Guidelines for the Use of **Denture Adhesives** and their Benefits for Oral and General Health

INDIA REPORT

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Better oral health for all

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Contents

Executive Summary

Our culture in India has inculcated in us, a set of values that hold the elderly in high regard. By 2050, the share of Indian population over the age of 60 is projected to increase from 8 per cent to nearly 20 per cent. Indians are living longer lives, and we must equip all age cohorts with medical and social infrastructure so they can continue to live with grace and dignity.

A division on rural and urban scenario may be mentioned in the case of a country like India where there is a mass divide and the prevalence of the edentulous states. The incidence of partial edentulous patients is on an upward swing in the urban areas though the rural regions will continue to have a high prevalence of fully edentulous patients. Hence there should also be an awareness drive on the use of the denture adhesives on partial denture prosthesis, which warrants its use along with that of complete dentures.

As people are living longer, they are likely to be partially or completely edentulous. However, there are almost no global guidelines for the proper use of denture adhesives by individuals who wear full dentures. There are only a few guides from dental associations and opinion leaders for denture wearers on how to use denture adhesives properly. Equally, dental professionals are uncertain about when is the best time to give advice. Denture wearers are often left without much guidance on how best to use denture adhesives.

Also, the advice on the type of adhesive to use, how to apply it, how much to use, how often to use it and how to remove it varies tremendously. Misusing or overusing adhesive may have consequences,but making the best use of it can improve quality of life, quality of diet and overall wellbeing for full-denture wearers.

The benefits of the optimal use of denture adhesives with full dentures are in improved:

1. Retention
2. Stability
3. Patient-perceived masticatory function, and
4. Masticatory performance and effectiveness.

Research has shown that food trapping and microbial growth can be reduced with optimal use of denture adhesives. All these benefits may help enhance the patient's wellbeing and improve their diet and social interaction.

1. Patient satisfaction has become a decisive factor for the overall success of prosthodontic treatment in full denture wearers.

2. Denture adhesives can enhance the retention of, and reduce food accumulation beneath, well-fitting complete dentures.

3. Denture adhesives can be beneficial to the patient. They may enhance comfort, provide psychological satisfaction, increase confidence and thus wellbeing while increasing retention and stability, and improving function.

4. The effectiveness of denture adhesives cannot compensate for significant denture deficiencies.

Many of the dental practitioners either are unaware or not informed of the positive effects on a patient on the use of a proper denture adhesive. This may also be compounded with the unavailability of these products in rural and semi-rural areas. The costing and packing of such a commodity also will play a major role and may be a smaller sized packing with a cost-effective seal may make the product more popular.

There are several types of denture adhesives in the market. Adhesive creams seem to be the most popular and are the only ones with some consistent usage instructions. Therefore, these guidelines are being developed to help dental health care professionals, caregivers, and patients on their optimal use. These are supported by the best evidence and based on consensus from key international experts.

1. Apply a small amount of denture adhesive cream to a clean and dry denture. One application a day should be sufficient.

2. After application, replace the denture in the mouth and firmly close the mouth for a couple of seconds. If the adhesive cream overflows, too much has been applied, and the adhesive should be removed (rather than swallowed). Patients should not consume food or drink within the first 5 minutes of application.

3. Before sleep, the denture should be removed, and the denture and oral cavity thoroughly cleaned to remove any remaining adhesive.

4. All patients who wear removable dentures should be enrolled in a regular recall and maintenance programme with their dental professional.

5. Dental professionals should provide guidance and instructions to the patient on the correct application and use of the adhesive, and on removing it and cleaning the denture.

6. The optimum time to advise on the use of an adhesive varies between patients. For well-fitting dentures, it might occur at a review appointment, or for patients finding problems with compliance at the time of fitting or soon after.

It is also recommended that the dental community invest in further research to refine the evidence. This would help produce more specific guidelines on the use of adhesive products to improve the experience of full denture wearers, and in particular on the frequency of application and on removal of the adhesive. We also need further insight into oral care professionals' attitude towards recommending denture adhesives for improving the lives of their denture-wearing patients.

India Task Force for Development of Guidelines on Use of Denture Adhesives

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Section 1:
Dentures: Description and Classification

According to the Glossary of Prosthodontic Terminology (Ed 9), a denture is an artificial substitute for missing natural teeth and adjacent tissues. They are custom-made devices and two types of removable dentures are available: complete and partial. However, there are many denture designs which, to keep dentures in place, rely on clasping to natural teeth or attaching to crowns or dental implants.
Complete (or 'full') dentures are worn by patients who have lost some or all their teeth in one or both jaws or 'arches'. These are called the maxillary (upper) or mandibular (lower) arches. The dentures are called 'complete' or 'full' dentures and because of the global nature of this white paper we have used both terms interchangeably throughout the document.

In removable complete dentures, the replacement teeth are attached to a base, usually made of acrylic. The dentures are supported and kept in place in the mouth by the surrounding soft and hard tissues. Saliva helps keep this seal in place.

Partial dentures are used when a patient still has one or more natural teeth. The replacement teeth are attached to an acrylic or metal framework (mainly cobalt chrome). Metal-based dentures use teeth for support to keep them in place. Acrylic dentures use the same method as full dentures, and may also use clips or clasps. 'Overdentures' use tooth roots or dental implants to help keep them in place. Some dentures have internal attachments/ implants that attach to the adjacent crowns (on natural teeth or on implants) which help to keep them in place.

Dentures are made for people that have lost some or all of their teeth, to help:

- improve their appearance
- maintain the occlusal dimension (normal distances between their nose, mouth and chin)
- support their lips and cheeks
- improve their self-esteem and confidence
- improve mastication (chewing ability) and so help maintain healthy nutrition.

For a patient with no natural teeth, psychological factors are just as important as aesthetic or mechanical ones.

In developed countries, fewer people are wearing complete dentures – the impact of preventive measures means people are keeping more of their natural teeth. In Europe, it has been shown that in some countries with low percentages of denture-wearing people, most dentures are worn by the relatively large groups of immigrants. However, recent iData research in the USA suggests that the full-denture market is stable, and, projected through to 2023, is growing slightly. This may be because of an increase in the aging population, who were born before effective oral hygiene measures were widespread. In developing markets though, complete dentures remain of major importance.

Partial dentures are increasing in number worldwide, because it has become less acceptable to be seen with missing teeth. Despite the success of dental implants, a lot of people rely on removable partial dentures as a simpler and less-costly option for replacing lost teeth. The removable partial denture market in the USA is growing at 6% a year, mainly due to the appearance of the newer 'flexible' removable partial dentures.

The purpose of these guidelines is to focus exclusively on the usage instructions for denture adhesives in cream or paste form and the benefits of their optimal use for complete denture wearers.

Section 2: Prevalence of Edentulism (with respect to Indian Subcontinent and Global Scenario)

Over the last 20 years, edentulism has declined globally. However, this is mainly due to the trend in most high income countries where more people are keeping their teeth. We see the opposite trend in low and middle income countries. Here the rate of edentulism is increasing.

The World Health Organisation's Global Health Survey, carried out between 2002 and 2004, showed that edentulism is a highly prevalent condition globally. For people aged 65 and over there was an overall average prevalence of 32.9%. In individual countries this ranged from as low as 7% in Egypt to 72% in Iceland.[1]

There was a large variation between countries that had similar income levels. This suggests that average income per head may not be the main explanation of the rate of edentulism in a given country. Other factors such as oral hygiene practices, nutritional habits, and socioeconomic inequalities have been suggested as being stronger driving factors.[2]

The following factors were associated with edentulism in older age groups:

- socio-demographic factors (for example, lower education)
- lifestyle habits (for example, smoking), and
- health conditions (for example, arthritis, asthma and diabetes).[3]

Because of ageing and increased life expectancy all over the globe, we expect edentulism to become more widespread and to be a growing public health problem. Although in developed countries extractions of natural teeth may be in decline, in developing countries they may still be the first remedy against toothache.

Tooth loss and denture wearing can have a substantial impact on self-esteem and psychosocial wellbeing. The concept of quality of life has been developed as an objective indicator and has been widely used in medical and sociological research. Several instruments in the form of questionnaires have been validated to measure 'oral health related quality of life' (OHRQoL) in a scientific manner. Several studies confirm that a reduced number of teeth leads to a decrease in OHRQoL.

Because there is an increased focus on self-esteem and social interaction for quality of life, people nowadays are more likely to go quickly to get their missing teeth replaced, rather than remaining edentulous as was readily accepted 50 years ago. For the same reason, we may see an increased use of denture adhesives by the current 'young-elderly' denture wearing population.

In low to middle income countries, edentulous people will look to replace their missing teeth by getting removable full dentures. In high income countries, more people can afford the more expensive implant supported or retained dentures.

The Aging Population

Globally the incidence of complete edentulism has been estimated to be between 7-69 %. In general the world population is aging. The national policy on older persons defines senior citizen/ elderly as a person whose age is 60 years or above. Population aging is a universal phenomenon that commenced in the last century with the developed countries and is now present even in developing nations.
Currently, six countries (China, USA, India, Japan, Germany, Russia) contain more than half (54%) of 80 plus aged people i.e. the oldest population. An increase in number of aged in India is estimated and India will soon jump to second position form the third position in the prevalence of aged.

Some world populations are aging at unprecedented rates, whereas others, mostly in Sub- Saharan Africa, Southeast Asia, and Central America, are increasing slowly - "Middle-old" (75 to 84 years) and "old-old" (≥85 years) populations. In Canada, for example, about half (47.8%) of the elderly population (≥ 65years) is older than 75 years.

These demographic changes have produced a major shift in health care from cure of acute disorders to management of chronic illness and their direct impact on the cost of health care. Women, in contrast, use preventive health care services more often than men and have benefited more from improved health care, especially in obstetrics, so that there are nearly twice as many older women than older men globally. Women on average have a longer life expectancy.

Trends in India

An increase in population of elderly can be attributed directly to improved medical facilities, economic well-being and indirectly to reduction in fertility.[3] In India while the rate of growth of population has been 18 % between 2001-2011, the rate of growth elderly has been 36 % during the same duration.

A. Increase in size of elderly: The population census of 2011 (India) reveals a total of 104 million elderly (more than 60 years) of which 53 million are females and 51 million are males. The demographic SAGE Census reported that Indian States of Maharashtra, Karnataka, West Bengal are advancing more rapidly towards aging population.

B. Increase in share of aging women: In the last two decades females have outnumbered males in terms of population growth. At present the life expectancy for the year 2015 in India is 66.9 (for males) and 69.9 (for females).

C. Rural Vs Urban: Of the total elderly population, 71 % is currently in rural areas and 29% is in urban areas.

D. State Wise Distribution of elderly in India: The maximum population of elderly is seen in the States of Kerala, Goa, Tamil Nadu, Punjab and Himachal Pradesh in the descending order. This may be attributed to improved medical facilities and improved lifestyles. It is to be noted that aged persons have increased in all the States and UTs, except in Daman & Diu.

E. Old age dependency ratio: The old dependency ratio is the number of adults 60 years per 100 persons in labor force/ economically active in 15-59 years age). This value has risen.

Extract : MacEntee MI, Brondani MA, Verma M, Nanda A, Kaur H. The Aging Edentulous Patient. In: Zarb G, Eckert S, Hobkirk J, Jacob R, Verma M, ed. by. Prosthodontic Treatment For Edentulous Patients Complete Dentures And Implant-Supported Prostheses. 1st South Asia ed. New Delhi: Elsevier.

F. Social Support System: Despite increase in number of eldery people in the population, there are less elderly per household, thus implying a less supportive social system.

G. Literacy: Edentulism has been associated with low education.

H. Chronic conditions: Among the chronic conditions, prevalence of co-morbidities reported is nearly 16.1%.

I. Health Care Utilization and Health Financing: 2% of households who utilize any health insurance coverage. 73% of households finance health care from current income and 25 % from the savings.

J. Support for the elderly: The Indian Ministry of Health and Family Welfare, the Ministry of Social Justice and Empowerment and Ministry of Rural Development have been working in unison to provide adequate social, financial security and improve the quality of life of the elderly. The Government of India has many acts and schemes that are beneficial to the patients, especially the elderly.

The Indian Prosthodontic Society (IPS) through its COMMUNITY OUTREACH PROGRAM, with the assistance of its members and country wide network of the IPS State Branches and various dental schools have touched the lives of many a needy of the elderly population through various free denture camps in the rural India .

Impact on Edentulism

In general, old people usually adapt poorly to new dentures, which probably explains why they seldom return to have old but familiar prostheses replaced. However, when they do complain, it is usually about difficulty chewing hard foods with uncomfortably loose dentures.

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Section 3:
Specifics of Denture Adhesives

Denture adhesives have been on the market in different forms for nearly a century. They are supplied as soluble or insoluble products. Creams, pastes, strips and powders are soluble adhesive products, while cushion pads and wafers are categorised as insoluble.

The words 'adhesive' and 'fixative' are both used equally in guidelines and in scientific research. However, because of the accepted use of the term 'denture adhesive' in the Glossary of Prosthodontics terms (9th Edition), along with the ISO 10873-2010 classification, we have chosen to use exclusively the word 'adhesive' in this paper.

All adhesives are intended to increase the retention and stability of the denture to improve comfort for the denture wearer in daily life. Denture adhesives may also help to maintain a seal around a denture and so reduce the accumulation of food debris underneath it. The cushioning effect of denture adhesives reduces the pressure and friction transmitted to the underlying mucosa. As a result, the appropriate use of denture adhesives may increase the patient's sense of security and satisfaction.

According to Kumar et al.[5], the main ingredients of denture adhesives could be classified into three groups:
• Adhesive agents delivering the adhesion between denture and mucosa: methyl-cellulose, hydroxyl-methyl cellulose, sodium carboxy-methyl cellulose, and synthetic polymers like acrylamides, acetic polyvinyl and polyethylene oxide
• Anti-microbial agents reducing microbial growth in the adhesive: sodium tetraborate, ethanol, hexachlorophene and sodium borate, and
• Other agents to help with application, storage and the delivery of freshness to the mouth: plasticizing agents; flavoring agents like oil of peppermint, oil of wintergreen, and spearmint; wetting agents, and so on.

However, more recent formulations tend to replace mineral oils and petrolatum with more biologic products like olive oil, aloe vera, myrrh, herbs and pine resin. These also have antibacterial, antifungal, anti-inflammatory and soothing properties. Active adhesive ingredients in current formulations can include combined polymethyl vinyl ether-maleic anhydride (PVM-MA) Zinc/Ca/Mg, Na – which are high-molecular-weight copolymers with adhesive and cohesive properties, and calcium salts with carboxymethylcellulose – a viscosity modifier.[6]

The basic mechanism of the action of adhesives was described in the early 1990s, but specific formula adjustments over the past decades have made them even more powerful. Cream, strip and powder adhesives absorb water from saliva and become viscous fluids. The adhesive functions through both increased adhesion between the adhesive layer, the denture and the soft tissues and by having a greater bond within the adhesive layer compared with saliva alone. Absorbing water helps the adhesive spread between the alveolar ridge and the mucosal (fit) surface of the denture. The materials may swell by up to 50–150% by volume in the presence of water, filling the spaces between the denture and the tissues.

The properties of current adhesives depend upon a combination of both physical and chemical properties, helping the dentures stay in place and preventing their movement during chewing. Saliva increases the viscosity of the adhesive, increasing the force needed to separate the denture from the tissue surface.
Newer adhesive materials provide stronger bioadhesive and cohesive forces. These include the free carboxyl groups formed by the hydration of adhesives such as methyl cellulose, hydroxyl methyl cellulose, sodium carboxyl-methyl cellulose or poly methyl vinyl-ether maleic anhydride.

They form electrovalent bonds that produce stickiness or bio-adhesion. The increased viscosity of the adhesive creams results in their lateral spread excluding air and saliva increasing the retention.

A recent in vitro model study, mimicking the denture gingival interface, evaluated the adhesion properties of a commercially available denture adhesive cream. It measured changes in the adhesion strength of the cream in response to specific conditions in the mouth:

- level of salivation
- pH, and
- temperature.

The results of lap shear, tensile test, and internal interactions suggested a cohesion failure, where the lowest adhesion strength was due to hyposalivation.[7]

Zhang et al.[8] found that the mechanical properties of commercially available denture adhesive hydrogels were critically dependent on both the formulation of the adhesives and their hydration level.

Another in vitro comparison of the tensile bond strengths of different denture adhesives on different denture bases, showed that denture adhesives had the greatest tensile bond strength after 5 minutes. However, there were significantly different results for each of the 3 denture bases tested.[9] The mechanical properties of adhesives are expected to be critical in defining the stability and removal of dentures from the supporting oral mucosa. A multi scale experimental mechanical approach to evaluate the performance of denture adhesive materials was used by An et al.[10] The failure of denture adhesive material was found to be critically dependent on the formation of fibrillar structures within the adhesive.

An in vitro study by Chowdry et al.[11] looked at the retention ability of different commercially available adhesive materials. It found that products delivered as a paste were more resistant to dislodgement than their powder form. Since no details about the exact formulations were provided, the different ingredients involved may also have contributed to these differences.

In another in vitro study Jian-Min et al.[12] measured the initial viscosity and the adhesive strength of 3 cream type and 3 powder type denture adhesives available on the market. The initial viscosity of all the cream type denture adhesives was lower than the powder type adhesives. However, after immersion in water the adhesive strength of cream type denture adhesives then increased significantly and exceeded that of the powder type denture adhesives. The researchers therefore concluded that dentures with cream type denture adhesives may be easier to adjust during insertion and then are held in place more effectively. Again, no details about the exact formulations were given and therefore the different ingredients involved may also have contributed to these differences.

Denture strips have been marketed with the aim of reducing mess, making the application of the adhesive easier and reducing the amount used. In a study by Kalra et al.[13] adhesive strips were found to be less effective than paste and powder formulations. Goncalves et al.[14] confirmed the results of this study and found the tested strips less effective than the cream adhesive they tested for mastication efficacy by looking at chewing cycle and chewing ability and performance. Munoz et al.[15] proved in principle that all tested denture adhesives increased the retention and stability of well-fitting and well-made dentures. Denture movement measured both objectively and subjectively was decreased. Adhesives also increased comfort, confidence and satisfaction with dentures in conjunction with chewing hard and brittle foods. Though not significantly different, the strips had lower scores on all measures. The authors assumed that the difference between the creams and the strip product was likely to be because strips do not contain a long acting synthetic polymer.

A literature review by Duqum et al.[16] set out to clarify the evidence for the advantages and disadvantages of the use of denture adhesive in complete denture patients. Their conclusions were straightforward:

- Denture adhesives improve the retention and function of complete dentures. However, standardized guidelines are needed for the proper use, application and removal of denture adhesives
- Long-term studies are needed on the biologic effects of denture adhesives on the denture-bearing mucosa
- There is a need to promote regular recall programmes for complete denture patients.

Allergies to denture adhesives or their components have been described, but no recent study has been found to show the exact causes of possible allergic reactions. Some products have been shown to release formaldehyde, which is cytotoxic to cell culture and fibroblasts and is a potent allergen. Also, zinc and coloring agents in a denture adhesive formula may act as an allergic stimulus. But no scientific study was found to confirm any of these assumptions. However, care should be taken when particular adhesives are used by patients suffering from these allergies. Hypersensitivity or allergy may not be recognized until the first time the adhesive is used in the mouth.

Special care is also needed with patients suffering from chronic xerostomia ('dry mouth'). These patients are often immunocompromised, and microorganisms they are exposed to must be considered potential pathogens.[18]

Denture adhesives are available on the market in different forms. The adhesive creams seem to be the most researched and are the only ones with some consistent usage instructions. Because we found only limited documentation on powders and strips, and because their use is not as widespread as creams, we did not include these in this review. The information on insoluble adhesives such as cushion pads was also scarce, and we therefore did not include these in our review.

Many dentists still feel that if their patients use adhesives this is a poor reflection on their clinical skills and prosthetic expertise. This is despite considerable documentation recommending the use of adhesives, and bodies such as the American College of Prosthodontists providing guidelines for the correct application of denture adhesives.

Although adhesives are widely used by many denture wearers around the world, dental professionals have not been recommending their use consistently and many warn patients against using these products. Many prosthodontists see prescribing denture adhesives as a way of compensating for poor quality of prosthodontic care. In reality, denture adhesives add to patient satisfaction and comfort, and are effective even with the best quality of professional care. The use of denture adhesives is supported by a considerable body of work showing:

- improved retention and chewing ability
- reduction in instability
- improved perceived comfort while using the denture, and
- reduction or elimination of the build-up of food debris beneath the dentures.

As a result, they increase the patient's sense of security and satisfaction.

Several studies confirmed a lack of knowledge of these benefits among dental professionals. Therefore, education seems to be the biggest opportunity for changing their understanding of this category of products for the benefit of their patients.[19, 20] In more recent research though, we have seen some more positive attitudes among dentists (and also therefore among denture wearers) towards denture adhesives.[21, 22]

Section 4: Existing Guidelines for Optimal Use of Denture Adhesives

The FDI (World Dental Federation) does not have any guidelines published on its website for the use of denture adhesives.

The Japan Denture Care Society also used specific guidelines for powder and cream type denture adhesives as part of the protocol for a multi-centre, randomized controlled trial to develop Japanese denture adhesive guidelines for patients with complete dentures (The Denture Adhesive Guideline trial).[23]

In India there are currently no prescribed guidelines available either to the dentist or patients other than those from various companies. The Indian Prosthodontic Society feels current guidelines should be further fine tuned through various clinical studies.

The FDA (US Food and Drug Administration) and the American College of Prosthodontics are the only professional organisations that mention the possible negative side effects of overusing a denture adhesive containing zinc, and recommend using zinc-free denture adhesives. The fixodent.com website has a warning about the excessive use of zinc containing products.
The opinion leaders have provided specific advice for spreading the adhesive on the dentures and a recommendation for wetting the adhesive before replacing the denture in the mouth.

There is some consistency in the published guidelines on how to apply the adhesive and on how much to use. Most of the guidelines mentioned include a warning against excessive use (more than once a day or overfilling). Different methods are recommended for removing the adhesive at night, ranging from sunflower oil to damp kitchen roll or just scrubbing. There is no consistent recommendations on removing the adhesive from the denture before overnight storage out of the mouth.

The Japan Denture Care Society are comparing cream and powder adhesive formulations in their Denture Adhesive Guideline Trial. Participants using the cream formulation are instructed to apply the denture adhesive in the morning and use the dentures all day to have breakfast, lunch, and evening meal. Those using the powder formulation apply it in the morning to use for breakfast and lunch, then re-apply before evening meal. The control group use applications of saline solution before the respective meals. Participants were asked to remove the remaining denture adhesive immediately before applying new denture adhesive or before sleeping at night.

In this study, the maximum occlusal force and masticatory performance were measured immediately after application of either the powder adhesive or cream adhesive (or in the control group, saline). Final results are not yet published but there is the issue about the relevance of different application timings in this study. However, the final publication may shed some light on this issue.

The lack of appropriate research is most probably the cause of this low level of available guidelines on the use of denture adhesives for professionals and the public at large.

Below is the list of Countries who have guidelines for optimal use of Denture Adhesives -

Country	Organisation
Australia	Government of South Australia - SA Health
France	UFSBD
Germany	BZAEK
Japan	Japan Denture Care Society
Spain	topdoctors.es
Switzerland	Dental Hygienists Association
UK	NHS
USA	American College of Prosthodontics
USA	American Dental Association
USA	DR Cagna (key opinion leader) | J Massad (Key opinion leader)
USA	FDA

Section 5: Effectiveness of Denture Adhesives with well-fitting dentures

Retention

Grasso et al.[24] study on denture movements showed -
- Mandibular denture movements, both with and without an adhesive, were significantly greater than maxillary denture movements.
- The adhesive significantly reduced movement of the maxillary and mandibular dentures during both chewing and biting, and
- The improvement happened immediately after the adhesive was applied and was maintained for the four hours of follow-up.

A study by Shamsolketabj et al.[30] looked specifically at the impact of denture adhesives on 3 groups of denture wearing patients with different levels of bone resorption of the residual ridges. Retention, chewing, talking, self-confidence and the efficiency of the dentures were improved in all patients. No statistical significant differences in these parameters were observed between the 3 groups.

Stability

Some of the retention studies measured stability but used measures such as mean chewing rate, denture movement, wobbling or dislodgement. In our opinion, these measures refer to stability rather than retention only.
Rendell et al.[32] carried out a controlled study to decide if a reduction in mandibular denture movement and improved chewing function could be seen in edentulous patients using adhesives. Munoz et al.[15] also confirmed in their study that denture adhesives significantly improved the retention and stability of well fitting dentures. Subjects had significantly fewer dislodgement while eating an apple after adhesive was applied to dentures.

Masticatory

To examine the effects of a denture adhesive on masticatory functions for complete denture wearers, the following have been suggested as possible measurements for performance:
- maximum biting forces
- masticatory performance, and
- electromyography of the masseter muscle during mastication.

A study by Fujimori et al.[34] considered the duration of both the chewing burst and chewing cycle.
In this research, the use of the denture adhesive increased maximum biting force and provided rhythmic masseter muscle activity during mastication for both good and poor denture bearing tissues.

Food trapping

A recognised secondary benefit of denture adhesives in patients with complete dentures is their ability to act as a barrier to help prevent the migration and accumulation of food particles under the dentures. A double-blind clinical trial by Torres-Sanchez et al.[39] revealed that denture adhesives significantly improved the satisfaction of edentulous patients.

Section 6: Health Challenges with use/ misuse of Denture Adhesives

Denture adhesives usually contain one or more ingredients that swell and become viscous and sticky as they absorb water. Many adhesives also contain coloring, flavoring, wetting and preserving agents. Some of these compounds could potentially cause or contribute to adverse reactions among users of denture adhesives. As a principle therefore, denture adhesives should:

- have neutral or slightly alkaline pH
- have minimal toxicity to the oral mucosa
- not promote microbial growth
- be odourless and tasteless, and
- retain the adhesive properties for 12 to 16 hours before reapplication is needed.

Neither the possible side effects on the oral mucosa of regular adhesive use or general health issues because of overuse and possible ingestion of denture adhesive materials have been fully researched and reported. Denture patients should be instructed in their proper use and cautioned against misuse.

1. Cytotoxic effects

Ekstrand et al.[40] in 1993 investigated the cytotoxic effects, microbial contamination and formaldehyde content of 19 commercially available denture adhesives. They reported that all the materials were cytotoxic to mouse fibroblast cells and some had microbial contamination. Other researchers have reported some level of cytotoxicity for certain adhesives, but none of the studies addressed the irritation potential of the denture adhesives.

Al et al.[41] in 2005 published a study that aimed to examine the in vitro biocompatibility of 5 denture adhesives. None of the tested denture adhesives showed a noteworthy acute irritation. None of the tested denture adhesives induced cytotoxicity. However, the authors did raise concerns that adhesives may contribute to mucosal inflammation in denture wearers, since they are commonly used throughout the day.

A recent study by Soares et al.[42] tested 3 different adhesives with older and younger donors and considered all the materials to be non-cytotoxic.

2. Toxicity of zinc containing adhesives

Zinc is a mineral that is an essential ingredient for good health. It is found in protein-rich foods such as shellfish, chicken and nuts, as well as in some dietary supplements. However, an excess of zinc in the body can lead to health problems such as nerve damage that only appears slowly and over a long period of time. Two published case series studies identified patients experiencing progressive neurological symptoms following extended overuse of zinc containing adhesives.

Another separate study by Hedera et al.[43] looked at the different sources of zinc intake among patients suffering from progressive myelopolyneuropathy. All had a history of ill-fitting dentures which needed large amounts of denture cream, resulting in significant zinc exposure.

Their copper and zinc normalized after they stopped using zinc-containing denture adhesive.

The FDA (US Food and Drug Administration) has not found conclusive evidence that these problems result from using zinc containing denture adhesive. The FDA warns of overuse of zinc containing denture adhesives, especially when combined with dietary supplements that contain zinc and other sources of zinc.

3. Microbial Growth

Denture adhesives often include antimicrobial agents such as hexachlorophene, sodium tetra borate, methyl salicylate and sodium borate. Therefore, the long-term use of adhesives may affect the oral micro-flora. A study by Özkan et al.[45] concluded that prolonged use of the denture adhesive (tested up to 2 months) did not lead to an increase in micro-organisms of the oral flora.
Similar results were recorded by Leite et al.[46] in a study that evaluated the effect of a denture adhesive on the formation of bio-film on the internal surface of complete dentures and the palatal mucosa of denture wearers. Similar colony counts were found with or without the use of adhesive for both the mucosa and internal surfaces of maxillary dentures.
Kim et al.[47] found no statistical difference between the test (adhesive use) group and control (no adhesive) group in terms of Candida species counts, either in the saliva or on the maxillary denture.
Borole et al.[49] also evaluated the effects of different denture adhesives on the growth of Candida Albicans in especially vulnerable diabetic patients. They found an overall increase in the number of CFU/ml of Candida species following the use of denture adhesives. However, the mean percentage increase in CFU/ml was not of any clinical significance.
No clinical study has demonstrated that denture adhesives promote an alteration of the oral microbial population. The antimicrobial and antifungal properties of denture adhesives have been confirmed in several in vitro studies. Recently Rajaram et al.[50] found that the 3 forms of commercially available denture adhesives they tested showed an antifungal effect. Polyzois et al.[51] They found that, under the conditions of their in vitro study, all the tested denture adhesives showed antimicrobial action.
In summary, although potential side effects exist there is no research available that definitively associates their long-term use with harm. In common with any product there is a balance between the benefit from the product and the potential for a side effect. Based on present evidence, we may assume that denture adhesives are safe, when used in line with the manufacturer's instructions.

4. Application and removal of adhesives

No reference could be found to studies that evaluated different ways to apply denture adhesives or for the most appropriate placement of the adhesive on the denture. There are also no studies reported to our knowledge that have evaluated the patient's ability to correctly apply denture adhesives on the surface of the denture.
Disadvantages of denture adhesives also include the difficulty of removing them. In light of the potential health challenges from using adhesives over the long term it must be clear that they need to be completely removed from the oral mucosa after some time and definitely before going to bed. Harada-Hada et al.[53] tested denture cleaners for the removal of denture adhesives. They found that cream adhesives were removed more completely after soaking in most denture cleaners than after soaking in water.
A recent study by Almeida et al.[55] concluded, taking into account the in vitro studies' limitations, that none of the techniques recommended by the manufacturers would remove the adhesive completely. Water brushing gave less efficient results. Soaking in an alkaline peroxide solution, followed by brushing, gave much better results.

5. Oral Cancer

To understand the possible link between ill-fitting dentures and the theoretical risk of developing oral cancer, Manoharan et al.[57] carried out a meta-analysis to see if there was a relationship between dentures and the development of oral cancer. They found that the use of ill-fitting dentures substantially increased this risk. Using adhesives may lead to patients not seeing a dental professional regularly, allowing oral cancer to develop unchecked.

Section 7: Health Opportunities associated with the use of Denture Adhesives

1. Denture Performance

Denture adhesives can maintain the performance of a best fitting denture. However, it is important to distinguish best fitting dentures from dentures that fit poorly. Denture adhesives should never be used to compensate for dentures that fit poorly. Most existing scientific evidence shows that retention and stability are increased significantly after the application of denture adhesives.

2. Psychological Confidence

It can be concluded that denture adhesives add to retention and so improve chewing ability, reduce any instability, provide comfort and eliminate the accumulation of food debris beneath the dentures. As a result, they increase the patient's sense of security and satisfaction.

3. Oral Health and General Health

The research showed that individuals who had poorer oral health had a higher risk of suffering from poor general health. The percentages of correct or close prediction for general health indicators from oral health indicators are high, being around 80% for all general health indicators. Also, having a poor oral health status was predictive of poor general health status at following assessments. Bartlett et al. [61] carried out a small pilot study comparing dietary intake for complete denture wearers who had a targeted dietary intervention and who also used a denture adhesive.

Nicolas et al.[62] assessed the oral health related quality of life of complete denture wearers when results showed that using a denture adhesive may improve subjects' ability to manage conventional dentures and enhance their oral health quality of life. A study by Polyzois et al.[63] shows that there is a definite improvement in 2 weeks after using an adhesive. This implies that adhesives do help the improvement of OHQoL in patients with new complete dentures and may be used to shorten the adaptation period for new dentures.

4. Xerostomia

Some experts believe that with these patients, the use of a denture adhesive, combined with artificial saliva, may enhance retention of the denture and improve the comfort for the patient. Recent gel forms of denture adhesives seem to behave as if they carry a reservoir of water to compensate for a lack of saliva. But no evidence for a better performance with xerostomia patients has been reported yet. A subjective feeling of 'increased saliva thickness' and a reduction of the palatal minor salivary gland flow rates among complete maxillary denture wearers.

In vitro studies done in Japan evaluated gel type oral moisturizers with commercially available denture adhesives. They concluded that the moisturizers had the same level of viscosity and provided the same retention strength as the denture adhesives. This suggested that a gel type oral moisturizer may serve as a denture adhesive.[67, 68, 69] The results suggest that 'stability', an 'uncomfortable feeling', and a 'dry feeling' were the main reasons for patients choosing either the denture adhesive or an oral moisturiser.[70] However, the exact working mechanism of denture adhesives in patients with dry mouth remains unknown. It could very well be that more of the limited saliva flow is used to keep dentures in place, and that the adhesive absorbs saliva initially but then reaches a balanced state and allows more saliva to remain in the mouth than would otherwise.

Section 8: Recommendations for Optimal Use of Denture Adhesives

Although it has been proven that denture adhesives improve the retention and function of complete dentures and lead to superior satisfaction with full denture wearers, most edentulous people do not use adhesives.

A more recent and broader study in India showed that 74.5% of denture wearers had never tried a denture adhesive, though 66.9% of dentists claimed to 'use' denture adhesives. A lack of awareness is the main reason for the low number of denture wearers that have tried a denture adhesive. Also, most dentists are still not familiar with their benefits.[76] By comparing older studies with later ones, we may see a positive change in attitude by denture wearers towards the use of denture adhesives. However, the current situation seems to depend a lot on the specifics of the country, the level of education, cultural differences and the socio-economic levels of the groups researched.

There is a lack of knowledge of the potential health benefits of denture adhesives, and a low level of professional recommendation of, or even a denial of their use with well-fitting dentures. These may be the reasons why most full-denture wearers do not make appropriate and regular use of denture adhesives. Most manufacturers use drawings on the packaging of the denture adhesives for recommending the exact amount used and appropriate application method. The size of the nozzles can be different.

However, it is not enough just to suggest dental professionals recommend the use of denture adhesives more often and in a more consistent way. It is desired that patients know what the guidelines are for their correct use. Only the correct use of denture adhesives will deliver the possible health benefits for denture wearers.

1. Apply a small amount of denture adhesive cream to a clean and dry denture. One application a day should be sufficient.
For the maxillary denture, apply 3-4 pea-sized increments of denture creams to the anterior ridge, midline of the palate and posterior border.
For the mandibular denture, apply three pea- sized increments of denture cream to several areas of the edentulous ridge. Seat the dentures independently; hold each firmly in place for five to 10 seconds.
(From ACP guidelines)

2. After application, replace the denture in the mouth and firmly close the mouth for a couple of seconds. If the adhesive cream overflows, too much has been applied and the adhesive should be removed (rather than swallowed). Patients should not consume food or drink within the first 5 minutes of application.

3. Before sleep, the denture should be removed and the denture and oral cavity thoroughly cleaned to remove any remaining adhesive.

4. All patients who wear removable dentures should be enrolled into a regular recall and maintenance programme with their dental professional.

Recommendations on Optimal Removal of Denture Adhesives:

Dental care education site by Crest advocates the following:

1. Dentures are removed from mouth and fitting surface is gently scrubbed with a tooth brush.
2. Denture is then immersed in warm water and the scrubbing with tooth brush is continued till all the adhesive is removed.
3. A small amount of tooth paste is applied to the brush and the denture base tissues are gently massaged.
4. Patient is asked to then hold some warm water in mouth and tissues are again massaged using tooth brush.

Ideal recomendations to removing denture adhesive from the
1.Denture
a. Soak the denture under water and wash the denture under running water and use a denture cleaning brush and gently scrub the adhesive off.
b. Use a reliable denture cleanser, soak and store for a few hours. After which it can be cleaned using the procedure described above.
c. A soft brissle brush and tooth paste can be used to scrub the undersurface of the denture to get it rid off the adhesive.

CAUTION :
Never use Hot water to clean the denture.
Do not use any caustic materials or hard or sharp objects to scrape the adhesive.

2. Mouth
a. Use warm water for gargling, hold it in the mouth till the adhesive dissolves. Repeat this for a few times if required.
b. Alternatively a soft brush dipped in warm water or use a pea sized tooth paste on it, which will create a froth and reduce surface tension and in effect assist in removing the adhesive.
c. Using a regular mouthwash can also help loosen the sticky adhesive remnants .

Section 9: Evidence for Consistent Professional Recommendations for Denture Adhesives

The FDI World Dental Federation recently developed a new and broader definition of oral health: 'Oral health is multi-faceted and includes the ability to speak, smile, smell, taste, touch, chew, swallow and convey a range of emotions through facial expressions with confidence and without pain, discomfort and disease of the craniofacial complex'.

Nowadays patient satisfaction has become the decisive factor in deciding on the overall success of prosthodontic treatment in complete denture wearers. Because denture adhesives deliver greater patient satisfaction and wellbeing, their recommendation by professionals may contribute to the complete success of a denture-making procedure. If a reduction in denture movement produces an improvement in chewing function, we would expect to see changes in the kinematic properties of mandibular opening and closing during the chewing cycle.

Marin et al.[37] published such a study. It assessed the effect of a denture adhesive on denture satisfaction and on the kinesiographic measurements of edentulous patients wearing well-fitting full dentures. The authors therefore concluded that the use of a denture adhesive was enough to improve patient satisfaction with their complete dentures and to change mandibular movements, leading to improved chewing function. Other benefits of using a denture adhesive include improved retention and stability, and less accumulation of particles under the denture.

In 2018 Torres-Sanchez et al.[22] published a randomized, double-blind crossover study. The study concluded that denture adhesives significantly improved the satisfaction of full-denture users. This is because there is better retention, better stability and less accumulation of food particles compared with non-use of denture adhesives.

1. Patient satisfaction has become a decisive factor for the overall success of prosthodontic treatment in full denture wearers.

2. Denture adhesives can enhance the retention of, and reduce food accumulation beneath, well-fitting complete dentures.

3. Denture adhesives can be beneficial to the patient. They may enhance comfort, provide psychological satisfaction, increase confidence and thus wellbeing, while increasing retention and stability, and improving function.

4. The effectiveness of denture adhesives cannot compensate for significant denture deficiencies.

5. Dental professionals should provide guidance and instructions to the patient on the correct application and use of the adhesive, and on removing it and cleaning the denture.

6. The optimum time to advise on the use of an adhesive varies between patients. For well-fitting dentures it might occur at a review appointment, or for patients finding problems with compliance at the time of fitting or soon after.

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