Oral Microbiology Immunology 2007: 22: 1–4
Printed in Singapore. All rights reserved

ORAL MICROBIOLOGY
AND IMMUNOLOGY

Effect of a chronic nail-biting habit on the oral carriage of Enterobacteriaceae

B. Baydaş[1], H. Uslu[2], İ. Yavuz[1], İ. Ceylan[1], İ.M. Dağsuyu[1]
[1]Department of Orthodontics, Faculty of Dentistry, Atatürk University, Erzurum, Turkey, [2]Department of Microbiology, Faculty of Medicine, Atatürk University, Erzurum, Turkey

Baydaş B, Uslu H, Yavuz İ, Ceylan İ, Dağsuyu İM. Effect of a chronic nail-biting habit on the oral carriage of Enterobacteriaceae.
Oral Microbiol Immunol 2007: 22: 1–4. © Blackwell Munksgaard, 2007.

Background/aims: Nail biting is a common oral habit in children and young adults. However, its effect on the oral carriage of Enterobacteriaceae is unclear. The purpose of the study was to evaluate the differences in prevalence of Enterobacteriaceae in saliva samples from subjects with and without a nail-biting habit.
Methods: Saliva samples were taken from 25 subjects who were nail-biters and 34 subjects with no oral habit. The mean chronological age for all subjects was 13.5 ± 1.9 years. The saliva samples were studied microbiologically. A Pearson chi-squared test was performed to compare the prevalence of Enterobacteriaceae in the saliva samples of the subjects with and without nail-biting habits.
Results: Statistically significant differences were found in the prevalence of *Escherichia coli* and total Enterobacteriaceae between both groups ($P < 0.001$). *E. coli*, *Enterobacter aerogenes*, *Enterobacter cloacae* and *Enterobacter gergoviae* were found in the saliva samples of 19 of the 25 nail-biting subjects (76%), whereas *E. coli*, *E. aerogenes* and *E. cloacae* were detected in the saliva samples of only nine of the 34 subjects who were not nail-biters (26.5%).
Conclusion: According to the results of the present study, the Enterobacteriaceae were more prevalent in the oral cavities of children with nail-biting habits than in children with no oral habit.

Key words: Enterobacteriaceae; nail biting; oral habit; prevalence

İ. Ceylan, Department of Orthodontics, Faculty of Dentistry, Atatürk University, Erzurum, Turkey
Tel.: +90 442 2311809;
fax: +90 442 2360945;
e-mail: iceylan@atauni.edu.tr
Accepted for publication March 3, 2006

Nail biting is a common oral habit in children and young adults (41). Nail biting is rarely noted in children younger than 3–6 years, whereas it is quite common around puberty (4, 24, 37). It is estimated that 20–33% of children between the ages of 7 and 10 years and 45% of adolescents are nail-biters (21).

The etiologies suggested for nail biting include stress, imitation of other family members, heredity, transference from the thumb-sucking habit, and poorly manicured nails. Nail biting is usually confined to the fingernails and most nail-biters bite all of the fingers equally rather than selectively (21).

In most cases, it is of cosmetic concern only; however, if not controlled, it can lead to serious morbidity (41). Complications of nail biting include damage to the cuticles and nails (21), dermatological problems of fingers such as melanonychia (32), self-inflicted gingival injuries and gingival swelling (7, 19, 28), dental problems such as increased incisal wear and apical root resorption (21, 26, 27). In addition, osteomyelitis has been reported in a phalanx as a result of chronic nail biting (39, 41).

Dentists and/or dental specialists are usually interested in dental and gingival problems as a result of chronic nail biting. However, the habit of nail biting can result in autoinoculation of pathogens and transmission of infection to distant body parts (40). For children with inadequate and poor toilet hygiene, enteric bacteria can pose a potential threat and danger by penetrating the body via the mouth as a result of nail biting; so they can lead to various infections there.

Members of genera belonging to the Enterobacteriaceae family have earned a reputation that places them among the most pathogenic and most frequently encountered organisms in clinical microbiology. These families consist of gram-negative, non-sporulating, rod-shaped

bacteria and can be found in almost all natural habitats (3, 25). They are the causative agents of such diseases as meningitis, bacillary dysentery, typhoid fever and food poisoning. *Escherichia coli* is the most frequently encountered bacterium in clinical microbiology. Not only is *E. coli* the primary cause of human urinary tract infections, but it is also linked to diseases in almost every other part of the body. The infections caused by *E. coli* include intestinal infections, bacteremia, pneumonia, cholecystitis, appendicitis, peritonitis, post-surgery infections, meningitis and sepsis in premature and neonatal babies, hemolytic uremia and traveler's diarrhea (1–3, 9, 10, 14, 15, 17, 34, 36, 38).

These findings suggest that *E. coli* and other enteric bacteria ingested through a chronic nail-biting habit could cause local and systemic infections. Therefore, determination of the prevalence of Enterobacteriaceae in the mouths of chronic nail-biters may be useful for clinicians.

The aim of the present study was to determine and compare the prevalence of *E. coli* and other Enterobacteriaceae in the saliva samples of children with and without chronic nail-biting habits.

Material and methods

The study group consisted of 25 subjects (eight boys and 17 girls) who had a chronic fingernail-biting habit. The subjects were selected from patients who applied to the Department of Orthodontics for orthodontic treatment. The age of the patients showing nail biting ranged from 11.9 to 16.5 years, with an average of 14.05 ± 1.17 years for girls and 13.99 ± 1.46 years for boys. In addition, 34 subjects (16 boys and 18 girls) who had no oral habits were chosen as a control group. The age of the patients with no oral habit ranged from 12.4 to 16.9 years, with an average of 13.94 ± 1.02 years for girls and 14.16 ± 1.34 years for boys.

Ethical requirements were met; the procedure was explained to the patients and their parents, and their verbal consent was obtained. All the patients in both groups were given standard oral hygiene instructions, including toothbrush use, and then they were called for an appointment 1 week later. However, no instruction was given to the patients in the study group concerning their nail-biting habit before their saliva samples were obtained. Subjects who had used antibiotics and antiseptic mouthwashes within the last 3 months were not included in this study. On the visit 1 week later, a Quigley & Hein plaque index as modified by Lobene et al. (22) was recorded.

Microbiological sampling and laboratory techniques

The oral coliform carriage rate of the subjects was evaluated using the oral rinse technique. This technique, described by Samaranayake et al. (33), was used for the quantification of Enterobacteriaceae in the sample. In brief, the subjects were instructed to rinse their mouths with 10 ml phosphate-buffered saline (0.1 M; pH 7.2) for 60 s. The rinse was then expectorated back into a universal container, on ice, and concentrated by centrifugation at 17,000 **g** for 10 min. Supernatant was discarded, and the deposit was re-suspended in 1 ml phosphate-buffered saline to obtain a concentrated oral rinse which was then inoculated on to MacConkey's agar, and blood agar (Oxoid Ltd, Basingstoke, UK) using the spiral plater system (Spiral System Marketing Ltd, Bethesda, MD) to assess coliform bacteria. The oral Enterobacteriaceae in a rinse sample were ascertained by incubating MacConkey's agar and blood agar plates at 37°C for 24 h. The Enterobacteriaceae that grew in MacConkey's agar were examined using a Gram stain. The organisms were purified by subculture on blood agar and identified using the commercially available API 20E method, which is the standard identification system for Enterobacteriaceae and other gram-negative rods. The same investigator performed all the microbiological assessments.

Statistical analysis

Student's *t*-test was used to compare the differences in the plaque index between both groups. Pearson's chi-squared test for trend was applied to compare the differences in prevalence of Enterobacteriaceae saliva samples of subjects with and without a nail-biting habit, and *P*-values were obtained. The data were subjected to 2 × 2 comparisons. The chi-squared test is known to be inaccurate for expected frequencies of less than five in a cell. Where this situation arose, Fisher's exact test was used as an alternative analysis.

Results

The mean values of the Quigley & Hein plaque index were 1.952 for the study group and 2.038 for the control group. Student's *t*-test indicated that there were no statistically significant differences in the plaque index between these two groups ($t = 0.396$; $P = 0.696$).

The microbiological findings are listed in Table 1. Enterobacteriaceae were detected in 19 of 25 subjects (76%) for the group of nail-biters, whereas Enterobacteriaceae were isolated in only nine of 34 subjects (26.5%) for the control group. Four species of Enterobacteriaceae, *E. coli*, *Enterobacter aerogenes*, *Enterobacter cloacae* and *Enterobacter gergoviae* were identified in the saliva samples of the subjects in both groups. In the study group *E. coli* was isolated in 15 subjects and *Enterobacter* species (*E. aerogenes*, *E. cloacae* and *E. gergoviae*) in four subjects. For the control group, however, *E. coli* and *Enterobacter* species (*E. aerogenes* and *E. cloacae*) were found in only seven and two subjects, respectively.

In addition, pathogenic microorganisms such as methicillin-resistant coagulase-negative *Staphylococcus* (MRCNS), β-hemolytic streptococcus, methicillin-resistant *Staphylococcus aureus* (MRSA) and *Candida* species were isolated, together with Enterobacteriaceae, in the saliva samples of some subjects in both groups. However, only the Enterobacteriaceae were considered in the present study.

The results of a Pearson chi-squared test for trend indicated that there were statistically significant differences in the prevalence of *E. coli* ($P < 0.01$) and total Enterobacteriaceae ($P < 0.001$) between the study and control groups. According to the result of the Fisher's exact test, however, no statistically significant differences were found in the prevalence of *Enterobacter* species between these two groups (Table 2).

Table 1. Enterobacteriaceae isolated from the saliva samples in both groups

Groups	Species	No. of patients	%
Study group (with nail biting) $n = 25$	*Escherichia coli*	15	60
	Enterobacter spp.	4	16
	Total Enterobacteriaceae	19	76
Control group (with no oral habit) $n = 34$	*Escherichia coli*	7	20.6
	Enterobacter spp.	2	5.9
	Total Enterobacteriaceae	9	26.5

Table 2. The results of a Pearson chi-squared test for trend

	Chi-squared for trend[1]	d.f.	*P*-value
Escherichia coli	10.048[2]	1	0.002
Enterobacter spp.	1.714[3]	1	0.223
Total Enterobacteriaceae	14.816[2]	1	0.000

[1]Computed only for a 2 × 2 table.
[2]No cells (0.0%) have expected count < 5. The minimum expected count is 9.17 for *Escherichia coli* and 11.67 for total Enterobacteriaceae.
[3]Two cells (50.0%) have expected count < 5. The minimum expected count is 2.50.

Discussion

Oral habits like thumb sucking and nail biting can damage the oral and dental structures and lead to the spread of infectious diseases (40). A nail-biting habit is associated with injury of the nail beds and gingiva. Gingival injury occurs when a nail fragment accidentally lodges in the gingival sulcus, causing inflammation and abscess formation on occasion (7). Inadvertent gingival injury can also occur if the child's hand slips and the fingernail scrapes the oral mucosa. Nail-biters who are inflicted with trauma around the unguis or nail create a portal of entry for microorganisms, leading to periungual infections (5, 32).

On the other hand, chronic nail biting can result in autoinoculation of pathogens and transmission of infection to other parts of the body. Pinworms are commonly found in school-age children. These children will have perianal irritation as a result of the infection. Children scratch to relieve the itching and Enterobacteriaceae, viruses and pinworm eggs lodge under their nails (40). The hand-to-mouth behavior in children who are fingernail-biters with inadequate or poor hand hygiene leads to many illnesses and infections with a fecal–oral route of transmission. Enterobacteriaceae and viruses are spread by the fecal–oral route through contaminated hands or environmental objects and are the major causes of morbidity and mortality worldwide (6, 30). Transmission may occur either by direct contact with an infected person and object or by ingestion of contaminated food or water.

The Enterobacteriaceae are usually considered to be only transiently present in the human oral cavity but oral structures are still known to become infected with them, although other sites of the body are much more frequently involved (25). Among the clinical conditions of oral structures involving enteric bacteria, there have been reports of post-extraction cellulites of the floor of the mouth and neck caused by *Salmonella choleraesuis* and an infection of a maxillary epithelial cyst caused by *Salmonella typhimurium* (18, 31). In some cases, an infection may involve gram-positive cocci in addition to the enteric bacteria. Osteomyelitis of the mandible, for example, by a mixed flora with *E. aerogenes* as the predominant organism and *E. coli* also present has been reported (23).

It has been reported that there are wide regional and ethnic variations in the oral carriage of Enterobacteriaceae (35). The study by Philpot et al. (29) from the Asian regions shows a coliform carriage prevalence of 4% for Malaysian children. This is in agreement with data from Hable et al. (12), who studied 490 healthy Minnesota children under the age of 16 years and found a 4.7% prevalence for Enterobacteriaceae. In an investigation of coliform prevalence in the plaque of 105 subjects in Scotland among young Caucasian students, the isolation rate was 5% (20). In addition, Hägg et al. (13) found an 11.1% coliform prevalence rate before the insertion of fixed orthodontic appliances. However, the coliform prevalence rates in the present study were higher in control subjects with no oral habit, and these differences in prevalence rates may be explained by the variations in geographical location, ethnicity and age.

The findings of the present study indicated that there were statistically significant differences in the prevalence of *E. coli* ($P < 0.01$) and total Enterobacteriaceae ($P < 0.001$) between the subjects with and without a nail-biting habit. Enterobacteriaceae were found in the saliva samples of 19 of 25 subjects for the study group, whereas Enterobacteriaceae were isolated in the saliva samples of only nine of the 34 subjects in the control group. On the other hand, *E. coli* was detected in 15 subjects with chronic nail biting while *E. coli* was isolated in seven subjects with no oral habit. Therefore, it can be said that there is a higher fecal–oral contamination risk for the nail-biting subjects in comparison with the subjects with no oral habit.

Management of patients who are at risk of the development of infection is crucial in all fields of dentistry. A transient bacteremia that occurs after various dental manipulations such as extraction, root scaling, endodontic treatment and some orthodontic procedures may lead to the development of infective endocarditis unless appropriate precautions are taken (8, 11). Nail biting is considered to be the cause of trauma to the gingival margin and/or oral mucosa. Therefore, it should be considered that a nail-biting habit might increase the risk of infection during dental procedures in particular.

In addition to the above points, fixed orthodontic appliances and space maintainers especially tend to retain bacterial plaque and food debris, resulting in mild-to-moderate gingivitis in most patients (13, 42). It has been shown that the mean population of bacteria in the oral cavity increases with the placement of orthodontic bands (13, 16). Hägg et al. (13) indicated that treatment with fixed orthodontic appliances might alter the ecology of the oral cavity by introducing new stagnant areas available for colonization by and retention of Enterobacteriaceae. For this reason, one could speculate that higher bacterial prevalence would be recorded on removal of the fixed orthodontic appliances and space maintainers compared to the pre-treatment period. Therefore, it can be said that the prevalence of the Enterobacteriaceae in the oral cavity of patients with chronic nail biting may increase more during fixed orthodontic and/or pedodontic applications. However, further longitudinal investigations with carefully designed methods are needed to clarify this hypothesis.

Recognition and elimination of an oral habit such as thumb sucking and nail biting is of utmost importance in the treatment of orthodontic and other dental problems. The treatment of a chronic nail-biting habit should be directed at any precipitating cause of stress. Reminders should only be used with the child's consent. Care of the nails and cuticles, behavioral modification techniques, positive reinforcement and regular follow-up are important aspects of the treatment (21).

In conclusion, the present study suggests that there is a significant increase in the prevalence of Enterobacteriaceae in the saliva samples of subjects with a chronic nail-biting habit compared with the subjects with no oral habit. Therefore, it can be said that the chronic nail-biters have a higher contamination risk than the patients with no oral habit. Dental specialists

should take into consideration the increase in prevalence of Enterobacteriaceae in patients with chronic nail biting during dental manipulations and, whenever required, should seek consultation with the patient's medical specialist.

In addition, patients who are chronic nail-biters should be given proper hand and oral hygiene instructions; the treating dental specialists must also decide whether psychiatric intervention is needed and should provide guidance concerning the various methods available to stop the undesirable habit.

References

1. Agustin ET, Gill V, Domenico P. CSF gram stain in meningitis. Intern Med 1994: **15**: 14–24.
2. Barnett BJ, Stephens DS. Urinary tract infection: an overview. Am J Med Sci 1997: **314**: 245–249.
3. Bopp CA, Brenner FW, Fields PI, Wells JG, Strockbine NA. *Escherichia*, *Shigella*, and *Salmonella*. In: Murray PR, Baron EJO, Jorgensen JH, Pfaller MA, Yolken RH, ed. *Manual of clinical microbiology*, *Vol. 1, 8th edn*. Washington, DC: ASM Press, 2003: 654–659.
4. Christensen JR, Fields HW. Oral habits. In: Pinkham JR, Casamassimo PS, McTigue DJ, Fields HW, Nowak A, eds. *Pediatric dentistry: infancy through adolescence*, *2nd edn*. Philadelphia, PA: WB Saunders Co., 1994: 366–373.
5. Cohen BA, Davis HW, Mallory SB, Zitelli JA. Pediatric dermatology. In: Zitelli BJ, Davis HW, ed. *Atlas of pediatric physical diagnosis*, *2nd edn*. London: Cower Medical Publishing, 1992: 8.1–8.42.
6. Cohen MB. Etiology and mechanism of acute infectious diarrhea in infants in the United States. J Pediatr 1991: **118**: 34–39.
7. Creath C, Steinmetz S, Roebuck R. A case report: gingival swelling due to a finger-nail-biting habit. J Am Dent Assoc 1995: **126**: 1019–1021.
8. Degling TE. Orthodontics, bacteremia, and the heart damaged patient. Angle Orthod 1972: **42**: 399–401.
9. Eisenstein BI, Jones GW. The spectrum of infections and pathogenic mechanisms of *Escherichia coli*. Adv Intern Med 1988: **33**: 231–252.
10. Einstein BI, Zaleznik DF. Enterobacteriaceae: infectious diseases and their agents. In: Mandell GL, Bennett JE, Dolin R, eds. *Mandell, Dauglas, and Bennet's principles and practice of infectious diseases*, *5th edn, Vol. 2*. Philadelphia, PA: Churchill Livingstone, A Harcourt Health Sciences Company, 2000: 2294–2305.
11. Erverdi N, Biren S, Kadir T, Acar A. Investigation of bacteremia following orthodontic debonding. Angle Orthod 2000: **70**: 11–14.
12. Hable KA, Washington JA, II, Herman EC, Jr. Bacterial and viral throat flora. Comparison of findings in children with acute upper respiratory tract diseases and in healthy controls in winter. Clin Pediatr 1971; **10**: 199–203.
13. Hägg U, Kaveewatcharanont P, Samaranayake YH, Samaranayake LP. The effect of fixed orthodontic appliances on the oral carriage of *Candida* species and Enterobacteriaceae. Eur J Orthod 2004: **26**: 623–629.
14. Hansing CE, Allen VD, Cherry JD. *Escherichia coli* endocarditis. A review of the literature and a case study. Arch Intern Med 1967: **120**: 472–477.
15. Harvey D, Holt DE, Bedfort H. Bacterial meningitis in the newborn: a prospective study of mortality and morbidity. Semin Perinatol 1999: **23**: 218–225.
16. Huser MC, Baehni PC, Lang R. Effects of orthodontic bands on microbiologic and clinical parameters. Am J Orthod Dentofacial Orthop 1990: **97**: 213–218.
17. Jonas M, Cunha BA. Bacteremic *Escherichia coli* pneumonia. Arch Intern Med 1982: **142**: 2157–2159.
18. Ködel G, Brühl P. Salmonellen in einer epithelzyste am oberkieferein ungewöhnlicher. Befunde Schweiz Mschr Zahnheilk 1966: **76**: 33–39.
19. Krejci CB. Self-inflicted gingival injury due to habitual fingernail biting. J Periodontol 2000: **71**: 1029–1031.
20. Leitich JA, Lang M, MacFarlane TW, MacKenzie D. The prevalence and distribution of yeasts and coliform in dental plaque. J Dental Res 1991: **70**: 709.
21. Leung AK, Robson WL. Nailbiting. Clin Pediatr 1992: **31**: 702–703.
22. Lobene RR, Soparkar PM, Newman MB. Use of dental floss. Effect on plaque and gingivitis. Clin Prev Dent 1982: **4**: 5–8.
23. Mashberg A, Carroll MA, Morrissey JB. Gram-negative infections of the oral cavity and associated structures: report of two cases. J Oral Surg 1970: **28**: 376–378.
24. Moyers RE. *Handbook of orthodontics*, *4th edn*. Chicago, IL: Year Book Medical Publishers Inc., 1988: 156 pp.
25. Nolte WA. *Oral microbiology*, *2nd edn*. St Louis, MO: The C.V. Mosby Company, 1973: 86–87.
26. Odenrick L, Brattstrom V. The effect of nailbiting on root resorption during orthodontic treatment. Eur J Orthod 1983: **5**: 185–188.
27. Odenrick L, Brattstrom V. Nailbiting: frequency and association with tooth resorption during orthodontic treatment. Br J Orthod 1985: **12**: 78–81.
28. Pattison GL. Self-inflicted gingival injuries: literature review and case report. J Periodontol 1983: **54**: 299–304.
29. Philpot CR, McDonald PJ, Chai KH. Significance of enteric Gram-negative bacilli in the throat. J Hyg (Lond) 1980; **85**: 205–210.
30. Richards GP. Enteric virus contamination of foods through industrial practices: a primer on intervention strategies. J Ind Microbiol Biotechnol 2001; **27**: 117–125.
31. Rubelman PA, Rebuck JF, Loveman CE. Post extraction acute cellulitis caused by *Salmonella choleraesuis*: report of a case. J Oral Surg 1961: **19**: 255–256.
32. Salman-Ehr V, Mohn C, Bernard P. Secondary longitudinal melanoncyhia secondary to onychophagia. Ann Dermatol Venereol 1999: **126**: 44–45.
33. Samaranayake LP, MacFarlane TW, Lamey PJ, Ferguson MM. A comparison of oral rinse and imprint sampling techniques for the detection of yeast, coliform and *Staphylococcus aureus* carriage in the oral cavity. J Oral Pathol Med 1986: **15**: 386–388.
34. Schimpff SC. Gram-negative bacteremia. Support Care Cancer 1993: **1**: 5–18.
35. Sedgley CM, Samaranayake LP. Oral and oropharyngeal prevalence of Enterobacteriaceae in humans: a review. J Oral Pathol Med 1994: **23**: 104–113.
36. Shea KW, Cunha BA. *Escherichia coli* sternal osteomyelitis after open heart surgery. Heart Lung 1995: **24**: 177–178.
37. Shetty SR, Munshi AK. Oral habits in children – a prevalence study. J Indian Soc Pedod Prev Dent 1998: **16**: 61–66.
38. Strohl WA, Rouse H, Fisher BD. Enteric Gram-negative rods. In: Harvey RA, Champe PA, ed. *Lippincott's illustrated reviews: microbiology.* Baltimore, MD: Lippincott, Williams & Wilkins, 2001: 175–178.
39. Tosti A, Peluso AM, Bardazzi F, Morelli R, Bassi F. Phalangeal osteomyelitis due to nail biting. Acta Derm Venereol 1994: **74**: 206–207.
40. Vogel LD. When children put their fingers in their mouths. Should parents and dentists care? N Y State Dent J 1998: **64**: 48–53.
41. Waldman BA, Frieden IJ. Osteomyelitis caused by nail biting. Pediatr Dermatol 1990: **7**: 189–190.
42. Zachrisson S, Zachrisson BU. Gingival condition associated with orthodontic treatment. Angle Orthod 1972: **42**: 26–34.