Masticatory efficacy and bite force in complete dentures: a study of denture adhesive

ABSTRACT

Objective. To compare masticatory efficacy and maximum bite force (based on the Modified Kapur Index Scale) until denture dislodgement (BFDD) of complete dentures, without and with denture adhesive. Methods. Complete dentures fulfilling the inclusion criteria were tested for masticatory efficacy and BFDD. Consuming a quarter of an apple was used to assess dislodgement of complete denture, while a disposable gnathometer was used to measure BFDD. Both tests were performed without and with denture adhesive application. The ease and comfort level of mastication were assessed without and with denture adhesive. Results. Number of chews until first denture dislodgement for both maxillary and mandibular complete dentures increased following denture adhesive application, but the difference was not statistically significant (P=0.37). All patients agreed that ease and comfort level of mastication increased with denture adhesive. After denture adhesive application, the BFDD improved significantly in 17 (59%) of those sampled (P=0.001). Correlations between the Modified Kapur Index Scale and BFDD without (r=0.081) and with denture adhesive (r=0.057) were weak. Conclusion. Retention of dentures lasts longer while chewing with denture adhesive. Patients were satisfied with the denture adhesive for mastication that made chewing more comfortable. In addition, bite force increased significantly after denture adhesive application.

Key words: Bite force; Denture retention; Mastication

Introduction

Denture adhesive is a material used to bond and retain dentures in their designated suitable denture-bearing areas 1. It is widely used as an aid to increase denture retention and stability, and various research studies indicated that its use significantly reduced displacement of mandibular and maxillary dentures during chewing, biting and speaking 1–3. Despite such benefits in prosthetic dental treatment, dental practitioners often hesitate to prescribe them, fearing that they do not provide adequate and acceptable results 4,5.

Denture adhesive has been used in the market since the 18th century, but there was no published record about these products until a century later 6. The first US patent for denture adhesive was recorded in 1913, and others in the 1920s and 1930s 6. By 1939, there were 15 million denture wearers and numerous manufacturers of denture adhesives 6.
Despite the widespread use of adhesives suggested by these numbers, dental practitioners continue to harbor negative attitude towards them, owing to suggestions that their ingredients could cause deleterious effects on the oral mucosa.

Most modern adhesives come in paste form, with ingredients that provide bio-adhesion via carboxyl groups. As the adhesive hydrates with the presence of saliva, free carboxyl groups form electrovalent bonds that produce stickiness. A synthetic copolymer having high levels of carboxyl groups is poly(methyl vinyl ether-maleic anhydride) [PVMMA]. Besides PVMMA, sodium carboxymethyl cellulose (CMC), a naturally derived adhesive ingredient, is also commonly used because of its carboxyl groups. Carboxymethyl cellulose has the advantage of being more soluble in water than PVMMA salts. Although CMC provides a strong initial hold when used alone, it quickly dissolves due to its high solubility.

A study by Slaughter et al. revealed a change of practice among dental practitioners. They referred to a series of issues related to denture adhesives among a group of leading academic prosthodontists. The Delphi technique survey method was used. This consisted of a series of survey questionnaires directed at a panel of experts to either develop a consensus (>70% agreement) or to clarify the reasons for multiple schools of thought on a particular topic. From these surveys, these leading academic prosthodontists reached a consensus regarding denture adhesives on most of the discussed issues. Specifically, the panel agreed that, in general, denture adhesives can enhance the fit of a denture and provide psychologic comfort to the patient but also had disadvantages, thus contributed to the development of certain oral conditions (denture stomatitis, candidiasis, alveolar bone resorption, and an imbalance in oral flora) but not leukoplakia or oral cancer. Moreover, the adhesives were appropriate for use at the post-insertion phase for conventional dentures, but only in patients with insufficient denture-bearing areas. It was also agreed that patient education was necessary about the appropriate use and misuse of adhesives for dentures. The panel was unable to reach a consensus on whether denture adhesives should be used immediately at the post-insertion phase, and whether they are a beneficial adjunct in denture patient management.

Furthermore through written comments, the panelists clearly expressed their concerns that neither dental practitioners nor patients should use denture adhesives as an alternative to good clinical practice or proper denture maintenance routines.

Literature emanating over the past decade reveals a change in general attitudes regarding adhesive usage, as more dental practitioners accept their utility, and indications and contra-indications for their clinical applications have become more clear. Regarding the latter, most authors suggest that dental adhesives improve retention and stability of complete dentures, as well as function and masticatory performance. On the other hand, they were not indicated for ill-fitting complete dentures, as this could lead to further problems in the oral cavity.

The aim of this study was to compare masticatory efficacy (ME) and maximum bite force until denture dislodgement (BFDD) of complete dentures, without and with denture adhesive, based on the Modified Kapur Index Scale (MKIS). For this purpose, only one denture adhesive was used, as the study did not aim to compare the effect of different denture adhesives on ME and BFDD.

The hypothesis for this study was that the use of the particular denture adhesive on complete dentures would improve both ME and BFDD. Patients should also be satisfied during mastication, whenever denture adhesive was used.

**Methods**

The experimental method used was a modification of techniques previously reported. A clinical trial was carried out between June and December 2008 among fully edentulous patients treated with complete dentures by dental students in the Faculty of Dentistry, Universiti Kebangsaan Malaysia (UKM) and by dental practitioners at the Klinik Kesihatan Putrajaya (KKP), Wilayah Persekutuan Putrajaya, Malaysia. The study was approved by the Ethics Committee of the Faculty of Dentistry, UKM. Inclusion criteria were: aged 18 years or above; conventional maxillary and mandibular complete dentures worn for at least 6 months and not more than 3 years; compliance with follow-up appointments; not being a denture adhesive user; no known allergy to latex, apple or denture adhesive. The complete dentures had to have an adequate MKIS (≥10), with a well-
Effectiveness of denture adhesive

Table 1  Modified Kapur Index Scale for retention and stability of maxillary and mandibular complete dentures 15

<table>
<thead>
<tr>
<th>Score</th>
<th>Retention</th>
<th>Stability</th>
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<tbody>
<tr>
<td>0</td>
<td>Denture displaces itself</td>
<td>Demonstrate extreme rocking on its supporting structures under pressure</td>
</tr>
<tr>
<td>1</td>
<td>Slight resistance to vertical pull and little or no resistance to lateral force</td>
<td>Demonstrate moderate rocking on its supporting structures under pressure</td>
</tr>
<tr>
<td>2</td>
<td>Moderate resistance to vertical pull and little or no resistance to lateral force</td>
<td>Demonstrate slight rocking on its supporting structures under pressure</td>
</tr>
<tr>
<td>3</td>
<td>Moderate resistance to vertical pull and lateral force</td>
<td>Demonstrate very slight rocking on its supporting structures under pressure</td>
</tr>
<tr>
<td>4</td>
<td>Very good resistance to vertical pull and lateral force</td>
<td>Demonstrate no rocking on its supporting structures under pressure</td>
</tr>
<tr>
<td>5</td>
<td>Excellent resistance to vertical pull and lateral force</td>
<td>-</td>
</tr>
</tbody>
</table>

fitting maxillary complete denture 15. Exclusion criteria were: a history of substance abuse, any uncontrolled medical problem, and any oral condition that might interfere with the research.

Sampling was carried out by a hand search of patient folders registered in UKM dental clinic, and computer search of patient records in the KKP since 2005. A copy of the research information was given to each patient and written consent was obtained. Complete dentures were examined for retention and stability; the scores for both maxillary and mandibular complete dentures were summed to obtain a MKIS (Table 1). Based on the score, complete dentures were then classified as excellent, good, fair or poor. Patients whose dentures were classified as fair or poor were excluded.

Masticatory efficacy of patient functioning with complete dentures was examined based on the consumption of a quarter of a peeled apple (4122 NZ QUEEN; New Zealand), without and with the application of denture adhesive (Polident; GlaxoSmithKline, Ireland). The patient was instructed to consume the entire piece of apple and inform the examiner if dislodgement occurred to either maxillary or mandibular dentures during the process of chewing. Each patient was then asked about the comfort of the denture adhesive during chewing.

The maximum BFDD of the complete dentures was assessed without and with application of the denture adhesive, using a disposable gnathometer (Polident) placed between the upper and lower central incisors. Each patient was instructed to bite hard on the allocated area (Fig 1) until the maxillary denture dislodged at the posterior palatal seal, and the resulting score was recorded. The procedure was repeated 3 times, both without and with application of the denture adhesive, and the average score was recorded.

Prior to the main research, a pilot study was conducted by two examiners and a prosthodontist so as to establish a gold standard. The data collected were calibrated and the consistencies assessed using Cohen’s Kappa test.

All data were analyzed using the Statistical Package for the Social Sciences (SPSS) Windows version 12.0.1 (SPSS Inc., Chicago [IL], USA). Paired t tests were used to compare means without and with application of denture adhesive, both for ME and BFDD. Correlation coefficients were used to determine the relationship between MKIS and BFDD.

Results

Table 2 shows the distribution of patients derived by hand and computer record searches in the UKM and KKP. Since

![Image](image-url)
2005, 201 patients were identified as receiving complete denture treatment in the UKM and 25 in the KKP. After further selection, only 143 patients from the UKM were included, as were 13 from the KKP. Only 50 patients agreed verbally (via telephone) to participate in this study; 45 from the UKM and 5 from the KKP (Table 3). Regarding the 50 patients that agreed to participate, only 31 (62%) came for the clinical examination; 29 (94%) from the UKM and two (6%) from the KKP.

Examination of 31 pairs of complete dentures based on the MKIS revealed that two (7%) sets of complete dentures were classified as fair, 19 (61%) as good, and 10 (32%) as excellent. Thus two more patients were excluded from the study, resulting in 29 patients that constituted the research sample (Fig 2a).

Using the procedure test for ME, dislodgement occurred to both maxillary and mandibular complete dentures during consumption of a quarter of a peeled apple. Among 29 patients, six and seven patients respectively claimed maxillary and mandibular complete dentures dislodged.
denture dislodgement during consumption of the apple, without denture adhesive application. With denture adhesive, only three patients claimed maxillary and two claimed mandibular complete denture dislodgement (Fig 2b). The number of chews until the first denture dislodgement for both maxillary and mandibular complete dentures increased after denture adhesive application, but the difference was not statistically significant (P=0.37). Overall, the time for both maxillary and mandibular complete denture dislodgement increased after denture adhesive application. Furthermore, the total number of dislodgements through the course of apple consumption decreased after denture adhesive application. All patients felt more comfortable chewing with the application of denture adhesive.

Using the disposable gnathometer, the mean BFDD score without denture adhesive was 3.7 (range, 1.0-10.0), and with denture adhesive it was 4.4 (range, 2.0-11.0). Of the 29 patients evaluated, 17 (59%) showed improvement of the BFDD score with denture adhesive, while in two (7%) the score decreased (Fig 3). The remaining patients showed no improvement at all. Paired t tests revealed significant improvement of BFDD scores after denture adhesive application (P=0.001). Means and standard deviations for MKIS, BFDD and ME are shown in Table 4.

There was a significant correlation (P<0.01) between the MKIS and the BFDD before (r=0.081) and after (r=0.057) the denture adhesive was applied, but the r values were weak (Fig 4).

Discussion

According to Zarb and Boucher 19, there are several factors accounting for retention of complete dentures, including: adhesion, cohesion, interfacial surface tension, capillary action, atmospheric tension, and oral or facial musculature. Not all of these act at the same time; some become effective only when needed to resist a certain dislodgement force. These factors, along with the appropriate fabrication of the complete denture, combine to retain the prosthesis 19. In this study, a majority of the dentures were categorized under the ‘good’ group based on the MKIS. The scale could be misleading as it was a collective score for both maxillary and mandibular complete dentures. Most scores for maxillary dentures were higher than those for mandibular dentures, and in certain cases the mandibular denture fell into poor category, with scores of 0. However, the collective score

<table>
<thead>
<tr>
<th>Table 4</th>
<th>Modified Kapur Index, bite force, and masticatory efficacy of patients before and after application of denture adhesive</th>
<th>Mean (standard deviation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modified Kapur Index</td>
<td>12.8 (2.7)</td>
<td></td>
</tr>
<tr>
<td>Bite force until denture dislodgement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without denture adhesive</td>
<td>3.7 (2.3)</td>
<td></td>
</tr>
<tr>
<td>With denture adhesive</td>
<td>4.4 (2.3)</td>
<td></td>
</tr>
<tr>
<td>Masticatory efficacy (chewing)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without denture adhesive</td>
<td>136.9 (58.8)</td>
<td></td>
</tr>
<tr>
<td>With denture adhesive</td>
<td>131.2 (60.9)</td>
<td></td>
</tr>
<tr>
<td>Masticatory efficacy (biting)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without denture adhesive</td>
<td>6.8 (2.1)</td>
<td></td>
</tr>
<tr>
<td>With denture adhesive</td>
<td>5.9 (2.0)</td>
<td></td>
</tr>
</tbody>
</table>
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has more effect on denture wearers with poor than good denture-bearing tissue. Tarbet et al. 14 also found that the biting force and denture dislodgement were reduced after use of denture adhesive, especially in those with unsatisfactory denture-bearing areas. Furthermore, Chew et al. 20 found that denture adhesive exerted its greatest effect with ill-fitting as opposed to well-fitting dentures.

When evaluating the effect of denture adhesive subjectively, all of the patients agreed that the denture adhesive improved their comfort level and ease of eating. These results were also supported by Kelsey et al. 21 and Kulak et al. 22 who found that most patients were satisfied with the performance of their dentures with denture adhesive application. The masticatory performance as well as retention and stability of dentures improved significantly. Tarbet et al. 14 also found that with the use of an adhesive most of the patients perceived improved chewing ability, confidence and comfort, as well as reduced wobbly effect and amounts of food particles collecting under the dentures.

The denture adhesive used in the present study improved retention and stability of the maxillary complete denture on BFDD for majority of the patients (P=0.001), whilst BFDD increased. These findings were supported by other studies 17,18,23 showing that denture adhesive was effective in improving maximum incisal force and retention of complete dentures. The BFDD was recorded using a disposable gnathometer, which is a simple but practical device to record incisal force. However, there was no research into determining its reproducibility, predictability and use in interpreting the BFDD unit in comparison with the universal unit 4. Besides, the score obtained by gnathometer cannot be interpreted in terms of Newtons. Thus, direct correlation with other research such as that by Grasso et al. 24 cannot be made as they measured BFDD in Newtons.

The research might have been more reliable and practical had the following factors been considered/ incorporated:
1. An increased sample size;
2. Investigation of the effect of denture adhesive over certain time periods;
3. Selection of an acceptable MKIS for mandibular complete dentures; and
4. Additional methods to investigate denture

Figure 4 Correlation coefficient between Modified Kapur Index Scale (MKIS) and bite force until denture dislodgement (BFDD) for patients (a) without denture adhesive, and (b) with denture adhesive could still be ‘good’ and thus misleading.

With the increased stability and retention provided by denture adhesives, denture wearers can apply more force during mastication, thus needing less chewing till deglutition 14. This leads to improved mastication. Less and later dislodgement occurred to the dentures with denture adhesive, which also improved mastication. In the present study however, the findings were not statistically significant (P>0.05). One reason may have been the condition of oral bearing tissues that were not examined. According to Fujimori et al. 16, the masticatory performance of complete dentures was improved only if the denture-bearing tissue was classified as poor. They also showed that chewing bursts are decreased and concluded that denture adhesive
performance (radiotelemetry, cineradiography, retentiometers).

Conclusion

Masticatory activity improved with denture adhesive; however the improvement was not statistically significant. With denture adhesive application, bite force until maxillary complete denture dislodgement increased significantly. Patients were satisfied with application of denture adhesive for mastication, as it made chewing more comfortable.

Acknowledgments

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References