The enhancement of retention and stability, which are major properties that determine the performance of a removable prosthesis, has always been a goal of prosthetic dentistry. Those who wear removable dentures, especially those with complete dentures, are often confronted with varying degrees of looseness of their prosthesis and complain of discomfort and/or reduced masticatory function or speech. Both functional disturbances and psychosocial problems have been reported to occur in edentulous patients treated with complete dentures.1,2

The use of denture adhesives or denture fixatives has been considered a useful treatment adjunct for the improvement of denture retention and stability. According to Zarb et al,3 the term “denture adhesive” refers to a commercially available, nontoxic, soluble material that is applied to the tissue surface of the denture to enhance retention, stability, and function. Although their first application was reported in 1913, followed by other patents in the 1920s and 1930s,4 it was not until 1935 that the American Dental Association Council on Dental Materials, Instruments, and Equipment characterized denture adhesives as nonmedical products.4,5

Grasso5 suggested that denture adhesives be categorized into soluble and insoluble groups. The soluble category includes creams, powders, and pastes, while the insoluble group consists of wafers and pads. Furthermore, on the basis of their composition, denture adhesives can be divided into natural or synthetic denture adhesives.

Although denture adhesives have been accepted by patients worldwide, prosthodontic educators and dental professionals have been reluctant to endorse these over-the-counter products.6,7 To date, the topics of their
effectiveness, recommended use, and biocompatibility remain a matter of debate in the dental community.

The effectiveness of denture adhesives has been extensively investigated, either objectively or subjectively, in terms of prosthesis retention, stability, and masticatory performance.8–29 Several in vivo studies have demonstrated that denture adhesives enhance the overall performance of complete dentures, increasing their resistance to forces of dislodgement.8–24 The outcomes of the available studies are associated with the situation of both the bearing tissues and the removable prosthesis, the type of the adhesive, and the patient’s opinion.8–29 The masticatory performance of complete denture wearers after the application of denture adhesives in relation to the duration of mastication rate or cycle time has also been an objective of investigation.13,14,24

Investigations into the biocompatibility of denture adhesives have focused on toxicity and potential microbial contamination; however, the available in vivo studies are few.30–35 The investigators have focused on the potential development of Candida albicans and a-hemolytic streptococci in the oral mucosa of denture wearers after the prolonged use of denture adhesives.32,34,35

Although data about the attitudes of dental educators toward denture adhesives are scarce, these dental materials should be introduced into the curriculum of dental schools.36 Several studies have reported the incidence of use of denture adhesives worldwide as well as patient disposition toward these materials.37–40 Any discrepancies in the reported patients’ attitudes toward these dental materials reflect socioeconomic differences among the countries.

The purpose of this article was to review the available literature with respect to denture adhesive effectiveness in terms of retention, stability, masticatory performance, and biocompatibility. This review also presents the attitudes of both patients and dental professionals toward denture adhesives.

**Clinical Implications**

Denture adhesives can enhance the overall performance of complete dentures. Although the available scientific evidence is limited regarding the biocompatibility of these materials, the data support their use. Dental practitioners should guide their patients in the appropriate use of denture adhesives.

**MATERIAL AND METHODS**

The overall search strategy is presented in Table 1. The evaluation criteria were defined in accordance with the PICO(S) (Patient or Population, Intervention, Control or Comparison, Outcome and Study types) criteria.

The review included all the studies in which participants wore removable dental prostheses and who were scheduled for the application of denture adhesives. Among the included removable prostheses were complete dentures, partial removable dental prostheses, and tooth- and implant-supported overdentures. There were no restrictions regarding the sex or age of participants.

Only in vivo studies involving commercially available denture adhesives were included. Denture adhesive type and manufacturer were documented. Within each included study, individuals wearing removable dentures with no application of denture adhesives were accepted as control groups.

Outcome parameters were defined with respect to existing reviews and the main outcome parameters of the included studies according to denture performance in terms of retention, stability, and masticatory function, as well as an evaluation of the biocompatibility of denture adhesives, including microbial population and toxicity.

**Table 1. Systematic search strategy**

**Focus question:** In patients wearing removable dental prostheses, what is the effect of denture adhesives in denture performance (retention, stability, or mastication ability) compared to no application of denture adhesives?

**Search strategy**

<table>
<thead>
<tr>
<th>Population</th>
<th>Patients with complete dentures or partial removable dental prostheses or tooth/implant overdentures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intervention or exposure</td>
<td>Application of denture adhesives (all types included, namely pastes, powder, strips, cushion)</td>
</tr>
<tr>
<td>Comparison</td>
<td>Patients with no application of denture adhesives</td>
</tr>
</tbody>
</table>

**Outcome**

- Retention
- Stability
- Masticatory performance
- Biocompatibility

**Search combination**

- Complete dentures AND denture adhesives
- Complete dentures AND denture fixatives
- Removable partial dentures AND denture adhesives
- Denture adhesives AND overdentures
- Denture adhesives AND attitudes

**Database search**

<table>
<thead>
<tr>
<th>Electronic database searched</th>
<th>PubMed</th>
</tr>
</thead>
</table>

**Selection inclusion criteria**

- English language
- Clinical studies of at least 10 treated patients
- Prospective: randomized controlled, nonrandomized controlled
- Cohort studies retrospective: controlled, case-control, single cohort
- Studies with commercially available denture adhesives

**Selection exclusion criteria**

- Studies in languages other than English
- Studies with <10 patients, case reports
- Studies with animal models or experimental in vitro studies
- Pilot studies
- Reviews
- Studies with no commercially available denture adhesives
An electronic search of English-language peer-reviewed dental literature was conducted in order to identify the relevant scientific evidence on denture adhesives. MEDLINE and PubMed searches were carried out by using the following keyword and phrase searches: complete dentures AND denture adhesives, complete dentures AND denture fixatives, complete dentures AND denture adherents, removable partial dentures AND denture adhesives, denture adhesives AND overdentures, denture adhesives AND attitudes. The publication year was not limited so that the search could include all the available scientific evidence provided in that particular database up to March 2014. Two independent observers independently scanned the abstracts and later the preselected full-text articles.

For studies meeting the inclusion criteria (Fig. 1), full-text articles were obtained and further evaluated. The titles and abstracts of all the collected articles were reviewed and assessed for appropriateness in order to fulfill the purposes of the current systematic review. Finally, a further manual search, including the citations of the finally collected articles, was done to supplement the electronic search.

RESULTS

The electronic search in the PubMed database provided a total of 216 abstracts that were considered potentially relevant. In the second phase of study selection, a full-text review of 33 articles was eventually carried out.8-40 These articles were further subdivided into 3 categories according to their objective: 22 articles examining denture performance in terms of retention, stability, and masticatory function after the application of denture adhesives;8-29 6 articles on the biocompatibility of denture adhesives;30-35 and 5 articles about the attitudes of both dental professionals and patients toward denture adhesives.36-40

Seventeen clinical trials aimed to objectively calculate denture movement by applying such methods as the cineradiography technique,11 the gnathodynamometer15,16,18,21,23 or retentiometer, magnetometer,13 the kinesiograph,10 and pressure transducers.19-21 Five clinical studies aimed to assess the effectiveness of denture adhesives subjectively on the basis of the responses of denture wearers to a questionnaire,25-29 while 2 studies used both objective and subjective methods (questionnaire) to evaluate the effectiveness of denture adhesives.15,17

Of the selected clinical studies on denture performance, 6 studies assessed the effectiveness of denture adhesives by examining the retention/stability of both maxillary and mandibular complete dentures,8,14,17,22-24 7 studies focused on only maxillary complete dentures,9,10,15,16,18,19,21 and 2 studies focused on mandibular complete dentures.11,20 Only 2 studies investigated the effectiveness of denture adhesives in implant overdentures.12,13 Additionally, the masticatory performance was evaluated objectively by measuring the mastication rate and duration of the mastication cycle time in 4 studies.8,13,14,24 Subjective assessment (questionnaire) of the effectiveness of denture adhesives in terms of masticatory performance was conducted in 7 studies.15,17,25-29

DISCUSSION

Studies regarding the effectiveness of denture adhesives are heterogeneous because of the multiple techniques used to objectively measure denture movement, including cineradiography, gnathodynamometer or retentiometer, magnetometer, and pressure transducers (Supplemental Table 1). Additionally, the methodology...
of the available studies included various types of denture adhesives, different protocols of denture adhesive application, and heterogeneity among the study population, including participants with either newly fabricated or existing ill-fitting removable dentures with a different status of denture-bearing tissues.

Nevertheless, the majority of the existing scientific evidence indicates that the retention and stability of removable dentures were increased significantly after the application of denture adhesives. Only 1 study demonstrated no significant improvement in denture dislodgment after the use of denture adhesives.23 Denture adhesives can lead to a reduction in mastication time, and the application of adhesive in both dentures is more effective than in only the maxillary prosthesis. All the collected studies concluded that denture adhesive led to an increase in mastication rate and a decrease in the duration of the masticatory cycle.13,14,24

The effectiveness of denture adhesives in terms of improved masticatory performance, incisal masticatory force, and patient satisfaction is more pronounced not only in patients with poor or fair dentures than in those with new ones but also in patients with newly fabricated dentures and a history of poor Kapur index.10,14 Two comparable subjective studies reported a cushion adhesive (Fittydent; Fittydent Intl GmbH) to be the most effective in clinical improvement in patients with poor/fair dentures or prosthesis-bearing tissues.25,26 This may be because a cushion adhesive acting as a reline material can adjust to both the supporting tissues and the intaglio of the denture. The duration of the retentive action of denture adhesives ranged between 3 to 12 hours, depending on the type of denture adhesive, based on the findings of the subjective studies.26-29 In particular, the action of the cushion adhesive has been reported to remain after 10 hours, while the majority of paste adhesives remained active for over 4 hours but fewer than 10 hours.27,29 The difference in the duration of action between paste and cushion adhesives can be attributed to the greater solubility of the paste adhesives.26,29 The duration of the action of paste adhesives is greater for maxillary than mandibular dentures.15 The majority of participants reported that denture adhesives improved their masticatory ability.13,17,25-29

Kalra et al23 compared the effectiveness of 3 types of denture adhesives (powder adhesives, adhesives pastes, and adhesive strips) on the incisal masticatory force of complete dentures. They reported that the paste type of denture adhesives was the most effective in improving incisal force, followed by powder and strip adhesives. The strip and cream adhesives differ in that strips do not contain a long-acting synthetic polymer. According to a study by Berg,25 among 4 different denture adhesives, patients expressed their preference for Fittydent paste (Fittydent International GmbH) in terms of improved mastication.

Compared to maxillary removable prostheses, mandibular dentures have lower retention, stability, and support because of their smaller coverage area (one third of the maxillary complete denture) and the effect of oral and tongue musculature leading to base disruption.41-43 The length of the effectiveness of denture adhesives for mandibular dentures has been demonstrated to be shorter than that of the corresponding maxillary denture.28

Despite the presence of commercially available products intended to improve the performance of partial removable dental prostheses, no scientific evidence is available on the impact of denture adhesives for patients with partial removable prostheses. Therefore, studies should investigate the role of denture adhesives in individuals with I, II, or IV Kennedy class partial removable dental prostheses. Additionally, scientific evidence is lacking with regard to the effectiveness of denture adhesives in individuals with maxillofacial prostheses who may benefit from adhesive use.

No scientific evidence supports the statement that denture adhesives, when properly used, can cause oral pathoses, excessive bone resorption, or alterations in the patient’s vertical dimension, occlusion, or taste.29-31,34 The available data regarding the topic of potential microbial contamination as a result of denture adhesives use are limited (Table 2). Few long-term in vivo studies have investigated either the development of microorganisms or possible alterations in the oral flora during the prolonged use of denture adhesives. Because no in vitro study can imitate the real oral environment conditions, the results should be interpreted with caution. Because oral mucous membranes are protected by mucus and keratinization, the effect of denture adhesive on oral mucous cells under in vitro conditions may lead to different outcomes regarding the growth of bacteria.44 Denture adhesives are nonsterile pharmaceuticals, as recognized by the United States Food and Drug Administration. Therefore, there is always a certain microbial load, and investigation into the use of denture adhesive in immunocompromised individuals is indicated.

Because alveolar bone resorption is a progressive process, patients with conventional removable dentures may be tempted to add increasing quantities of adhesives to stabilize their ill-fitting prosthesis rather than seeking professional care. Therefore, the risks of continued wear of the existing dentures, the potential hyperzincemia derived from excessive ingestion of denture adhesives,36 and the concealment of an underlying condition such as a tumor should be communicated to the public, especially in individuals wearing ill-fitting dentures where increased thickness of a denture adhesive is applied. Guggenheimer and Hoffman45 reported that 59% of oral cancer cases occurred in individuals who were completely edentulous.
Only one study, involving a Delphi Technique questionnaire, has been conducted to identify the viewpoints of leading prosthodontic educators regarding the specific topic of dentures adhesives. The Delphi questionnaire solicits general perceptions, indications and contraindications of denture adhesive use, and patient education on denture adhesives. The majority of prosthodontic educators acknowledged the beneficial role of denture adhesives, which implies they improve denture fit and patient comfort. Indeed, the main reasons that denture wearers use adhesives are the improvement of masticatory ability, denture fit, and comfort. The majority of educators also voiced concerns about negative aspects arising from denture adhesive use, including the avoidance of good clinical practice by dentists, the masking of underlying denture problems, and the patient’s unwillingness to schedule necessary dental visits. Prosthodontic educators also agreed that denture adhesives could promote the development of oral diseases/conditions, including denture stomatitis, candidiasis, oral flora imbalance, and alveolar bone resorption; however, they claimed that neither oral cancer nor leukoplakia can result from denture adhesives. However, the aforementioned viewpoints contradict the available scientific evidence on the biocompatibility of denture adhesives, which does not support the adverse effects of the long-term use of adhesives. Regarding the issue of denture adhesive use or misuse, academic respondents agreed to the contributory role of adhesives in stabilizing trial bases and the trial arrangement of teeth. Finally, on the whole, the academic panelists agreed that the topic of denture adhesives should be integrated into both denture wearers toward denture adhesives in Istanbul. According to their findings, 92% of the patients had never used denture adhesives, and 87% of them were unaware of their existence. Only 9 participants had tried denture adhesives (mainly paste adhesives) but no longer used them. Furthermore, the knowledge of denture

Table 2. In vivo studies investigating denture adhesives in terms of biocompatibility

<table>
<thead>
<tr>
<th>Study (Year)</th>
<th>Purpose</th>
<th>No. of participants</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdelmalek and Michael (1978)</td>
<td>To investigate whether denture adhesives can cause histologic alterations in oral mucosa of patients</td>
<td>45</td>
<td>Decline of surface keratin levels because of prolonged use of adhesives No other inflammatory effects on tissues were observed except from patients with poor oral hygiene No increase in incidence of mucosal irritation</td>
</tr>
<tr>
<td>Tarbet and Grossman (1980)</td>
<td>To investigate occurrence and severity of tissue irritation in denture wearers after 6 months of denture adhesive use</td>
<td>111 with complete dentures</td>
<td>Patients with coexisting tissue irritation showed improvement or elimination of their symptoms</td>
</tr>
<tr>
<td>Kim et al (2003)</td>
<td>To evaluate oral quantities of Candida albicans in both dentures and saliva of individuals who used denture adhesives for a 14-day period</td>
<td>12</td>
<td>Patient’s hygiene plays contributory role to lack of significant microbial alterations During follow-up, no statistically significant alterations in populations of Candida albicans and α-hemolytic streptococci in saliva, palate, and dentures</td>
</tr>
<tr>
<td>Hedera et al (2009)</td>
<td>To investigate impact of excessive use of denture adhesive in 11 patients with myelolymphoid neuropathy associated with hypocupremia and hyperzincemia</td>
<td>12</td>
<td>Eleven (100%) of 11 patients with copper deficiency syndrome ingested large amounts of zinc from denture cream because of application of high amounts of denture cream Cessation of dental adhesive use resulted in significant reduction of serum zinc concentration and consequently increase of serum copper concentration</td>
</tr>
<tr>
<td>Özkan et al (2012)</td>
<td>To investigate population of Candida albicans and α-hemolytic streptococci in saliva, palate, and dentures at time intervals of 1 and 2 months and in patients who use/do not use denture adhesives</td>
<td>30</td>
<td>During all time intervals (1-2 months), there were no statistically significant alterations in the populations of Candida albicans and α-hemolytic streptococci in saliva, palate, and dentures Amount of accumulated microorganisms in group of adhesive denture wearers was similar to those who did not use adhesives during observation period</td>
</tr>
<tr>
<td>Leite et al (2014)</td>
<td>Investigation of effect of denture adhesives on biofilm formation via collection of material from both mucosa and intaglio surface of maxillary denture after 15 days use of denture adhesive</td>
<td>30</td>
<td>No statistically significant difference (&lt;.05) in population of Candida spp and Streptococcus mutans after application of denture adhesive</td>
</tr>
</tbody>
</table>
Table 3. Incidence or number of denture wearers in different countries who have used adhesives

<table>
<thead>
<tr>
<th>Study (Year)</th>
<th>Country</th>
<th>Incidence of Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grasso'</td>
<td>U.S.</td>
<td>5 million Americans</td>
</tr>
<tr>
<td>Coates8</td>
<td>Adelaide, South Australia</td>
<td>32.9%</td>
</tr>
<tr>
<td>Özkan et al</td>
<td>Istanbul, Turkey</td>
<td>8%</td>
</tr>
<tr>
<td>Polyzox and de Baat11</td>
<td>Athens, Greece</td>
<td>26%</td>
</tr>
<tr>
<td>Divaris et al12</td>
<td>Nijmegen, Netherlands</td>
<td>20%</td>
</tr>
<tr>
<td>Divaris et al12</td>
<td>Athens, Greece</td>
<td>15%</td>
</tr>
</tbody>
</table>

wearers about the existence of denture adhesives is limited. Coates38 reported that 26% of participants had tried a denture adhesive but no longer used it, and only 20% of participants were aware of their existence. In a more recent 2-country study, denture adhesives had been used by 26% of Greek patients and 33% of Dutch patients, while 27% of the Greek and 0% of the Dutch denture wearers did not know about those materials.39 Divaris et al10 reported 15% of Greek denture wearers used adhesives. A striking finding reported by Grasso5 was that 5 million Americans use denture adhesives, and nearly 75% of all dentists suggest that their denture patients use adhesives.

The main reasons to recommend the use of denture adhesives are to improve the function of an existing denture or to adapt to a new denture.37-39 The main reason for stopping use is lack of improvement in the function of denture-bearing tissues.38,39 Although a 30-year period is a rare phenomenon, several patients ranges from 1 week to 30 years.38,39 Although a 30-year period is a rare phenomenon, several patients have reported using these materials from more than 1 week to 3 years.39 This emphasizes the need for further longitudinal in vivo studies investigating the topic of their biocompatibility.

CONCLUSIONS

This systematic review demonstrated that denture adhesives can significantly improve the overall performance of complete dentures. Although the available biocompatibility data are limited, no clinical study demonstrated that denture adhesives promote an alteration of the oral microbial population. In general, denture wearers have a positive disposition toward these dental materials, as is reflected by the incidence of usage.

REFERENCES

Zirconia-based crowns up to 5 years in function: A retrospective clinical study and evaluation of prosthetic restoration and failures

Guncu MB, Cakan U, Muhtarogullaris M, Canay S

Purpose. The purpose of this retrospective study was to evaluate the 5-year clinical performance and failure rate of single- or multiple-unit zirconia-based crowns.

Materials and Methods. A total of 148 patients (39 men and 109 women, mean age: 46.9 ± 10.6 years) treated in university and private practices with 618 single- or multiple-unit zirconia-based (Lava) crowns made on natural teeth from January 2007 to December 2008 were included. Two hundred fifty-nine anterior and 359 posterior crowns were examined. A core and/or veneer fracture that required replacement of the restoration was considered to be a failure. The cumulative survival rate (CSR) was described with Kaplan-Meier survival functions. The crowns replaced for other reasons were deemed lost to follow-up, and esthetic, functional, and biologic complications were rated.

Results. At the 5-year follow-up, no zirconia core fractures were observed. Twelve veneer fractures that required crown replacement were detected. The CSR was 98.1%. There was a statistically significant difference between survival of the anterior and posterior restorations (P < .001). In total, 116 crowns experienced biologic and technical complications. The most common complications were smooth veneer fracture (4, 0.6%), loss of retention (7, 1%), staining because of smoking (24, 4%), and gingival recession (48, 8%).

Conclusions. According to the 5-year CSR (98.1%) observed in this study, zirconia-based single or multiple crowns may be considered an acceptable treatment modality for the replacement of anterior and posterior teeth. Results from the current study should be supported by additional randomized clinical trials.

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Supplemental Table 1. In vivo studies objectively investigating efficacy of denture adhesives

<table>
<thead>
<tr>
<th>Study</th>
<th>Purpose</th>
<th>No. of Participants</th>
<th>Trade Name/Type of Adhesive</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kapur et al. (1965)</td>
<td>To investigate effects of three different denture adhesives on denture retention, masticatory performance and taste thresholds</td>
<td>26</td>
<td>Fastteeth, powder adhesive (Shionogi), Wernet’s, cream adhesive, experimental adhesive</td>
<td>Increased denture base retention, no improvement of masticatory ability/no alteration in taste thresholds, no differences in clinical performance between three adhesives, and substantial loss of retention in mandibular dentures after mastication and sipping.</td>
</tr>
<tr>
<td>Karlsson et al. (1981)</td>
<td>Assessment of maxillary denture mobility via cineradiographique technique</td>
<td>10</td>
<td>Karaya gum, carboxymethylcellulose sodium</td>
<td>No substantial difference in denture mobility between the pre- and post-adhesive application; no recognizable effect of denture adhesives on denture mobility in patients with mild alveolar resorption.</td>
</tr>
<tr>
<td>Chew et al. (1985)</td>
<td>Assessment of effectiveness of denture adhesives in maxillary complete dentures via kinesiograph at both chewing sides and at time intervals of 1h, 3h, and 5h adhesives</td>
<td>10</td>
<td>Fixodent paste (Richardson-Vicks), Secure, powder (Richardson-Vicks), Super polygrip paste (Block Drugs)</td>
<td>All denture adhesives improved retention and stability of maxillary dentures; secure powder most effective adhesive/more pronounced retentive effect in ill-fitting dentures.</td>
</tr>
<tr>
<td>Karlsson et al. (1990)</td>
<td>Evaluation of retention of mandibular complete denture via cineradiographique technique</td>
<td>10</td>
<td>Not reported/powder type</td>
<td>Significant decrease in denture dislodgment only at peak values.</td>
</tr>
<tr>
<td>Grasso et al. 2000</td>
<td>Measurement of mandibular movement via two coils incorporated in implant post and denture base at times intervals of 0h, 2h, and 4h</td>
<td>110</td>
<td>Fixodent cream (Procter and Gamble)</td>
<td>Mandibular denture movement combined or not with adhesive greater than maxillary one; significant reduction of maxillary and mandibular denture movement at all time intervals.</td>
</tr>
<tr>
<td>Rendell et al. (2000)</td>
<td>Mean chewing rate (via multichannel magnetometer) between dentate (control) and complete denture wearers (test) at 0h, 2h, and 4h</td>
<td>20 (10 for each group)</td>
<td>Fixodent cream (Procter and Gamble)</td>
<td>Statistically increased (P&lt;0.01) mean mastication rate at all time intervals; no statistically differences (P&gt;0.05) in mastication rate between test group and control group.</td>
</tr>
<tr>
<td>Fujimori et al. (2002)</td>
<td>Assessment of maximum masticatory force, masticatory performance, electromyography of masseter muscle with or without denture adhesive</td>
<td>16 (with poor bearing tissues)</td>
<td>Correct paste (Shionogi)</td>
<td>More pronounced effect in individuals with poor denture bearing tissues; significant reduction of mastication burst and improvement in mandibular dentures performance.</td>
</tr>
<tr>
<td>Figueiral et al. (2011)</td>
<td>Assessment of denture adhesives retentive effect; examination of maxillary dentures retention via intraoral transducer</td>
<td>26</td>
<td>Protefix cream (BMP Production), Corega cream (Stafford-Miller), Corega ultra powder (Stafford-Miller), Protefix powder (BMP Production), Corega strips (Stafford-Miller)</td>
<td>Except from Corega strips, all denture adhesives improved statistically significantly (P&lt;0.05) retention of complete dentures.</td>
</tr>
<tr>
<td>Psillakis et al. (2004)</td>
<td>Assessment of maxillary complete denture performance via measurement (gnathometer) of maximum force of dislodgement and participants' perception of denture adhesive</td>
<td>194</td>
<td>Fixodent (Procter and Gamble)</td>
<td>63.4% improvement in occlusal force with the use of adhesive and 79.4 % enhanced denture performance according to patients’ perception.</td>
</tr>
<tr>
<td>De Baat et al. (2007)</td>
<td>Assessment of maximum incisal force in new or previous maxillary complete dentures using disposable gnathometers</td>
<td>88 (from four different countries)</td>
<td>Kukdent Pro (Procter and Gamble) (experimental)</td>
<td>Significant improvement of maximum incisal force of both new and previous complete dentures; more pronounced effect on maximum incisal force in previous than in new complete dentures.</td>
</tr>
<tr>
<td>Pradies et al. (2009)</td>
<td>Measurement of resistance to dislodgement of complete dentures with two adhesives; subjective assessment of dentures quality through questionnaire.</td>
<td>24</td>
<td>Super Corega (Stafford-Miller), Corega Ultra (Stafford-Miller), Super Corega Powder (Stafford-Miller), Fittydent Caticionic</td>
<td>Increased resistance to dislodgement with both adhesives; five times higher in the maxilla than in mandible; 87% of patients characterized denture retention as very good /or good for both materials.</td>
</tr>
<tr>
<td>Polyzois et al. (2011)</td>
<td>To evaluate (via a disposable and electronic gnathodynamometer) dislodgement resistance in maxillary complete dentures under application of incisal and premolar forces</td>
<td>12</td>
<td>Super Corega (Stafford-Miller), Corega Ultra (Stafford-Miller), Super Corega Powder (Stafford-Miller), Fittydent Caticionic</td>
<td>These two devices cannot be used interchangeably; at least 55 % higher the applied premolar forces than incisal ones; all denture adhesives reduced significantly denture dislodgement; Fittydent Caticionic least effective/Equally effective rest materials.</td>
</tr>
<tr>
<td>Mañes et al. (2011)</td>
<td>Evaluation of retentive ability via tip of spring scale applied in margin of in mandibular dentures</td>
<td>30</td>
<td>Benfix (Vitafarma), Fittydent (Fittydent Int.GMBH), Super Corega (Stafford-Miller)</td>
<td>Statistically significant improvement (P&lt;0.05) retention of mandibular dentures Fittydent paste mattered best results, followed by Benfix and Supercorega.</td>
</tr>
</tbody>
</table>

(continued on next page)
**Supplemental Table 1. In vivo studies objectively investigating efficacy of denture adhesives (continued)**

<table>
<thead>
<tr>
<th>Study</th>
<th>Purpose</th>
<th>No. of Participants</th>
<th>Trade Name/Type of Adhesive</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Munoz et al(^a) (2011)</td>
<td>Evaluation of retention and stability (Kapur index, occlusal force) in well-fitting dentures after application of 3 cream denture adhesives</td>
<td>36</td>
<td>Super Polgrip Free, test crème, Test grip Super Polgrip Comfort Seal Strips, Cream adhesive, (GlaxoSmithKline Consumer Healthcare)</td>
<td>Statistically significant ($P&lt;.05$); improved retention/stability, fewer dislodgements, increased levels of confidence and comfort, improved satisfaction levels for cream adhesives</td>
</tr>
<tr>
<td>Kalra et al(^b) (2012)</td>
<td>Evaluation of incisal occlusal force of maxillary dentures via pressure transducers</td>
<td>30 (3 groups: A, good; B, fair; C, poor dentures)</td>
<td>Fixon, powder (ICPA Health Products), Fittydent, paste (Dr Reddy Laboratories), Poligrip Comfort Seal strips (Stafford-Miller Ltd)</td>
<td>Statistically significant ($P&lt;.05$); improved incisal force derived from all denture adhesives, Fittydent/paste most effective adhesive followed by powder and strips and more pronounced improvement in C group</td>
</tr>
<tr>
<td>Polyzois et al(^c) (2014)</td>
<td>Investigation of occlusal forces of the dislodgement (OFD) on existing and new fabricated dentures after insertion (baseline), 45 and 90 days (adaptation period) later via electronic gnathodynamometer</td>
<td>15</td>
<td>Super Polgrip Comfort Seal Strips (GlaxoSmithKline), Protefix Adhesive cushion (Queisser Pharma)</td>
<td>OFD for new dentures increased with time (adaptation period), no effect on OFD with regard to different type of adhesive, OFD of new and existing dentures not significantly different ($P &lt; .872$); OFD of new or existing dentures with/without adhesives did not differ significantly ($P &lt; .211$)</td>
</tr>
<tr>
<td>Colçalves et al(^d) (2014)</td>
<td>Investigation of effect of denture adhesives on masticatory performance, mandibular movements, and ability in patients with complete dentures (mainly with unfavorable denture-bearing tissues) via kinesiograph</td>
<td>30 (with new fabricated complete dentures)</td>
<td>Corega strips (GlaxoSmithKline), Corega cream (GlaxoSmithKline)</td>
<td>In patients with unfavorable bearing tissues masticatory performance was increased ($P &lt; .001$) after application of denture adhesive cream followed by denture adhesive strips in participants with favorable bearing tissues masticatory performance was increased ($P &lt; .05$) after application of denture adhesive; no difference between type of adhesive; decrease in chewing cycle time</td>
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