Curr Phys Med Rehabil Rep (2016) 4:257–261
DOI 10.1007/s40141-016-0135-4

SWALLOWING DISORDERS (RUTH E MARTIN, SECTION EDITOR)

Role of Oral Health in Dysphagic Stroke Recovery

Koichiro Matsuo[1]

Published online: 4 October 2016

Abstract
Purpose Oral health deteriorates easily in stroke patients, which may lead to aspiration pneumonia. The purpose of this review was to elucidate the importance of oral health in stroke recovery.
Recent findings In the acute phase, ventilator-associated pneumonia (VAP) is the most serious respiratory complication and increases the mortality of stroke. Chemical cleaning with chlorhexidine along with mechanical oral care may decrease VAP risk. Maintaining oral health in stroke patients remains important in rehabilitation and nursing home settings. In the chronic phase, oral care performed by the individual is often inadequate due to hemiplegia and may require caregiver assistance. After mechanical removal of oral contaminants, mouth wipes represent an alternative to rinsing with water to reduce the risk of aspiration-related pneumonia. Proper denture hygiene will also reduce pneumonia risk and improve outcome in stroke patients.
Summary To prevent aspiration pneumonia in stroke recovery, oral health care as well as exercises that enhance swallowing ability are essential. It is important to maintain oral health from the acute phase through to the chronic phase of stroke recovery.

Keywords Stroke · Dysphagia · Oral health · Oral care · Pneumonia · Periodontal disease · Gram-negative bacteria · Dentures

This article is part of the Topical Collection on *Swallowing Disorders*.

✉ Koichiro Matsuo
kmatsuo@fujita-hu.ac.jp

[1] Department of Dentistry, School of Medicine, Fujita Health University, 1-98 Dengakugakubo, Kutsukake, Aichi, Toyoake 470-1192, Japan

Introduction

Dysphagia is common after stroke from the acute phase through to the chronic phase and is significantly associated with the development of pneumonia from aspiration [1]. Post-stroke pneumonia also increases mortality, morbidity, and medical costs [2•, 3]. Dysphagia and malnutrition are the main risk factors of pneumonia following stroke [4], the former of which increases the chance of aspirating not only foods when eating, but also saliva secretions. Dysphagia rehabilitation and diet modification can lower the risk of aspiration pneumonia. For instance, the bypass of food passage with gastric tubing prevents the aspiration of chewed food or liquid, although regurgitation remains a threat. Moreover, even if oral food intake is halted, the aspiration of saliva cannot be avoided completely since it is constitutively secreted. The oral health of stroke patients is often deteriorated as well as overlooked. Poor oral hygiene increases the likelihood of aspirating oral pathogenic bacteria with saliva and ensuing aspiration pneumonia. Since saliva aspiration cannot be completely prevented in dysphagic stroke patients, it becomes essential to improve the quality of aspirated saliva by maintaining good oral and pharyngeal health. Thus, during stroke recovery, oral health is as important as dysphagia rehabilitation to prevent local and systemic disorders.

The Importance of Oral Health in Stroke Recovery

The Role of Saliva

A total 1–1.5 L of saliva is secreted and swallowed daily in normal individuals. Saliva has several important roles in promoting oral health: enzymes and immunoglobulins in

the saliva control the colonization of microorganisms in the oral cavity and reduce biofilm build-up on the tooth surface, while mucin protects the mucosal membrane from ulceration via its lubricating properties. Saliva is also a buffer that neutralizes acid produced by bacteria or gastric acid before it reaches the oral cavity by gastro-esophageal reflux or regurgitation. Oral digestive enzymes, including amylase and lipase, decompose starch and lipids to help digestion. Before swallowing, saliva lubricates the food to assist in optimized bolus formation on the tongue surface during mastication.

Oral health conditions often deteriorate under hospital or nursing home care in stroke patients, which provides a favorable condition for the formation of dental plaque biofilm. Poor oral hygiene may produce dental caries and periodontal disease and increase the risk of systemic complications [1, 5]. As stroke patients often present with compromised oral hygiene [5, 6], aerobic gram-negative bacilli are frequently observed in acute stroke patients and are associated with mortality [7]. The oral pathogenic bacteria subsequently flow into the pharynx mixed with saliva. Dysphagic individuals have difficulty dealing with normal amounts of salivary secretion, resulting in overflow aspiration.

Dental Biofilm Formation in the Oral Cavity

Oral pathogenic bacteria are considered to be the cause of aspiration pneumonia [8], infective endocarditis, and the other systemic diseases [9]. The composition of microorganisms in the oral cavity includes hundreds of species of bacteria [10], most of which are normal flora that control the balance of bacterial species and suppress the colonization of foreign microorganisms in the oral cavity for host protection. To survive in such environments containing saliva and antimicrobial peptides [11], oral microorganisms attach to host surfaces and begin biofilm formation. Bacterial dental plaque is a dynamic environment composed of an extracellular matrix containing a complex community of many bacterial species [12]. The bacteria create colonies and interact with each other within the glycocalyx, an extracellular capsular polysaccharide matrix. Approximately 10^8 oral bacteria exist in 1 mg of dental plaque. Oral bacteria forms biofilm on both hard and soft tissues in the oral cavity, including the tooth surface, tongue surface, gingival sulcus, pharynx, and saliva [13], and therefore pathogenic periodontal bacteria can be detected even in edentulous individuals [14].

The composition of bacterial flora in the mouth is diverse and depends on location [10]. Oral bacteria are often sub-categorized according to their need for oxygen. As oxygen concentration is relatively high on the surface of soft tissues, aerobic bacteria and fungi readily colonize in these areas. In contrast, anaerobic bacteria tend to predominate in the periodontal pocket or gingival sulcus, where oxygen concentration is less than 1 %. The species of colonizing bacteria change depending on the stage of oral biofilm formation [12]. In the early period, colonizers include many types of oral streptococci and other natural microbiota, which are not known as respiratory pathogens [10]. In the later stages of colonization, the biofilm microenvironment becomes anaerobic and suitable for more pathogenic colonizers, such as *Fusobacterium nucleatum, Tannerella forsythia, Treponema denticola,* and *Porphyromonas gingivalis,* to populate the biofilm and increase the risk of systemic infections [15, 16]. These earlier and later colonizers exhibit interspecies adhesive interactions to enhance biofilm formation.

Periodontal Disease and the Incidence of Stroke

Frequently associated with atherosclerosis and stroke [17•, 18, 19], periodontal disease is a chronic infectious condition characterized by a gradual loss of periodontal connective tissue and alveolar bone support. Dental plaque accumulating in the periodontal pocket is a cause of gingival tissue inflammation. The gram-negative bacteria in the plaque and their secreted endotoxins invade blood vessels from inflamed tissues to trigger inflammatory responses in blood vessel walls and produce inflammatory cytokines that further promote atherosclerosis. Several meta-analyses have presented strong evidence associating periodontal disease and tooth loss with the occurrence of stroke [17•, 18, 19]. Thus, although poor oral hygiene is often witnessed in stroke patients due to insufficient oral care in admitted hospitals [5, 6], oral health may have already been compromised before the onset of stroke.

Oral Health Care in Stroke Recovery

Pneumonia is a severe complication of stroke that increases mortality [20]. Dysphagia elevates the risk of pneumonia at all stages of stroke recovery, from the acute phase in the intensive care unit (ICU) through to the rehabilitation period [2•]. In the ICU, stroke patients are often mechanically ventilated by endotracheal intubation, which may cause respiratory infection via the intubation tube [21, 22]. On the other hand, the incidence of pneumonia is also high in community-dwelling patients with cerebrovascular disease [23]. Pneumonia in nursing home residents and the dependent elderly is termed HCAP. Many admitted patients with HCAP have dysphagia, and thus are considered to have aspiration pneumonia [23, 24]. There are numerous studies describing the benefits of oral care on the prevention of ventilator-associated pneumonia (VAP) and

other forms of pneumonia in hospital and nursing home patients.

Oral Health Care During Acute Phase Stroke Recovery

The incidence of pneumonia is 6–20 times higher in patients who receive mechanical ventilation in the ICU [25]. VAP prolongs the length of stay in the ICU and increases mortality and medical costs [26, 27]. Bacterial colonization of the oral cavity is considered to be a reservoir for respiratory pathogens [8]. During intubation, oral bacteria count may increase from secretion accumulation, suppressed swallowing reflex, or low consciousness level as critically ill patients in the ICU are often unconscious or sedated. Patients receiving mechanical endotracheal ventilation have a risk of aspirating contaminated secretions pooled in the oral cavity or pharynx, such that deep sedation has been discouraged for ventilated patients since it increases the risk of aspiration.

The microorganisms contained in the biofilm forming on the endotracheal tube during intubation have been associated with the onset of VAP [28]. Biofilm develops on both the inside and outside of the tube. Although the endotracheal tube cuff is designed to block the leakage of saliva from the oropharynx, it does not protect the lower airway completely since the inflated cuff has folds. As a result, some secretions reach the subglottal area. The distal end of the endotracheal tube was found to have a greater diversity of microorganisms [28]. Thus, continuous subglottic secretion drainage above the cuff during endotracheal intubation can reduce VAP risk by eliminating pooled secretions that leak down to the trachea [29]. Oropharyngeal dysphagia often remains after extubation of the endotracheal tube [30]. Accordingly, the maintenance of oral health is also important at this time, and patients should avoid aspirating secretions or contaminated rinsing water since subglottal suction is impossible once the tube is removed.

Hospitalized stroke patients frequently exhibit an inability to brush their teeth due to hemiplegia or cognitive problems. Assistance by caregivers is therefore needed to maintain oral hygiene and prevent pneumonia. There are many studies describing the effectiveness of oral care on pneumonia avoidance, particularly in hospitalized and critically ill patients [5, 31, 32, 33•]. Established oral care protocols can enhance effectiveness and decrease the risk of aspiration pneumonia [32]; and mechanical dental plaque removal with a toothbrush along with the use of sponge swabs, a tongue scraper, and/or chemical decontamination with chlorhexidine (CHX) have been broadly introduced in many regimens [5, 31, 34]. Shi et al. conducted a meta-analysis on the effect of CHX on VAP prevention in critically ill patients [33•]. In over 17 randomized control trials, mechanical oral care with CHX provided a significant reduction in VAP over regimes without CHX (OR 0.60, 95 % CI 0.47–0.77).

Oral Health Care After Hospital Discharge

Pneumonia remains a common complication after discharge from the hospital after stroke. Pneumonia is classified as hospital-acquired pneumonia (HAP), community-acquired pneumonia (CAP), and healthcare-associated pneumonia (HCAP). A relatively new category, HCAP includes any patient who was hospitalized in an acute care hospital for two or more days within 90 days of the infection; resided in a nursing home or long-term care facility; received recent intravenous antibiotic therapy, chemotherapy, or wound care in the past 30 days of the current infection; or undergoes hemodialysis [35]. Carratala reported that patients with HCAP were older and had greater comorbidity [23], such as cerebrovascular disease. Aspiration pneumonia was also significantly more frequently encountered in patients with HCAP than in those with CAP [23, 24]. Dysphagia is relatively common in such individuals, who are therefore more prone to aspiration. A recent study has also demonstrated oral health to be associated with quality of life among nursing home residents and stroke patients at home [36•, 37]. Although reports on oral care in community-dwelling patients are relatively few compared with those on hospitalized patients, several have found significant reductions in the risk of pneumonia by formal oral care regimens in nursing home residents [38], while others have shown that professional oral care by dental hygienists decreases the risk of pneumonia and influenza [39]. The procedures for nursing home residents included mechanical cleaning using a tooth brush, sponge swab, and/or tongue scraper. Dentures were cleaned with a denture brush. Less is known on chemical cleaning using CHX, which is more popular and supported in hospitalized patients, especially those with endotracheal ventilation.

Oral Care Procedures

Dysphagia increases the risk of aspiration pneumonia, but this can be reduced by regular oral care. The amount of displaced contaminants rises in the oral cavity by the mechanical removal of dental plaque [40], at which time prompt elimination has an important role in preventing their aspiration. However, rinsing of residual oral contaminants carries the risk of aspiration as rinse water can easily reach the pharynx due to its rheological properties, the patient's diminished consciousness, and gravity. Ikeda et al. reported that removing contaminants with mouth wipes after mechanical brushing significantly reduced the amount of oral bacteria without rinsing, indicating that this

method may be a suitable alternative because of no additional fluid [40].

The Hygiene of Dentures

Many stroke patients are elderly individuals who wear dentures. Denture hygiene deteriorates easily and proper fitting is lost when the oral condition is neglected during prolonged hospital stays. The surface of dentures is rough and hydrophobic, both of which are amenable to the formation of biofilm. Denture plaque and candidiasis colonies gradually accumulate if the denture or its contact teeth are not adequately cleaned. Poor hygiene of the denture surface and denture plaque are prominent risk factors for denture stomatitis (i.e., local infection), and recent literature has indicated that they are predisposing elements for pneumonia (i.e., systemic infection) as well [41, 42•].

Continuous denture wearing during sleep is also associated with diminished oral hygiene and leads to biofilm formation on the denture surface. There are numerous respiratory pathogens on the denture surface [41, 43]. The swallowing reflex becomes dull when unconscious, resulting in the silent aspiration of contaminated saliva secretions. Iinuma et al. reported that the risk of pneumonia doubled when the dentures were worn during sleep [42•]. Taken together with the above findings, proper cleaning of dentures and their removal while sleeping is imperative in dysphagic stroke patients with high aspiration risk to decrease the chance of pneumonia.

For cleaning, dentures should be removed from the mouth and scrubbed with a denture brush. As this does not prevent subsequent biofilm formation on the denture surface, chemical cleaning by soaking in a commercial disinfectant solution is also important after brushing [44].

Conclusions

The oral health of stroke patients deteriorates easily, which increases the risk of local and systemic infections. To prevent aspiration pneumonia, exercises that enhance swallowing ability as well as oral health care are essential. It is necessary to maintain oral health care from the acute phase through to the chronic phase of stroke recovery. In the acute phase, VAP is the most serious respiratory complication and should be prevented by oral care to decrease the mortality of stroke. Chemical cleaning with CHX along with mechanical oral care is effective in avoiding this outcome. The maintenance of good oral health in stroke patients remains important in rehabilitation and nursing homes. In the chronic phase, oral care performed by stroke patients themselves is often inadequate due to hemiplegia and may require assistance. After the mechanical removal of oral contaminants, mouth wipes may be a suitable alternative to rinsing and suctioning. Removal and proper cleaning of dentures will also aid in the prevention of aspiration pneumonia and improve prognosis in stroke patients.

Compliance with Ethics Guidelines

Conflict of Interest Koichiro Matsuo reports grants from Wakodo Co., Ltd.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

References

Papers of particular interest, published recently, have been highlighted as:
- • Of importance

1. Martino R, Foley N, Bhogal S, Diamant N, Speechley M, Teasell R. Dysphagia after stroke: incidence, diagnosis, and pulmonary complications. Stroke. 2005;36:2756–63.
2. • Hannawi Y, Hannawi B, Rao CP, Suarez JI, Bershad EM: Stroke-associated pneumonia: major advances and obstacles. Cerebrovasc Dis. 2013;35:430–43. *This review paper presented that risk factors for stroke associated pneumonia (SAP) were stroke severity, dysphagia, aspiration, and mechanical ventilation and the others; dysphagia and aspiration were reported as the risk factor for SAP in multiple studies.*
3. Katzan IL, Dawson NV, Thomas CL, Votruba ME, Cebul RD. The cost of pneumonia after acute stroke. Neurology. 2007;68:1938–43.
4. Serra-Prat M, Palomera M, Gomez C, Sar-Shalom D, Saiz A, Montoya JG, Navajas M, Palomera E, Clave P. Oropharyngeal dysphagia as a risk factor for malnutrition and lower respiratory tract infection in independently living older persons: a population-based prospective study. Age Ageing. 2012;41:376–81.
5. Lam OL, McMillan AS, Samaranayake LP, Li LS, McGrath C. Randomized clinical trial of oral health promotion interventions among patients following stroke. Arch Phys Med Rehabil. 2013;94:435–43.
6. Maupome G, Gullion CM, White BA, Wyatt CC, Williams PM. Oral disorders and chronic systemic diseases in very old adults living in institutions. Spec Care Dent. 2003;23:199–208.
7. Millns B, Gosney M, Jack CI, Martin MV, Wright AE. Acute stroke predisposes to oral gram-negative bacilli—a cause of aspiration pneumonia? Gerontology. 2003;49:173–6.
8. El-Solh AA, Pietrantoni C, Bhat A, Okada M, Zambon J, Aquilina A, Berbary E. Colonization of dental plaques: a reservoir of respiratory pathogens for hospital-acquired pneumonia in institutionalized elders. Chest. 2004;126:1575–82.
9. Hirschfeld J, Kawai T. Oral inflammation and bacteremia: implications for chronic and acute systemic diseases involving major organs. Cardiovas Hematol Disord Drug Targets. 2015;15:70–84
10. Aas JA, Paster BJ, Stokes LN, Olsen I, Dewhirst FE. Defining the normal bacterial flora of the oral cavity. J Clin Microbiol. 2005;43:5721–32.
11. Abiko Y, Saitoh M. Salivary defensins and their importance in oral health and disease. Curr Pharm Des. 2007;13:3065–72.

12. Wright CJ, Burns LH, Jack AA, Back CR, Dutton LC, Nobbs AH, Lamont RJ, Jenkinson HF. Microbial interactions in building of communities. Mol oral Microbiol. 2013;28:83–101.
13. Mager DL, Ximenez-Fyvie LA, Haffajee AD, Socransky SS. Distribution of selected bacterial species on intraoral surfaces. J Clin Periodontol. 2003;30:644–54.
14. Sachdeo A, Haffajee AD, Socransky SS. Biofilms in the edentulous oral cavity. J Prosthodont. 2008;17:348–56.
15. Periasamy S, Kolenbrander PE. Central role of the early colonizer Veillonella sp. in establishing multispecies biofilm communities with initial, middle, and late colonizers of enamel. J Bacteriol. 2010;192:2965–72.
16. Whitmore SE, Lamont RJ. The pathogenic persona of community-associated oral streptococci. Mol Microbiol. 2011;81: 305–14.
17. • Lafon A, Pereira B, Dufour T, Rigouby V, Giroud M, Bejot Y, Tubert-Jeannin S. Periodontal disease and stroke: a meta-analysis of cohort studies. European J Neurol. 2014;21:1155–1161, e1166–1157. *This review paper shows that periodontitis and tooth loss are associated with the occurrence of stroke*.
18. Mustapha IZ, Debrey S, Oladubu M, Ugarte R. Markers of systemic bacterial exposure in periodontal disease and cardiovascular disease risk: a systematic review and meta-analysis. J Periodontol. 2007;78:2289–302.
19. Sfyroeras GS, Roussas N, Saleptsis VG, Argyriou C, Giannoukas AD. Association between periodontal disease and stroke. J Vasc Surg. 2012;55:1178–84.
20. Vermeij FH, Scholte op Reimer WJ, De Man P, Van Oostenbrugge RJ, Franke CL, De Jong G, De Kort PL, Dippel DW. Netherlands Stroke Survey I: stroke-associated infection is an independent risk factor for poor outcome after acute ischemic stroke: data from the Netherlands Stroke Survey. Cerebrovasc Dis. 2009;27:465–71.
21. Hilker R, Poetter C, Findeisen N, Sobesky J, Jacobs A, Neveling M, Heiss WD. Nosocomial pneumonia after acute stroke: implications for neurological intensive care medicine. Stroke. 2003;34:975–81.
22. Walter U, Knoblich R, Steinhagen V, Donat M, Benecke R, Kloth A. Predictors of pneumonia in acute stroke patients admitted to a neurological intensive care unit. J Neurol. 2007;254:1323–9.
23. Carratala J, Mykietiuk A, Fernandez-Sabe N, Suarez C, Dorca J, Verdaguer R, Manresa F, Gudiol F. Health care-associated pneumonia requiring hospital admission: epidemiology, antibiotic therapy, and clinical outcomes. Arch Intern Med. 2007;167: 1393–9.
24. Teramoto S, Fukuchi Y, Sasaki H, Sato K, Sekizawa K, Matsuse T. Japanese Study Group on Aspiration Pulmonary D: high incidence of aspiration pneumonia in community- and hospital-acquired pneumonia in hospitalized patients: a multicenter, prospective study in Japan. J Am Geriatr Soc. 2008;56:577–9.
25. American Thoracic S, Centers for disease C, prevention, infectious diseases society of A: American Thoracic Society/Centers for Disease Control and Prevention/Infectious Diseases Society of America: controlling tuberculosis in the United States. Am J Respir Crit Care Med. 2005;172:1169–1227
26. Melsen WG, Rovers MM, Koeman M, Bonten MJ. Estimating the attributable mortality of ventilator-associated pneumonia from randomized prevention studies. Crit Care Med. 2011;39:2736–42.
27. Nair GB, Niederman MS. Nosocomial pneumonia: lessons learned. Crit Care Clin. 2013;29:521–46.
28. De Souza PR, De Andrade D, Cabral DB, Watanabe E. Endotracheal tube biofilm and ventilator-associated pneumonia with mechanical ventilation. Microsc Res Tech. 2014;77:305–12.
29. Muscedere J, Rewa O, McKechnie K, Jiang X, Laporta D, Heyland DK. Subglottic secretion drainage for the prevention of ventilator-associated pneumonia: a systematic review and meta-analysis. Crit Care Med. 2011;39:1985–91.
30. Skoretz SA, Flowers HL, Martino R. The incidence of dysphagia following endotracheal intubation: a systematic review. Chest. 2010;137:665–73.
31. Prendergast V, Kleiman C, King M. The bedside oral exam and the barrow oral care protocol: translating evidence-based oral care into practice. Intensive crit care. 2013;29:282–90.
32. Ames NJ, Sulima P, Yates JM, McCullagh L, Gollins SL, Soeken K, Wallen GR. Effects of systematic oral care in critically ill patients: a multicenter study. Am J Crit Care. 2011;20:e103–14.
33. • Shi Z, Xie H, Wang P, Zhang Q, Wu Y, Chen E, Ng L, Worthington Helen V, Needleman I, Furness S. Oral hygiene care for critically ill patients to prevent ventilator-associated pneumonia. Cochrane Database Syst Rev. 2013. doi: 10.1002/14651858.CD008367. *This systematic review concluded that oral health care using tooth brushing and chlorhexidine is most effective to prevent ventilator associated pneumonia.*
34. Sumi Y, Nakamura Y, Michiwaki Y. Development of a systematic oral care program for frail elderly persons. Spec Care Dent. 2002;22:151–5.
35. American Thoracic S, Infectious Diseases Society of A: guidelines for the management of adults with hospital-acquired, ventilator-associated, and healthcare-associated pneumonia. Am J Respir Crit Care Med. 2005;171:388–416.
36. • Porter J, Ntouva A, Read A, Murdoch M, Ola D, Tsakos G. The impact of oral health on the quality of life of nursing home residents. Health Qual Life Outcomes. 2015;13: 1–8. *The study demonstrated that oral health conditions were significantly associated with QOL in nursing home residents, indicating that maintaing oral health is important not only to prevent systemic infections but maintain their QOL.*
37. Jang EJ, Kim EK, Lee KS, Lee HK, Choi YH, Hwang TY, Kim SK, Jo MW. Oral health related quality of life and it's related factors of stroke patients at home in Korea. Arch Gerontol Geriatr. 2015;61:523–8.
38. Adachi M, Ishihara K, Abe S, Okuda K. Professional oral health care by dental hygienists reduced respiratory infections in elderly persons requiring nursing care. Int J Dent Hyg. 2007;5:69–74.
39. Abe S, Ishihara K, Adachi M, Sasaki H, Tanaka K, Okuda K. Professional oral care reduces influenza infection in elderly. Arch Gerontol Geriatr. 2006;43:157–64.
40. Ikeda M, Miki T, Atsumi M, Inagaki A, Mizuguchi E, Meguro M, Kanamori D, Nakagawa K, Watanabe R, Mano K, Aihara A, Hane Y, Mutoh T, Matsuo K. Effective elimination of contaminants after oral care in elderly institutionalized individuals. Geriatr Nurs. 2014;35:295–9.
41. O'Donnell LE, Smith K, Williams C, Nile CJ, Lappin DF, Bradshaw D, Lambert M, Robertson DP, Bagg J, Hannah V, Ramage G. Dentures are a reservoir for respiratory pathogens. J Prosthodont. 2016;25:99–104.
42. • Iinuma T, Arai Y, Abe Y, Takayama M, Fukumoto M, Fukui Y, Iwase T, Takebayashi T, Hirose N, Gionhaku N, Komiyama K. Denture wearing during sleep doubles the risk of pneumonia in the very elderly. J Dent Res. 2015;94: 28S–36S. *The risk of incidence of pneumonia was double in people who wore denture during sleep than in people who removed dentures at night.*
43. Sumi Y, Miura H, Sunakawa M, Michiwaki Y, Sakagami N. Colonization of denture plaque by respiratory pathogens in dependent elderly. Gerodontology. 2002;19:25–9.
44. von Fraunhofer JA, Loewy ZG. Factors involved in microbial colonization of oral prostheses. General dentistry. 2009;57: 136–43 **quiz 144–135**.