

A Simplified Technique to Measure Plaque on the Intaglio Surfaces of Complete Dentures

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Abstract

Objective: The main aim of this study was to develop a simplified quantitative denture plaque index that could help dentists to motivate denture patients to maintain optimal oral hygiene. The secondary aim was to assess specific areas of dentures more prone to accumulate plaque and subjects' oral hygiene habits related to their dentures.

Methods: One hundred subjects who wore maxillary and/or mandibular complete dentures for at least one year were included in the study as a powered sample. Fifteen females and 85 males, age range 45-75 years, were recruited. The study was carried out at King Saud University (KSU), College of Dentistry. A plaque disclosing solution was used to assess the plaque covered areas of denture. A quantitative percentage (10 x 10%) score index was developed by assessing plaque scores from digital images of intaglio surfaces of the dentures. The weighted kappa method was used to assess inter-examiner agreement in the main study.

Results: The new denture plaque index was identified as ASKD-DPI (Almas, Salameh, Kutkut, and Doubali-Denture Plaque Index). It ranged from 0 - 100%, and reflected the percentage of the intaglio surfaces of maxillary and mandibular complete dentures that contained plaque. It also classified quantitative percentages: 30 subjects ranged from 0 - 30% (low DPI), 50 subjects ranged from 31 - 70% (moderate DPI), and 20 subjects ranged from 71 - 100% (high DPI) denture plaque score.

Conclusions: A simplified denture plaque index (ASKD-DPI) technique was developed and tested in this study. ASKD-DPI may be used for evaluating denture plaque scores, monitoring denture hygiene, and measuring compliance of patients regarding plaque control for complete dentures.

Key words: Complete denture, plaque index, hygiene, Candida, denture stomatitis

Introduction

The loss of all permanent teeth (complete edentulism) has been estimated for between 7% and 69% of adult populations internationally (Petersen *et al.*, 2005). Denture stomatitis has been identified frequently among

denture wearers and varies widely (Gendreau and Loewy, 2011). Recent epidemiological studies have reported the prevalence of denture stomatitis among denture wearers from 15% to over 70% (Gendreau and Loewy, 2011). It has been identified as an inflammatory process characterized by erythema of the oral mucosal areas covered by complete or partial dentures (Arendorf and Walker, 1987; Odds, 1988; Reichart, 2000; Samaranayake and Macfarlane, 1990; Wilson, 1998). The etiology appears to be multi-parametric and includes old age and concomitant decline of the immune system, systemic diseases, smoking, continual wearing of removable dentures, and poor

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oral hygiene resulting in accumulation of denture plaque. Bacterial and yeast contamination of denture intaglio surfaces have been proposed as predisposing factors (Cannon and Chaffin, 1999; Guggenheimer *et al.*, 2000; Rossie and Guggenheimer, 1997; Sakki and Knuutila, 1997). However, it is generally acknowledged that the main etiologic factors are related to microbial populations, including the presence of the opportunist pathogen *Candida albicans* in denture plaque. In addition, poorly fitting dentures have been known to increase mucosal trauma (Budtz-Jorgensen and Bertram, 1970; Radford *et al.*, 1999; Theilade and Budtz-Jorgensen, 1988).

Denture plaque in patients with denture stomatitis is a complex, variable mixture of several bacterial species, most of them Gram-positive (Abelson, 1981; Cawson, 1966). Denture plaque is a tenacious mass, consisting of micro-organisms, their byproducts, and salivary components that form on the surface of teeth (Koopmans *et al.*, 1988). Researchers and clinicians alike have realized the importance of dental plaque accumulation on tooth surfaces as the major etiologic factor in both caries and periodontal disease. Hence, plaque indices have been developed to monitor the treatment of such diseases. Similarly, denture plaque has constituents capable of developing inflammatory lesions. However, there have been few quantitative studies on the relationship between plaque levels on dentures and oral tissue health (Budtz-Jorgensen, 1974; Coulthwaite and Verran, 2007; Theilade and Budtz-Jorgensen, 1988; Webb *et al.*, 1998; Ramage *et al.*, 2004).

High quality prostheses with satisfactory levels of oral hygiene are the most important factors to prevent and control inflammation of oral mucosa (Khasawneh and al-Wahadni, 2002; Kulak-Ozkan *et al.*, 2002). A large percentage of denture wearers do not know how important it is to clean their dentures properly (Khasawneh and al-Wahadni, 2002; Kulak-Ozkan *et al.*, 2002). Clear instructions to denture wearers by dentists and prosthodontists on the importance of maintenance and use of a daily cleaning protocol are required (Khasawneh and al-Wahadni, 2002; Kulak-Ozkan *et al.*, 2002). Because of the relationship of biofilm to stomatitis, dentists and other health care providers must carefully instruct edentulous patients in proper mechanical and chemical methods for cleaning and maintaining dentures to prevent malodor, poor esthetics, and accumulation of plaque and calculus on dentures (Khasawneh and al-Wahadni, 2002; Kulak-Ozkan *et al.*, 2002).

Denture plaque, although colorless, is detectable by the naked eye only after the plaque has reached a certain thickness. When too sparse to be detected visually, dental plaque may be revealed with the use of disclosing solutions (Jeganathan *et al.*, 1996). Several reliable methods and indices have been reported that have quantified plaque on the intaglio surfaces of removable prostheses based on scoring of photographs and measuring the percentage area of staining of plaque (Ambjørnsen *et al.*, 1982; Coulthwaite

and Verran, 2009; Jeganathan *et al.*, 1996; Nishi *et al.*, 2012; Paranhos *et al.*, 2004; Paranhos Hde *et al.*, 2010; McCabe *et al.*, 1996; Poulsen *et al.*, 1983). Because it was difficult to measure consistently the distribution of plaque on dentures by means of only visual inspection, the aims of this study included the development of a simplified new quantitative denture plaque index technique using a plaque detector and morphometric analysis. This may benefit dentists in their ability to motivate denture patients to maintain optimal oral hygiene and intraoral health as well as to assess denture intaglio surfaces more prone to accumulate plaque.

Materials and methods

The study was carried out on 100 subjects wearing complete dentures from King Saud University (KSU), College of Dentistry. There were 15 female and 85 male patients; age range 45-75 years. Forty-one subjects had maxillary and mandibular complete dentures and 59 subjects wore single dentures. A total of 70 maxillary and 71 mandibular complete dentures were included in the study. A pilot study was conducted on 10 subjects who had complete dentures for calibration and to test inter- and intra-examiner reliability. There was above 90% agreement in the pilot study. The digitized images were stored in a personal computer. The SPSS (Statistical Package for Social Sciences) was used to analyze the data. The weighted kappa statistic was used for inter-examiner agreement.

The denture plaque index development

The study was approved by the institutional review board (IRB) at KSU. Subjects wore maxillary and/or mandibular complete dentures for at least one year. Dentures were retentive and stable in function.

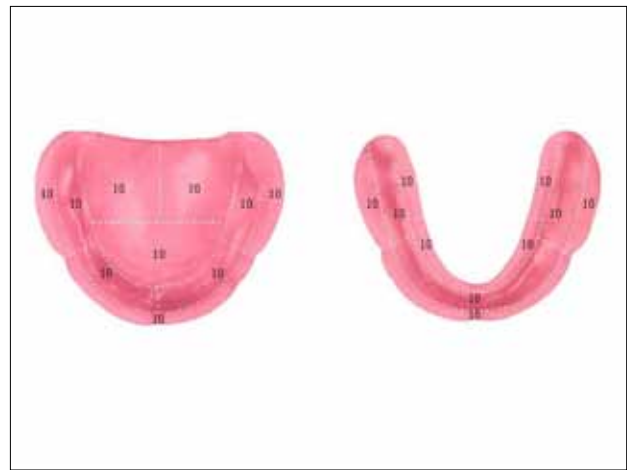
Maxillary and mandibular dentures were soaked in a bowl of water for 1 minute to remove food debris. Fifteen drops of an erythrosine solution (Red-Cote #28 red dye) was poured in a bowl having 30 ml of water at room temperature. The dentures were soaked for 2 minutes and then rinsed under running water for 1 minute to remove unattached dye. Pictures of disclosed plaque on the intaglio surfaces of maxillary and mandibular complete dentures were taken with a Nikon digital camera at a standard distance (Ambjørnsen *et al.*, 1982).

Plaque scoring for intaglio surfaces in the maxillary and mandibular complete dentures

The intaglio surfaces of the maxillary complete dentures were divided into 10 areas and each area was scored 10 percent as assessed from the pictures of the maxillary complete dentures (Table 1, Figures 1 & 2). Four areas on the inner crestal part of intaglio surface (1 - 4), three areas of flanges (5 - 7), and four areas of the rugae and posterior palatal seal (8 - 10) were the most common plaque retention areas on maxillary complete dentures.

Table 1. Areas of plaque retention on intaglio surfaces of maxillary dentures

Area designation	Plaque retention area description
1	Mesial of central incisor to distal of right 1st premolar
2	Mesial of central incisor to distal of left 1st premolar
3	Distal of 1st premolar to the right posterior end
4	Distal of 1st premolar to the left posterior end
5	Distal of right canine to distal of left canine
6	Distal of right canine to the right posterior end of flange
7	Distal of left canine to the left posterior end of flange
8	Rugae area
9	Posterior palatal area bounded by rugae anteriorly, midpalatal suture medially, rugae anteriorly, and distal flange laterally on right side
10	Posterior palatal area bounded by rugae anteriorly, midpalatal suture medially, rugae anteriorly, and distal flange laterally on left side

**Figure 1:** Plaque retention marked in pink on the fitting (intaglio) surfaces in maxillary and mandibular complete dentures.**Figure 2:** Area distribution of denture plaque index (DPI)**Table 2.** Areas of plaque retention on intaglio surface of mandibular dentures

Area designation	Plaque retention area description
1	Distal of right canine to distal side of left canine
2	Distal of right canine to the right posterior end of crestal surface
3	Distal of left canine to the left posterior end of crestal surface
4	Distal of right canine to distal of left canine on facial flange
5	Distal of right canine on facial flange
6	Distal of left canine on facial flange
7	Lingual area from midline to half distance to distal end on right side
8	Disto-lingual half of the lingual flange on right side
9	Lingual area from midline to half distance to distal end on left side
10	Disto-lingual half of the lingual flange on left side

The intaglio surfaces of mandibular complete dentures were also divided into 10 areas and each area was scored 10 percent as assessed from the pictures of the mandibular complete dentures (Table 2, Figures 1 & 2). Three areas on the crestal part (1 - 3), three areas of facial flange (4 - 6), and four areas on the lingual flange (7 - 10) were the most common plaque retention areas on mandibular complete dentures.

Results

Inter- and intra-examiner reliability was above 90% in the pilot study after reading the images and scoring the plaque on two different occasions. The main study was conducted after all three examiners were familiar with the procedures. The inter-examiner agreement ranged from fair to good. The percentage score was evaluated for each case based on the 10 x 10 percent scoring system for both upper and lower dentures. The new denture plaque index was identified as ASKD-DPI (Almas, Salameh, Kutkut, and Doubali-Denture Plaque Index). It ranged from 0 - 100%, and reflected the percentage of the intaglio surfaces of maxillary and mandibular complete dentures that contained plaque. It also classified quantitative percentages based on clinical observation: 30 subjects ranged from 0 - 30% (low DPI), 50 subjects ranged from 31 - 70% (moderate DPI), and 20 subjects ranged from 71 - 100 % (high DPI). Higher plaque scores of ASKD-DPI indicated a quantitative increase of denture stomatitis. There was a correlation between patients who scored a high ASKD-DPI (71-100% plaque areas), poor denture hygiene and the presence of denture stomatitis. Those patients reported lack of brushing or soaking habits on a daily basis. On the other hand, patients who scored low and moderate ASKD-DPI (less than 70% plaque areas) reported fair to good denture hygiene with minimally inflamed tissue. Those patients reported daily brushing for dentures, tongue, and gingival tissue along with soaking the dentures in denture cleanser overnight.

Apart from the visual fatigue, the newly developed denture plaque index was found simple, easy to use, less time-consuming, and practically possible in dental offices. As it is related to area coverage with plaque on denture surface (intaglio), the qualitative analysis of polymicrobial biofilm (plaque) was not done yet. The index correlated with the amount (quantitative relationship) of yeast and bacteria collectively as amount of plaque. Future multicenter projects will be concentrated on utilizing the ASKD-DPI to correlate it with quantitative polymicrobial (yeasts and oral bacteria) analysis in dentures.

Discussion

The proposed denture plaque index has been tested and proven reproducible with a high level of inter-examiner agreement. It has been named after the investigators: Almas, Salameh, Kutkut and Doubali (ASKD). ASKD-DPI may be used widely because it is simple, easy to use, easy to calculate,

and practically possible in any dental office. The percentage score is easy to understand by clinicians and patients alike. It ranges from 0-100 percent, reflecting the percentage of areas distributed on fitting surfaces of maxillary and mandibular complete dentures. For further convenience, it can also be classified from quantitative percentages to quantitative ranges, *i.e.*, 0 - 30% (low), 31 - 70% (moderate) and 71 - 100% (high) denture plaque score (Table 3).

Table 3. Classification of Almas, Salameh, Kutkut, and Doubali-Denture Plaque Index (ASKD-DPI)

DPI	Percentage of plaque areas
Low	0 - 30%
Moderate	31 - 70%
High	71 - 100%

The advantage of this simple denture index based on percentage plaque scores and low, moderate, and high classifications is that it can be used to improve patients' motivation and self-care (home-care of the denture), to have better quality of life, fewer oral problems and a healthier oral environment for complete denture patients.

To avoid visual fatigue, a computer software program is being developed to measure the plaque score automatically from denture surface pictures. Meanwhile, a plastic transparency sheet grid is ready for manual assessment of the ASKD-DPI. The ASKD-DPI offers advantages in simplicity and flexibility. Its reproducibility is favorable and it is not affected by the patient's age. Additionally, it is inexpensive and can be used within the available resources of any dental office.

Denture plaque, like dental plaque, is capable of causing an inflammatory lesion. The relationship of denture plaque on intaglio surfaces of the denture to the health of the oral tissues has been neither widely recognized by the profession nor well publicized to denture wearers. It is important for the profession to realize that plaque accumulation on any surface in the oral cavity is capable of compromising the dynamic oral ecological system (Ambjørnsen *et al.*, 1982; Coulthwaite and Verran, 2008; Monsenego, 2000; Nishi *et al.*, 2012).

During the past 40 years, numerous indices based on clinical characteristics have been developed for measuring the presence and severity of dental diseases (Paranhos *et al.*, 2007). These indices give numerical values for health and disease. Davies (1968) proposed that an ideal plaque index should be simple, reliable, economical and quickly assessed. In addition, a good index ought to be suitable for both clinical and field work and should give information for preventing and treating the disease (Stratford, 1975).

The ASKD-DPI is a quantitative denture plaque index. Previous microbiological studies on denture plaque indicated that it is the quantity of denture plaque rather than its composition that is important for the development of denture stomatitis (Budtz-Jorgensen and Theilade, 1983; Theilade and Budtz-Jorgensen, 1988; Theilade *et al.*, 1983; Walker *et al.*, 1981). This review is supported by epidemiological and clinical studies that have shown a positive correlation between the amount of denture plaque and the severity of denture stomatitis (Barbeau *et al.*, 2003; Bergendahl, 1982; Emami *et al.*, 2014; Vigild, 1987). The criteria that define the components of an index should promote diagnostic reproducibility both within and between examiners (Davies, 1968). The high value of concurrence between examiners (inter-examiner) and within examiners (intra-examiner) in the present study indicates that the criteria set out for the ideal denture plaque index have been satisfied.

The oral health of the completely edentulous patient is an essential factor associated with the quality of life, nutrition, social interactions and general systemic health of denture-wearing patients. The presence of oral biofilm on complete dentures has been associated with denture stomatitis, as well as with more serious systemic conditions, especially in the dependent elderly (Verran, 2005). Failure to properly clean the accumulated biofilm from dentures is associated with an increased incidence of localized denture stomatitis (Srinivasan and Gulabani, 2010).

Guidelines for maintaining good oral hygiene and care of dentures has been reported in the literature based on the best available evidence (Felton *et al.*, 2011). It is important to minimize denture stomatitis by removing the bacterial biofilm adhered to the oral cavity and on complete dentures on a daily basis. Patients who wear dentures should clean their dentures outside of the mouth by soaking and brushing with nonabrasive denture cleanser every day. Dentures should be thoroughly rinsed after soaking and brushing with denture-cleansing solutions prior to reinsertion into the oral cavity. This will reduce levels of biofilm and harmful bacteria and fungi present on the dentures. Annual evaluation of dentures and professional cleaning at a dentist's office using ultrasonic cleanser may minimize biofilm accumulation on the dentures. Denture wearers should be instructed not to boil their dentures in water at any time, and not to soak them in sodium hypochlorite bleach more than 10 minutes to prevent any damage to the dentures. To prevent warping of the dentures, they should be immersed in water after cleaning when not replaced in the oral cavity. Denture adhesives should be used properly to improve the retention and stability of dentures and to seal out the accumulation of food particles beneath the dentures, even in well-fitting dentures. Denture adhesives should not be used for more than six months.

Annual assessment of denture quality and health of the supporting tissues should be evaluated by a dentist, prosthodontist or dental professional for maintenance of optimum denture fit and function, for evaluation for oral lesions and bone loss, and for assessment of oral health status. Inappropriate use of zinc-containing denture adhesives may have adverse side effects. Therefore, as a protection measure, zinc-containing denture adhesives should not be used. Denture adhesive should be used only in appropriate quantities on each denture to provide enough retention and stability for the prostheses. Denture adhesives should be completely removed from the intaglio surfaces of the prosthesis as well as the oral cavity every day. Continuous wearing of the dentures is not recommended to reduce or minimize denture stomatitis (Felton *et al.*, 2011; Lalla and Dongari-Bagtzoglou, 2014).

Conclusions and recommendations

The combined use of plaque disclosing dye and the percentage score of the denture plaque index to measure it seems to provide reliable information about the quantity of microbial plaque accumulated on the fitting surfaces of the denture. The newly developed ASKD-DPI is simple to use and can be carried out in a very short time in any dental office. The ASKD-DPI is helpful for monitoring plaque scores, monitoring health or disease, and for evaluating and improving patients' motivation and compliance with denture hygiene instructions.

Certainly, the ASKD-DPI would help to improve the quality of life of denture-wearing patients. As a computer program is being developed for more objective reading of the DPI, it is recommended that in the future the ASKD-DPI be used for a larger population wearing dentures, on a community level. It can be used for patients' motivation and oral health education among the edentulous population. ASKD-DPI may achieve its scientific applicability and recognition soon as it has potential clinical implications as well.

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