their intended clinical use: *(1)* category A: several clinical studies exist of adequate study design (cohort, prospective); *(2)* category B: fewer than two such studies exist, although additional case reports have been published; and *(3)* category C: no identified clinical studies have been published to support use of the product. Only 1 product qualified to be listed in category A, while 5 products were in category C.

Category A. Several clinical studies. Vectris/Targis has been described in 6 different clinical studies. The general consensus of these studies varies. The longest and largest studies do not support the use of Vectris/Targis as a permanent treatment.

Category B. Few clinical studies. Fiberspan NSI, Ribbond, FibreKor/Sculpture, Splint-it, and Stick/Sticknet/Everstick fall into this category. These products are described in at least 1 cohort study and/or case series. The papers, in general, favor the use FRP as an alternative to conventional fixed prosthodontics. One needs to be aware that Stick, Sticknet, and Everstick represent three generations of the same product, although the basic components remain similar. Only Stick has been evaluated, in 2 studies, and Sticknet and Everstick remain undocumented. However, the follow-up times are relatively short, which is also acknowledged in some of the papers. Ribbond has been described in as many as 10 case reports but only in one case series and no cohort studies.

Category C. Reports are lacking or are inadequate. Connect fibers, DVA fibers, Fiber-splint, Fibreflex, and GlasSpan can be classified as category C. No clinical data beyond an occasional case report for GlasSpan and Connect fibers could be identified.

Discussion

Most of the articles used by the manufacturers mentioned in this report to support their claims of high success rates of their products are case reports. In general, the papers favor the use of FRP-FPD, with the belief that the patient is provided with an acceptable esthetic result with reduced costs and a substance-conserving preparation leading to less tooth trauma and a long-lasting restoration. The longitudinal studies reported general failure rates between 5% and 16% over periods up to 4 years.[22,27,34] One study reported a much higher failure rate of 40% over a 3-year period.[33] To compare the success rates of different studies, one must be sure that the same treatment outcome criteria are being assessed and assessed consistently in the same way. Clinical conclusions that focus on handling, cost, and esthetics are difficult to compare because these criteria are often assessed subjectively. Some of the reports give the impression of "it works in my hands." This is not necessarily bad, as all data from clinical studies are an important part of the development in the field of dentistry. However, the fact that some treatment techniques work for some clinicians does not permit the clinical outcome to be generalized to a larger population of practitioners.

No papers could be identified where 2 different FRP products were compared on a longitudinal basis. This invalidates any attempts to compare the clinical performance of different products, because of the vast number of identified and confounding variables affecting the outcomes of such treatments—operator, material, and possibly patient cofactors.

Examples of operator variables are the design of the abutment preparation (if any), eg, inlay, full-crown coverage, and with or without buccal and lingual flanges. Moreover, the amount of fibers incorporated in the construction is relevant; for example, one study showed that a high-volume FRP-FPD had a higher success rate compared to constructions with a low volume of fibers.[22] Furthermore, the quantity of the polymer—notwithstanding the possible covariation effect with the quality of this polymer—has a direct influence of the success rate of the construction. Also, the marginal adaptation of the FRP-FPD to the abutments may influence the retention of plaque and risk of biologic complications. Finally, it may be assumed that FRP-

Table 2 Fracture Resistance and Strength Values of Fiber-Reinforced Polymer Products Based on In Vitro Experimental Studies

Product (fibers/ composite resin)	Behr et al[43]	Behr et al[44]	Kolbeck et al[45]	Loose et al[46]	Pfeiffer and Grube[47]	Saygili et al[48]	Vallittu[49]
Polyethylene							
Connect/Belleglass	–	940 N	898 N	–	–	–	–
Ribbond/Sinfony	–	–	–	–	252–429N†	–	–
Glass							
Fibrekor/Sculpture	–	524 N	368 N	–	–	–	–
Vectris/Targis	1457–1553 N	923–1361N	723 N	1305–1470 N	640–658 N†	–	–
Stick (experimental)/ Stick/Sinfony	–	–	634 N	–	–	–	973N†
Kevlar	–	–	–	–	–	91 MPa†	–
E-Glass	–	–	–	–	–	109 MPa†	–

All values are the median values, except where stated otherwise.
†Mean values.

FPDs made intraorally will be more prone than laboratory-made ones to negative influences of operator factors. This is especially relevant for the most technique-sensitive products, which remain unidentified.

Variations in material factors include the type of core fiber materials and their form, the method of pretreatment of the fibers, and the compatibility with a specific or proprietary polymer. The relevance of these factors remains to be determined in clinical trials, as it is not possible to deduce which of these elements have direct effects on clinical behavior. The core material can be made out of various forms of glass, polyethylene, Kevlar, or carbon fibers, which all display different physical-mechanical properties. Moreover, the fiber may be unidirectional, braid, mesh/network, "Leno" woven, or woven. This may be of importance when it comes to adaptability and manageability of the fibers, the degree to which they unravel when cut or manipulated, their ability to reinforce multidirectionally, and finally, the durability and impact absorbance of the fibers. The majority of the few published clinical studies report on unidirectional glass fibers. Whether this is a reflection of truly better effectiveness of these fiber-reinforced materials, of publication bias, or of lack of commercial funding for carrying out trials is unknown, but all alternatives are relevant explanations.
One may attempt to identify the risk factors for clinical failure of FRP-FPDs by methodically recording the reasons for failures of FRP-FPDs. Unfortunately, these are rarely reported or described in detail. Technical failures prevail over biologic problems. Several investigators report that the main clinical problems with FRP-FPDs seem to be delamination or partial delamination of the veneering material from the fiber framework, wear, and discoloration, especially if the fiber materials are exposed.[32] Fewer failures resulting from debonding from the tooth or actual fracturing of the fiber framework have been reported.[19,35] Other authors have reported, in contrast, that fractures along with discoloration are the second most common problem.[34] The variety in the reasons for failure may be the result of differences in products and handling and are probably also time-related. However, the general impression is that it is the polymer veneering material and its adhesion to the core fibers that seems to be the weakest link of these constructions.

When good clinical trials are lacking, it is tempting to extrapolate estimates of clinical behavior on the basis of morphologic and/or mechanical-technical properties. Some differences are revealed when published laboratory data are examined (Table 2). However, many of these data have been produced without taking into account various highly relevant clinical elements. One example is water absorption, which dramatically affects a property such as flexural strength[50] and may have an influence on survival rate in vivo. There are also several problems when comparing the laboratory data. For example, in some reports the fracture resistance is reported in Newtons—ie, the size of the external force applied to the material—whereas other reports provide this statistic in megapascals, which is the employed force per surface area (1 MPa = 1 N/mm^2).

Moreover, the wide range of reported values can be explained by different experimental variables related to the test sample, the experimental setup, and/or the loading setup. The test sample may vary in construction design (and may or may not resemble an actual FPD), in span lengths, geometries, and the amount of fibers incorporated into the sample. The abutments that retain the test sample have variable surface qualities and geometries, and both extracted teeth and casts made from a wide spectrum of materials have been used. Occasionally, the test samples have even

been retained by cement, which also introduces additional confounding variables into the measurement interpretations. The loading speed and the geometry of the loading apparatus will influence the results. Finally, the testing environment is very important. For example, measurements such as these should preferably be done in a wet environment, since these constructions are meant to be placed intraorally, and laboratory measurements made in a dry experimental environment are of questionable relevance.

Conclusion

Different technologies for FRPs intended for fabrication of FPDs have been developed. Very few of the commercial products based on these technologies demonstrate robust clinical documentation to support their use. The scientific evidence for advocating FRP-PRDs as an alternative to conventional FPDs is poor, as evidenced by a small number of published studies, nonrigorous study designs, and short observation periods. Although FRP-FPDs have the potential to become a cost-effective treatment option in selected patient cases, these solutions should be considered as an interim treatment until larger and longer trials employing more rigorous study designs have been published.

References

1. Carr AB, McGivney GP, Brown DT. McCracken's Removable Partial Prosthodontics, ed 11. St. Louis, MO: Elsevier/Mosby, 2005.
2. Milleding P. Abutment preparation. In: Karlsson S, Nilner K, Dahl BL (eds). A Textbook of Fixed Prosthodontics. The Scandinavian Approach. Stockholm, Sweden: Förlagshuset Gothia, 2000:155–172.
3. Valderhaug J, Jokstad A, Ambjornsen E, Norheim PW. Assessment of the periapical and clinical status of crowned teeth over 25 years. J Dent 1997;25:97–105.
4. Tay WM. Resin-Bonded Bridges. A Practitioner's Guide. London: Martin Dunitz, 1992.
5. el-Mowafy O, Rubo MH. Resin-bonded fixed partial dentures—A literature review with presentation of a novel approach. Int J Prosthodont 2000;13:460–467.
6. Kern M, Schwarzbach W, Strub JR. Stability of all-porcelain, resin-bonded fixed restorations with different designs: An in vitro study. Int J Prosthodont 1992;5:108–113.
7. Dickerson WG. A conservative alternate to single tooth replacement: A three-year follow-up. Pract Periodontics Aesthet Dent 1993;5:43–48.
8. Eskitaşcioğlu C, Eskitaşcioğlu A, Belli S. Use of polyethylene ribbon to create a provisional fixed partial denture after immediate implant placement: A clinical report. J Prosthet Dent 2004;91:11–14.
9. Ferreira ZA, de Carvalho EK, Mitsudo RS, Bergamo PM. Bondable reinforcement ribbon: Clinical applications. Quintessence Int 2000;31:547–552.
10. Belli S, Özer F. A simple method for single anterior tooth replacement. J Adhes Dent 2000;2:67–70.
11. Shuman IE. Replacement of a tooth with a fiber-reinforced direct bonded restoration. Gen Dent 2000;48:314–318.
12. van Wijlen P. A modified technique for direct, fibre-reinforced, resin-bonded bridges: Clinical case reports. J Can Dent Assoc 2000;66:367–371.
13. Miller TE, Margalit S, Tirnodiy J, Creamer TJ. Emergency direct/indirect polyethylene-ribbon-reinforced composite resin, fixed partial denture: A case report. Compend Contin Educ Dent 1996;17:182–190.
14. Miller TE, Hakimzadeh F, Rudo DN. Immediate and indirect woven polyethylene ribbon-reinforced periodontal-prosthetic splint: A case report. Quintessence Int 1995;26:267–271.
15. Miller TE, Rudo DN. Emergency direct fabrication of a resin fixed partial denture by using a ceramometal crown with reinforcing woven polyethylene ribbon as a pontic. Gen Dent 1995;43:560–563.
16. Dickerson WG. The concept bridge. Dent Econ 1994;84:67–68.
17. Miller TE, Barrick JA. Pediatric trauma and polyethylene-reinforced composite fixed partial denture replacements: A new method. J Can Dent Assoc 1993;59:252–256.
18. Terry DA, McGuire M. The perio-aesthetic-restorative approach for anterior reconstruction—Part II: Restorative treatment. Pract Proced Aesthet Dent 2002;14:363–369.
19. Culy G, Tyas MJ. Direct resin-bonded, fibre-reinforced anterior bridges: A clinical report. Aust Dent J 1998;43:1–4.
20. Bae JM, Kim KN, Hattori M, et al. The flexural properties of fiber-reinforced composite with light-polymerized polymer matrix. Int J Prosthodont 2001;14:33–39.
21. Abel MG. Alernative bridge design. Oral Health 1994;84:23–24, 39–40.
22. Freilich MA, Meiers JC, Duncan JP, Eckrote KA, Goldberg AJ. Clinical evaluation of fiber-reinforced fixed bridges. J Am Dent Assoc 2002;133:1524–1534.
23. Estafan DJ, Dussetschleger F. Fabrication of resin-bonded three-unit prostheses. Am J Dent. 1999;12:51–52.
24. Meiers JC, Duncan JP, Freilich MA, Goldberg AJ. Preimpregnated fiber-reinforced prostheses. Part II. Direct applications: Splints and fixed partial dentures. Quintessence Int 1998;29:761–768.
25. Nixon RL, Weinstock A. An immediate-extraction anterior single-tooth replacement utilizing a fiber-reinforced dual-component bridge. Pract Periodontics Aesthet Dent 1998;10:17–26.
26. Meiers JC, Freilich MA. Chairside prefabricated fiber-reinforced resin composite fixed partial dentures. Quintessence Int 2001;32:99–104.
27. Vallittu PK, Sevelius C. Resin-bonded glass fibre-reinforced composite fixed partial dentures: A clinical study. J Prosthet Dent 2000;84:413–418.
28. Vallittu PK. Survival rates of resin-bonded, glass fiber-reinforced composite fixed partial dentures with a mean follow-up of 42 months: A pilot study. J Prosthet Dent 2004;91:241–246.
29. Ahlstrand WM, Finger WJ. Direct and indirect fiber-reinforced fixed partial dentures: Case reports. Quintessence Int 2002;33:359–365.
30. Vallittu PK. Case report: A glass fibre-reinforced composite resin bonded fixed partial denture. Eur J Prosthodont Restorative Dent 2001;9:35–38.
31. Vallittu PK. Prosthodontic treatment with a glass fiber-reinforced resin-bonded fixed partial denture: A clinical report. J Prosthet Dent 1999;82:132–135.
32. Behr M, Rosentritt M, Handel G. Fiber-reinforced composite crowns and FPDs: A clinical report. Int J Prosthodont 2003;16:239–243.
33. Bohlsen F, Kern M. Clinical outcome of glass fiber-reinforced crowns and fixed partial dentures: A three-year retrospective study. Quintessence Int 2003;34:493–496.
34. Monaco C, Ferrari M, Miceli GP, Scotti R. Clinical evaluation of fiber-reinforced composite inlay FPDs. Int J Prosthodont 2003;16:319–325.
35. Edelhoff D, Spiekermann H, Yildirim M. Metal-free inlay-retained fixed partial dentures. Quintessence Int 2001;32:269–281.

36. Göhring TN, Schmidlin PR, Lutz F. Two-year clinical and SEM evaluation of glass-fiber-reinforced inlay fixed partial dentures. Am J Dent 2002;15:35–40.
37. Göhring TN, Mörmann WH, Lutz F. Clinical and scanning electron microscopic evaluation of fiber-reinforced inlay fixed partial dentures: Preliminary results after one year. J Prosthet Dent 1999;82:662–668.
38. Jain P, Cobb D. Evaluation of a glass-fiber-reinforced, bonded, inlay-supported fixed partial denture: 4-year results. Compend Contin Educ Dent 2002;23:779–788.
39. Rosenthal L, Trinkner T, Pescatore C. A new system for posterior restorations: A combination of ceramic optimized polymer and fiber-reinforced composite. Pract Periodontics Aesthet Dent 1997;9(suppl 5):6–10.
40. Altieri JV, Burstone CJ, Goldberg AJ, Patel AP. Longitudinal clinical evaluation of fiber-reinforced composite fixed partial dentures: A pilot study. J Prosthet Dent 1994;71:16–22.
41. Hannon SM, Breault LG, Kim AC. The immediate provisional restoration: A review of clinical techniques. Quintessence Int 1998;29:163–169.
42. Malquarti G, Berruet RG, Bois D. Prosthetic use of carbon fiber-reinforced epoxy resin for esthetic crowns and fixed partial dentures. J Prosthet Dent 1990;63:251–257.
43. Behr M, Rosentritt M, Lang R, Chazot C, Handel G. Glass-fibre-reinforced composite fixed partial dentures on dental implants. J Oral Rehabil 2001;28:895–902.
44. Behr M, Rosentritt M, Ledwinsky E, Handel G. Fracture resistance and marginal adaptation of conventionally cemented fiber-reinforced composite three-unit FPDs. Int J Prosthodont 2002;15:467–472.
45. Kolbeck C, Rosentritt M, Behr M, Lang R, Handel G. In vitro examination of fracture strength of 3 different fiber-reinforced composite and 1 all-ceramic posterior inlay partial denture systems. J Prosthodont 2002;11:248–253.
46. Loose M, Rosentritt M, Leibrock A, Behr M, Handel G. In vitro study of fracture strength and marginal adaptation of fibre-reinforced-composite versus all ceramic fixed partial dentures. Eur J Prosthodont Restorative Dent 1998;6:55–62.
47. Pfeiffer P, Grube L. In vitro resistance of reinforced interim fixed partial dentures. J Prosthet Dent 2003;89:170–174.
48. Saygili G, Sahmali SM, Demirel F. The effect of placement of glass fibers and aramid fibers on the fracture resistance of provisional restorative materials. Oper Dent 2003;28:80–85.
49. Vallittu PK. The effect of glass fiber reinforcement on the fracture resistance of a provisional fixed partial denture. J Prosthet Dent 1998;79:125–130.
50. Lastumaki TM, Lassila LV, Vallittu PK. Flexural properties of the bulk fiber-reinforced composite DC-tell used in fixed partial dentures. Int J Prosthodont 2001;14:22–26.

Literature Abstract

In practice evaluation of a denture adhesive using a gnathometer

The purpose of this clinical study was to evaluate the effect of denture adhesive on maxillary denture performance and patient perceptions. Private practitioners were solicited to assist in recruitment of their own patients as subjects and to administer the study. The participating clinicians recruited 194 patients (39% male, 61% female) with maxillary complete dentures. Of this population, 50.2% had a mandibular removable complete denture, 34.4% had a mandibular removable partial denture, and 15.4% had lower natural dentition and/or an implant supported prosthesis in the lower arch. The average age of the subjects was 66.6 years old, and 61.8% were currently using adhesives. The gnathometer was used to assess the subjects' anterior bite force (0 to 10 scale) to denture dislodgement before and after the application of a denture adhesive on their maxillary complete denture. Subjects were also asked to evaluate denture performance, speaking and chewing, fit and comfort, and confidence as “improved,” “same,” or “worse” with the adhesive versus without the adhesive. The average force of dislodgement for dentures without adhesives was 3.3 compared to 5.2 with adhesive. At least 63.4% of the subjects found an improvement in bite force with the use of the adhesive. Subjects also perceived improvement with use of adhesive as compared to without adhesive in the following areas: 79.45% in denture performance, 55.9% in speaking and chewing, 55.9% in fit and comfort, and 64.0% in confidence. Unfortunately, no data was collected on instrument reliability, and no statistical analysis was carried out on the data collected.

Psillakis JJ, Wright RF, Grbic JT, Lamster IB. *J Prosthodont 2004*;13:244-250. **References:** 19. **Reprints:** Dr Jason J. Psillakis, Columbia University, School of Dental and Oral Surgery, PH 7 East-Room 115, 630 West 168th Street, New York, NY 10032. E-mail: jpsillakis@yahoo.com—*Alvin G. Wee, OSU College of Dentistry, Columbus, OH*